INTERNATIONAL COURT OF JUSTICE

DISPUTE OVER THE STATUS AND USE OF THE WATERS OF THE SILALA

(CHILE v. BOLIVIA)

ADDITIONAL PLEADING OF THE REPUBLIC OF CHILE

ANNEX 100 TO THE ADDITIONAL PLEADING AND ANNEXES XV - XVI TO THE EXPERT REPORT

VOLUME 2 OF 2

16 SEPTEMBER 2019

VOLUME 2

LIST OF ANNEXES

Annex 100

100.1 Note from the Agent of the Republic of Chile to the Agent of the Plurinational State of Bolivia, 27 May 2019

100.2 Note from the Agent of the Plurinational State of Bolivia to the Agent of the Republic of Chile, 17 June 2019

(Originals in English)

REPUBLICA DE CHILE
MINISTERIO DE RELACIONES EXTERIORES

27 May 2019

His Excellency
Mr. Eduardo Rodríguez Veltzé
Agent
Plurinational State of Bolivia

Sir,

On behalf of the Government of the Republic of Chile, and with reference to the Dispute over the Status and Use of the Waters of the Silala (Chile v. Bolivia), I have the honour to refer to the Rejoinder filed by the Plurinational State of Bolivia on 15 May 2019 and, in particular, the sensitivity analysis conducted by the Danish Hydraulic Institute ("DHI") as reported in Annex 25 of the Rejoinder.

After consulting with its expert Prof. Howard Wheater, my Government wishes to convey that, in Prof. Wheater's expert opinion, the DHI sensitivity analysis model runs cannot be fully scrutinized without the relevant modelling data, including all model set-up, input and output files for all model runs that were reported in Annex 25 of the Rejoinder.

My Government requests submission of these modelling data that are essential to the analysis of DHI's recent results. It also requests that a copy of the data shall be formally deposited with the Registrar and be considered part of the record of the case. Finally, my Government suggests that the requested data shall be submitted promptly and no later than two weeks following receipt of this Note, to ensure their timely analysis by Chile's experts.

Attached you will find a letter from expert Prof. Howard Wheater, indicating the need for the requested information in order to complete the analysis of DHI's results.

Accept, Sir, the assurances of my highest consideration,

Ximena Fuentes Torrijo
Agent of the Republic of Chile

EMBASSY OF THE PLURINATIONAL STATE OF BOLIVIA
The Hague – The Netherlands

EB.NL.-Cs- 31/2019

The Hague, 17 June 2019

Excellency
Mrs. Ximena Fuentes Torrijo
Agent of the Republic of Chile

Madam,

With reference to the case concerning the Dispute over the Status and Use of the Waters of the Silala (Chile v. Bolivia) and following my note dated 7 June 2019 regarding your request of the modelling data used by the Danish Hydraulic Institute (DHI) in the "Updating of the mathematical hydrological model scenarios of the Silala spring waters with: Sensitivity analysis of the model boundaries", submitted in the Rejoinder of the Plurinational State of Bolivia as Annex 25, I hereby attach a USB containing the requested information.

Accept, Madam, the assurances of my highest consideration.

Eduardo Rodríguez Veltzé
Agent of the Plurinational State of Bolivia

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Annex XV

Muñoz, J.F, Suárez, F., Sanzana, P. and Taylor, A., 2019.
Assessment of the Silala River Basin Hydrological Models Developed by DHI

ASSESSMENT OF THE SILALA RIVER BASIN HYDROLOGICAL MODELS DEVELOPED BY DHI

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August 2019

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1. INTRODUCTION

The National Director of Borders and Boundaries (DIFROL) of the Ministry of Foreign Affairs, Mrs. Ximena Fuentes, asked professors José F. Muñoz and Francisco Suárez to review the study "*Study of the Flows in the Silala Wetlands and Springs System*", commissioned by the Bolivian counterpart to the Danish Hydraulic Institute (DHI), and presented in the Bolivia's Counter-Memorial (BCM) in 2018.

It was only after two requests that Bolivia provided Chile with the files used by DHI for the modelling reported in Bolivia's Counter-Memorial, and these were received after Chile's Reply (CR) of 15 February 2019 had been finalized. This report is based on the analysis of those files and complements and extends the previous analysis of DHI modelling, presented in Wheater and Peach, 2019 (CR, Vol.1, pp 85-154).

The focus of the DHI study was the surface water flow crossing the Chile-Bolivia international border in the Silala River, including the impacts of historical channelization. To analyze the hydrological behavior of the Silala River basin, DHI divided the study area into the Far Field and the Near Field:

- "The Near Field area covers all surface water features and immediate surroundings including springs, wetlands and canals" (BCM, Vol. 2, p. 367).
- The Far Field "is the full area contributing to the discharge through the springs and canals on the Bolivian territory" (BCM, Vol. 2, p. 328). The boundaries of the Far Field are uncertain, but a hydrological catchment was delineated by DHI (BCM, Vol. 2, p. 328; Figure 1-1). The Far Field catchment is roughly equivalent to the groundwater catchment described in the Chilean Reply (CR, Vol. 1, p. 105).

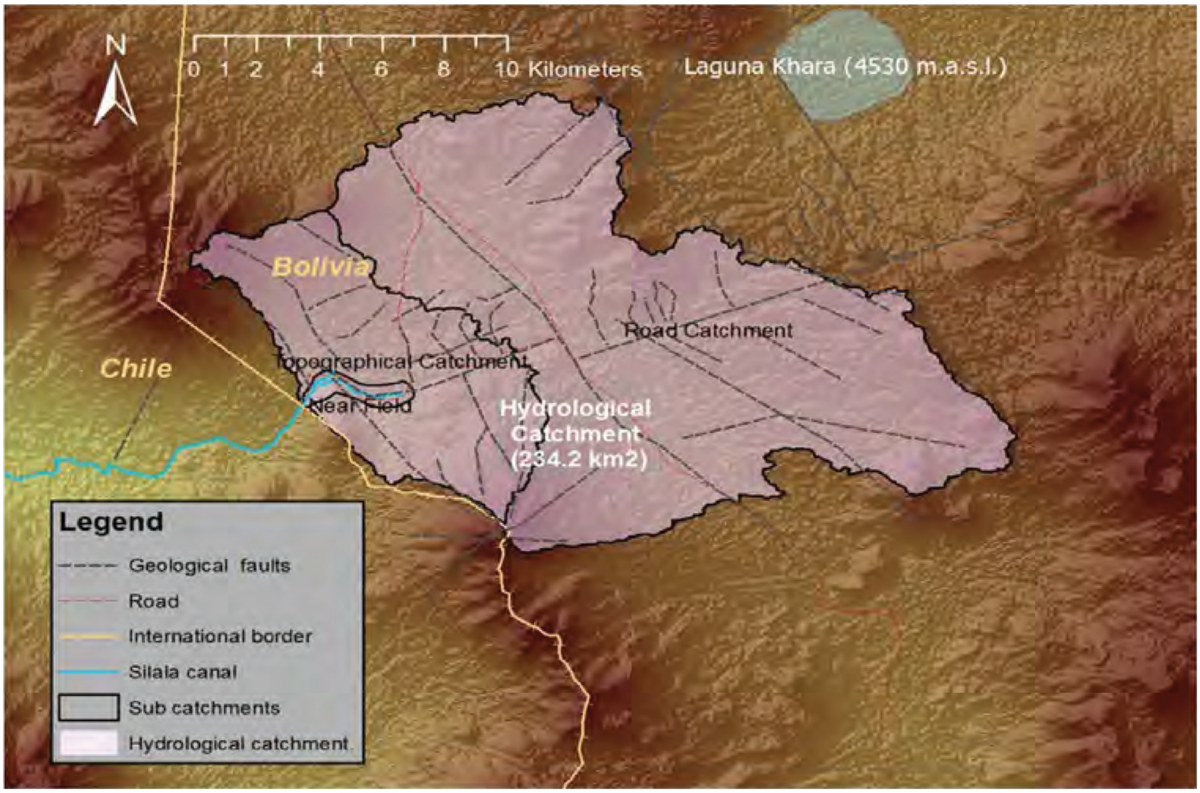


Figure 1-1. Hydrological catchment and Silala Near Field area defined in DHI (2018) (BCM, Vol. 2, p. 328).

DHI (2018) built three hydrological models: a Water Balance Model (WBM), a Near Field Model (NFM) and a Near Border Model (NBM). Each of these consists of a numerical model based on a conceptual model of the hydrological/hydrogeological processes. For the numerical models, DHI used an integrated groundwater/surface water model based on the MIKE-SHE model for coupled surface and groundwater flows. For one of the scenarios investigated (the Baseline scenario, representing current channelization) they also used the MIKE-11 modelling system for 1D open water flows.

The domain of each model is presented in Figure 1-2. The Water Balance Model covers the whole groundwater catchment of the Silala River upstream of the international border, excluding the area immediately adjacent to the wetlands. The excluded area is simulated in the Near Field Model. The Near Border Model covers the area of the Near Field Model between the confluence of the Orientales and Cajones tributaries and the international border. The NBM is not directly relevant to the main issues that remain in dispute between the parties and is therefore not considered further in this report.

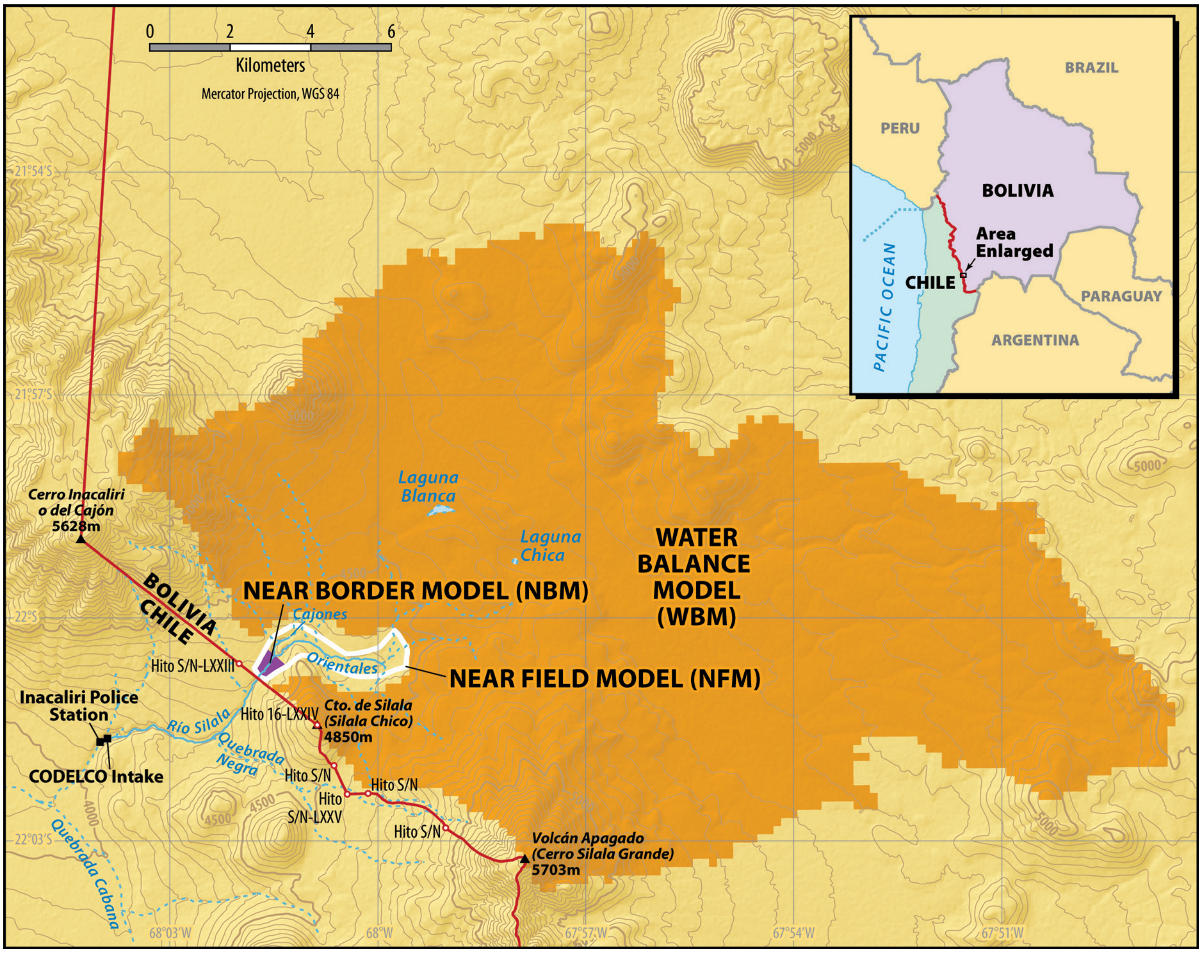


Figure 1-2. Domains covered by the three different DHI models.

The WBM was mainly used to estimate recharge and the available water resources in the Silala River Basin but was not used to assess surface or groundwater flow changes across the Chile-Bolivia international border. The NFM was used to compare scenarios with and without channelization and to quantify the influence of the channelization on the Silala River flow. The NBM was used by DHI to investigate infiltration from surface water to groundwater close to the border (between the confluence of the spring tributary channels and the border).

The NFM has been used to simulate various scenarios, in which the configuration of the model, and its inputs, are changed to evaluate the impact of the channelization. Three scenarios were used:

i) Baseline: represents the current situation with channelization.

ii) No Canal: represents the situation without channels.

iii) Undisturbed: represents a 'restored' situation without channels and with assumed long-term development of wetland peat soils.

After the submission of the Bolivia's Counter-Memorial in 2018, Chile requested the data files of the three models. Two requests from Chile were necessary before DHI provided the requested files, which were received after Chile's Reply had been finalized. In this report, we review the DHI hydrological/hydraulic modelling in the light of this new information, in particular those aspects that deal with channelization impacts. The files provided by the Bolivian counterpart are specified in Appendix A.

Given its relevance to the continuing dispute between the Parties, the main focus of this report is a critical review of the Near Field Model, in which the impact of the channelization is evaluated using the three scenarios defined above. Additionally, we assess the consistency between the WBM and the NFM.

1.1 Objectives

The objectives of this study are therefore:

- To review the configuration, inputs, results and water balances of the Far Field and Near Field models.
- To carry out a critical review of the Near Field Model. Specifically, to evaluate whether the modelling approach is consistent with the available data and conceptual understanding of the Silala River basin and whether the scenarios selected are appropriate to represent the impacts of channelization.

1.2 Structure of the report

The structure of the remainder of this report is as follows: Section 2 presents relevant background information obtained from the Bolivian Counter-Memorial. Section 3 presents a brief review of the Water Balance Model, and in Section 4 the Near Field Model is analyzed in detail. In Section 5 the main conclusions are summarized and in Section 6 the references are presented.

2. REVIEW OF BACKGROUND INFORMATION USED BY BOLIVIA FOR THE SILALA RIVER BASIN

The background information collected by Bolivia and DHI for the hydrogeological study of the Silala River basin is presented in the BCM and associated annexes. A geological map of the entire basin is presented (BR, Complete Copies of Certain Annexes Vol.2, Annex 23.5 Appendix a, p.69, reproduced here as Figure 2-1). Also, the hydrological catchment delimitation is provided (BCM, Vol.2, p. 328, reproduced here as Figure 1-1), along with a Digital Elevation Model.

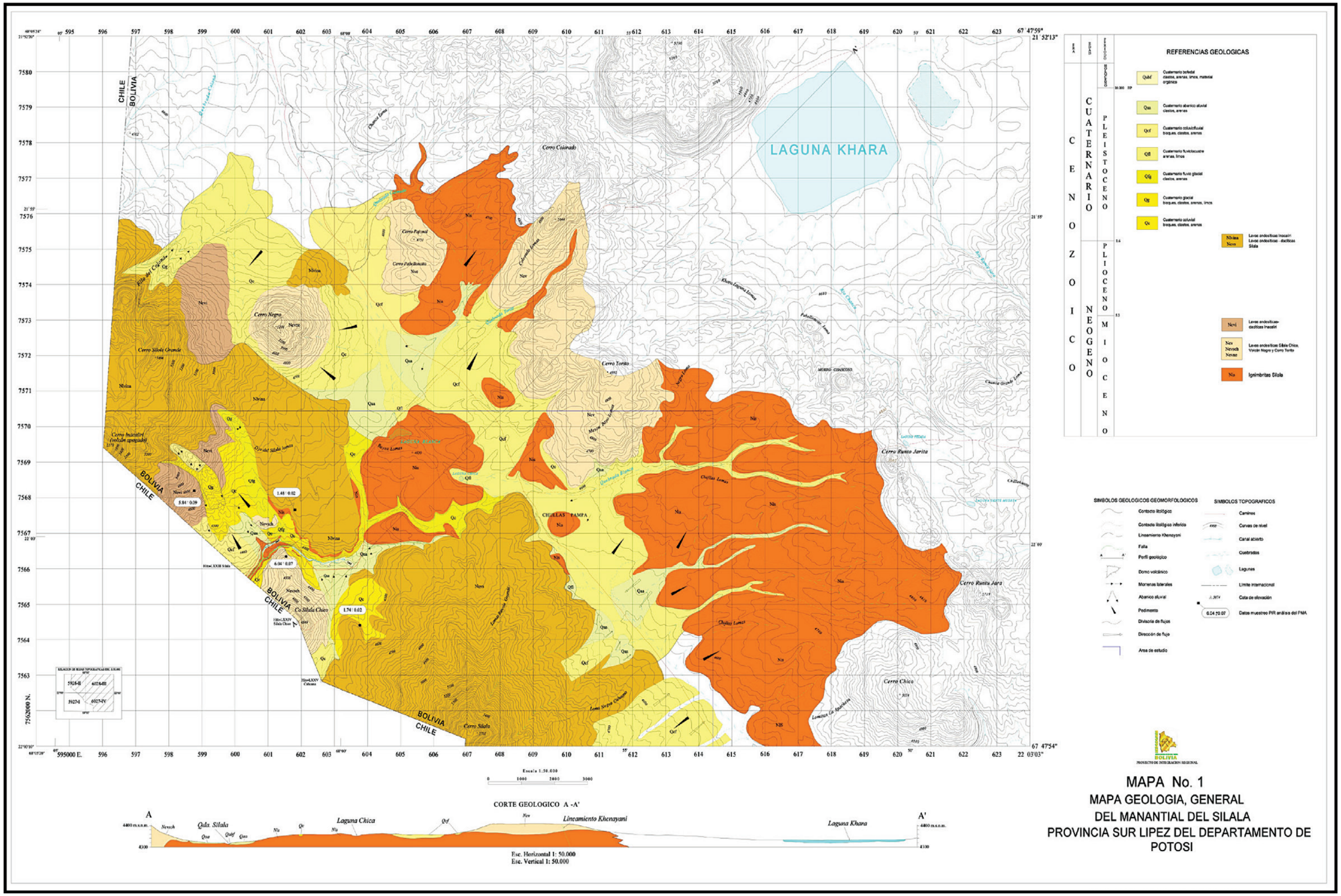


Figure 2-1. Geologic Map of the Silala Study Area (BR, Complete Copies of Certain Annexes, Vol. 2, Annex 23.5 Appendix a, p. 69). See also Figure 2-9 for larger legend

The Bolivian counterpart collected an extensive amount of field data in the Silala Near Field, including hydrogeological drilling and testing, surface flow, surface geological mapping, soil sampling in the wetlands and geophysical transect investigations.

For the hydrogeology study, presented in Annex F to the DHI Report (2018) (BCM, Vol. 4), wells and piezometers were drilled in the Silala Near Field. The locations of the boreholes and piezometers drilled are presented in Figure 2-2.

Figure 2-2. "Location of the boreholes and piezometers in the Silala Near Field" [Original Caption]. (BCM, Vol. 4, p. 25).

Water level monitoring was carried out by the Bolivian counterpart in these boreholes by taking manual measurements, typically on a daily basis. Groundwater level contours in the Silala Near Field, interpolated from piezometer wells, spring elevations, and wetland excavations for soil sampling, are presented in Figure 2-3, which is reproduced, together with the figure caption, from BCM, Vol.2, p. 293.[1] According to DHI (BCM, Vol. 4, p. 95) "[t]he contours reflect the interpretation of significant discharge to the Southern Wetlands from the north and northeast areas of the catchment as well as from recharge on Volcán Silala Grande".

[1] The same figure, without the arrow, is also presented in BCM, Vol.4, p. 97.

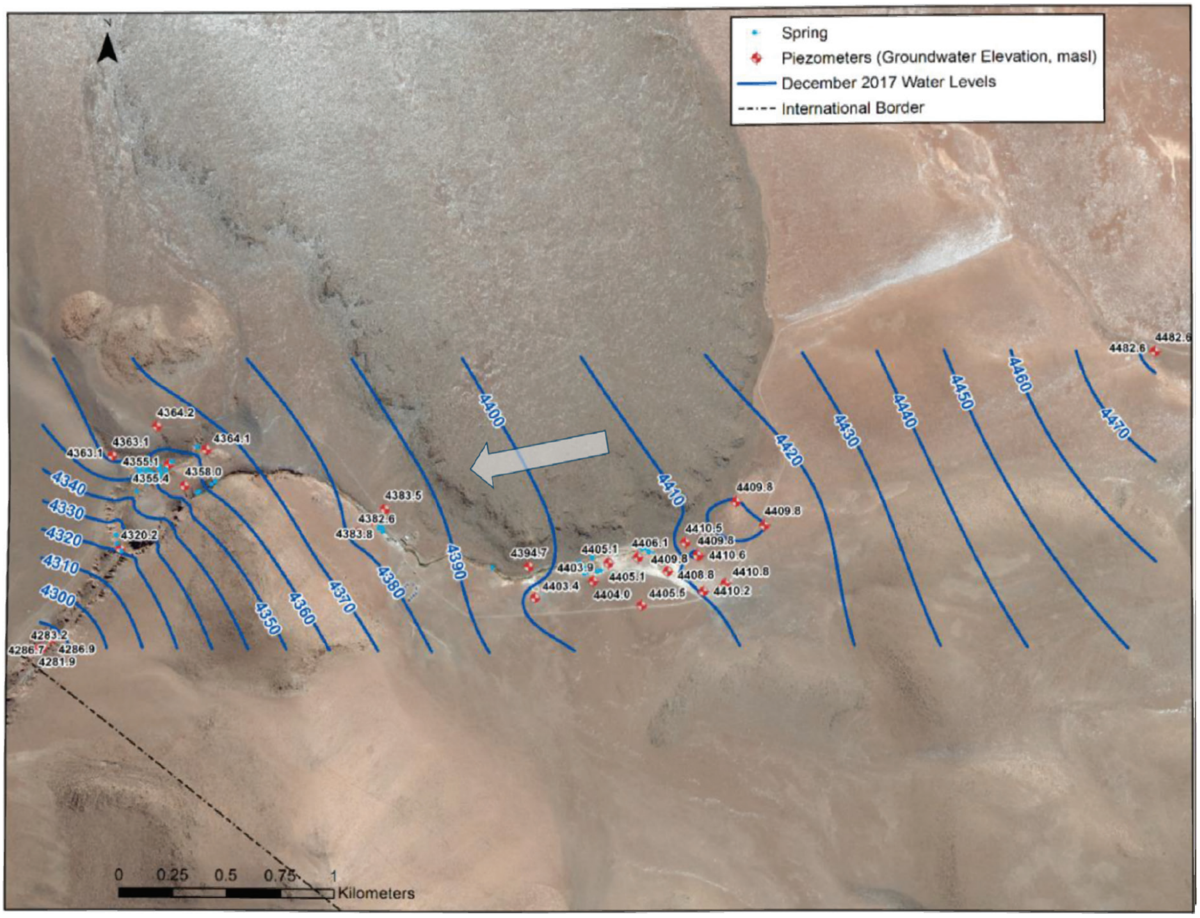


Figure 2-3. "Borehole locations and groundwater level contours in the Silala Near Field, interpolated from Piezometer wells spring elevations and wetlands excavations for soil sampling. N.B. the contouring away from the wetlands and the boreholes are uncertain" [Original Caption]. (BCM, Vol. 2, p. 293).

The surface flow study was presented in Annex C to the DHI Report, 2018 (BCM, Vol. 2, Annex 17). Its key objective was to quantify the flows in the Silala Near Field. For this study, simultaneous stream flow measurements were made at 21 locations and continuous flow records were collected at seven weirs (Figure 2-4).

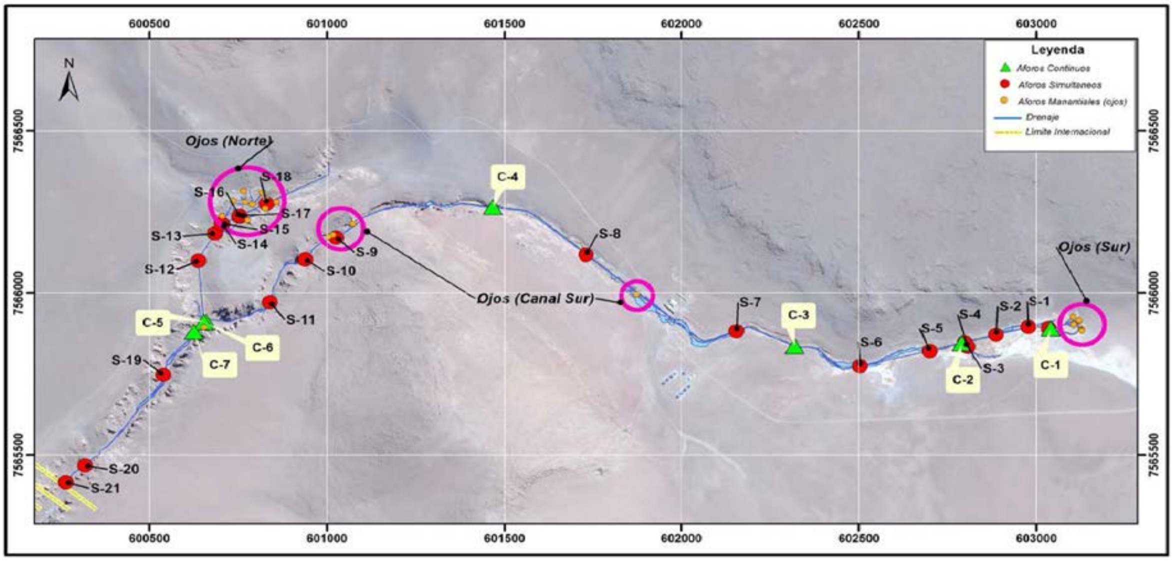


Figure 2-4. "Overview of flow measurement locations" [Original Caption].
(BCM, Vol. 2, p. 381).

The DHI analysis of these measurements resulted in a conceptual understanding of the Near Field groundwater flows, which is reproduced in our Figure 2-5 and Figure 2-6. Figure 2-5 shows the conceptual model of the groundwater flows, where the overall flow directions proposed by DHI are shown by gray and blue arrows.

Additionally, the estimation of the diffuse groundwater inflow into the Silala River is presented in Table 2-1, which shows that an important part of the Silala River flow comes from diffuse groundwater inflows (as opposed to discrete spring flows). Specifically, an important diffuse inflow is observed between C-4 and C-5, which is a narrow gorge.

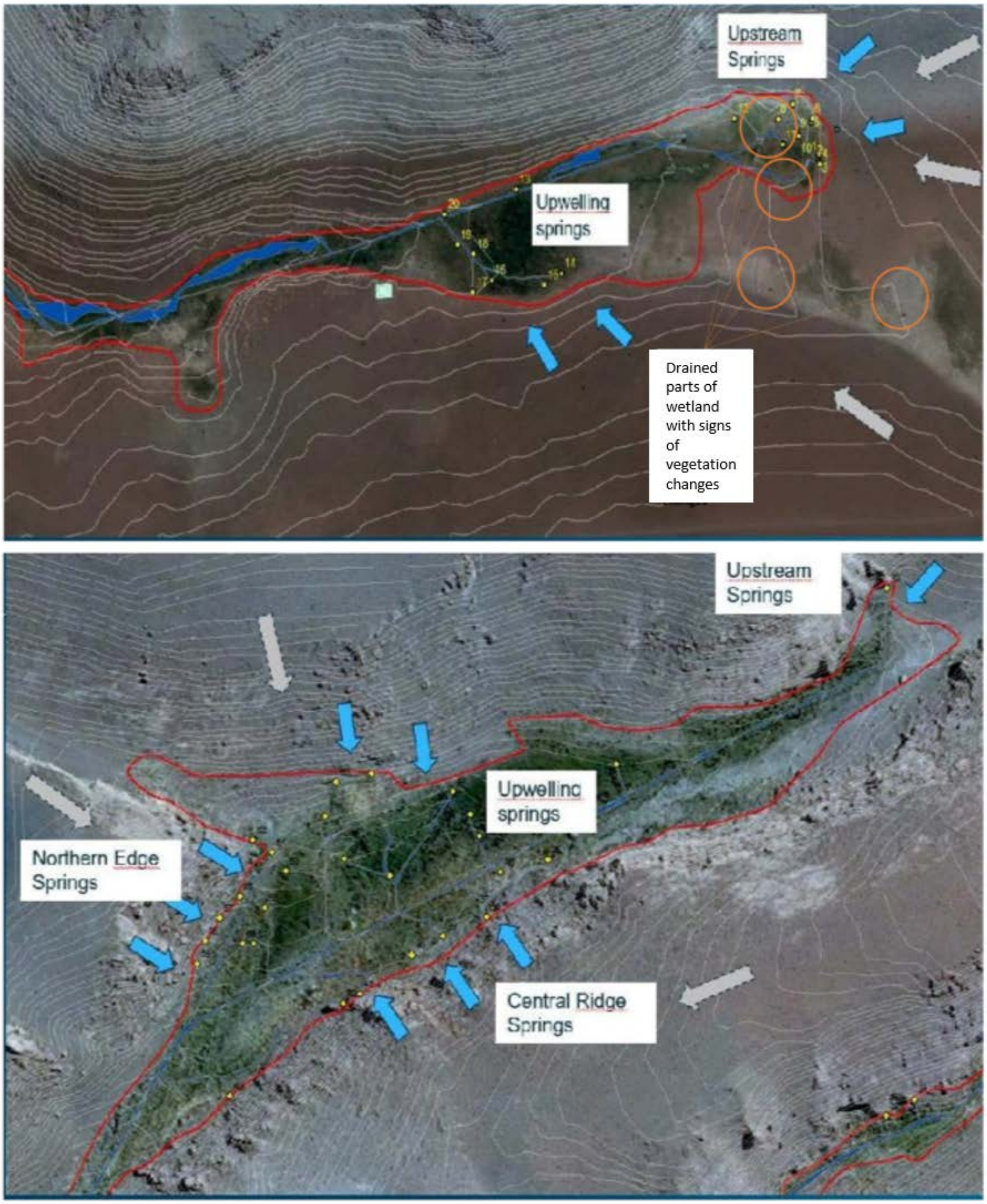


Figure 2-5. Southern (upper picture) and Northern (lower picture) wetlands "overview map showing extent (red polygon), canal network (blue line), springs (yellow dots) and overall flow directions by gray and blue arrows. Drained and drier wetland area with clear signs of vegetation changes are highlighted by orange circles" [part of the original caption]. (BCM, Vol. 2, p. 371).

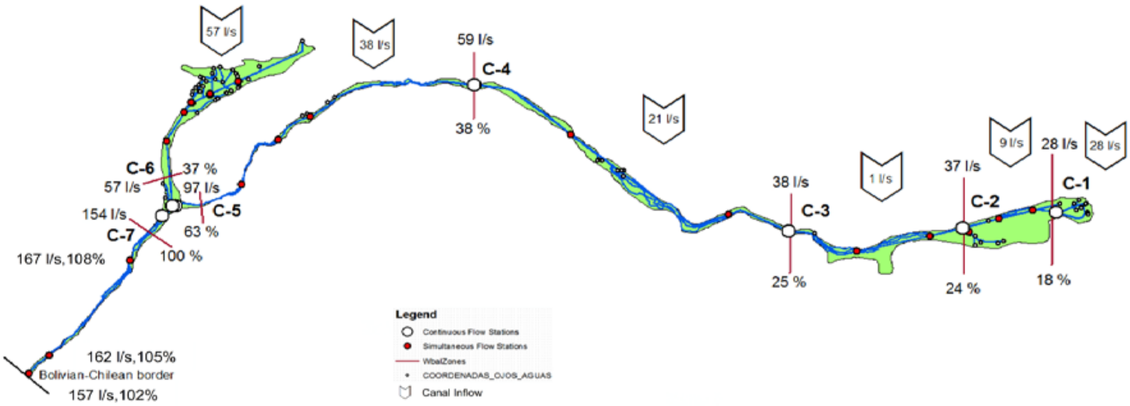


Figure 2-6. "Mapping of flows and net inflows based on simultaneous mean canal flow measurements (in l/s)" [Original Caption]. (BCM, Vol. 2, p. 391).

Section	Measured spring flow (l/s)	Measured Canal Flow (l/s)	Difference, canal-springs (l/s)
C1, springs 1-12 (Zone 2)	23.8	27.8	4.0
C2, springs 1-20 (Zone 2)	41.2	36.7	-4.5
C3, springs 1-21 (Zone 2)	41.2	38.0	-3.2
C4, springs 1-22 (Zone 3)	45.2	59.5	14.3
C5, springs 1-32 (Zone 4)	56.9	97.0	40.1
C6, springs 33-64 (Zone 1)	46.1	56.9	10.8
C5+C6, springs 1-64	103.0	154.0	51.0

Table 2-1. "Canal flows by section, accumulated upstream spring inflows and derived diffuse inflows [Difference, canal-springs]. The flows represent the average of all 10 measurement campaigns" [Original Caption]. (BCM, Vol. 2, p.386).

2.1 Geological interpretation

The Near Field modelling is based on the hydrogeological map generated by DHI (2018) (BCM, Vol. 4, p. 67), which is presented in Figure 2-7, and the definition of the hydrogeological units is presented in Table 2-2. In turn, the hydrogeological map is based on Bolivia's interpretation of the geology of the Silala River system, which is flawed in several respects. A detailed examination of the geological reports supporting the Bolivian Counter Memorial and presented in the Bolivian Rejoinder is available in SERNAGEOMIN (2019b) **(Chile's Additional Pleading (CAP), Vol.2, Annex XVI)**.

Bolivian geologists (SERGEOMIN, 2017) have determined that in Bolivia the Ignimbrite succession can be divided into three distinct geological units (Nis-1, Nis-2 and Nis-3) (BR, Vol. 4, pp. 43-61), whereas in Chile only two ignimbrite units have been identified, in surface outcrops and borehole cores (SERNAGEOMIN 2017, 2019b and Arcadis, 2017). In the area of the Bolivian wetlands there may be, at depth, further ignimbrite units, but these have not been found in Chile.

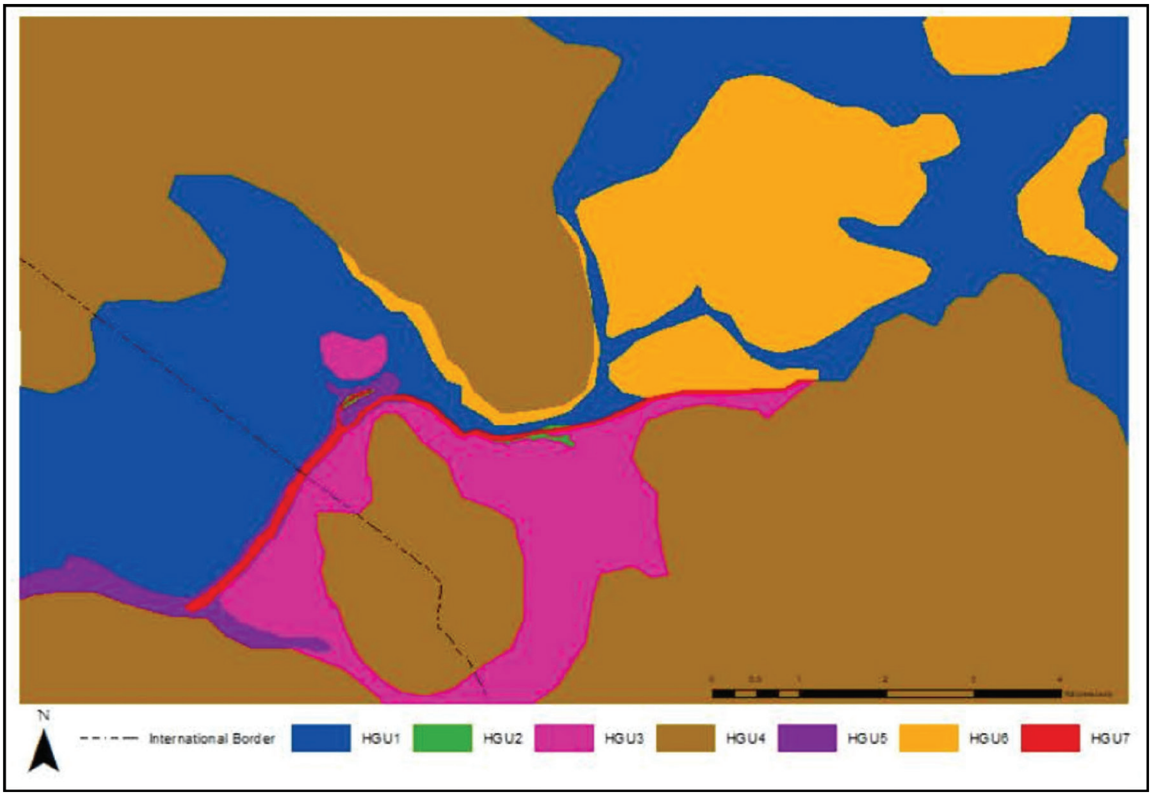


Figure 2-7. "Delineation of hydrogeological units (HGUs) in the Silala area" [part of the original caption]. (BCM, Vol 4, p. 67).

Hydrogeological Unit	Basic Lithology	Approximate Thickness (m)
HGU1	Colluvial and alluvial deposits	1 to 10 m
HGU2	Glacial deposits, sandy loams	1 to 10 m
HGU3	Weathered lava flows	1 to 30 m
HGU4	Felsic volcanic sequences	Up to 600 m
HGU6 Upper	Ignimbrite deposits with a high degree of welding	Up to 150 m
HGU5	Ignimbrite deposits with a low degree of welding	10 to 120 m
HGU6 Lower	Ignimbrite deposits with a high degree of welding	Up to 300 m; assumed to be 300 m in the model
HGU7	Fault zones believed important for groundwater flow	50 to 100 m wide, depth to base of ignimbrite (assumed)
HGU8	Volcanic neck of Silala Chico	650 to 760 m diameter; depth to base of ignimbrite

Table 2-2. Bolivian defined "Hydrogeological Units" [Original Caption] (BCM, Vol. 4, p. 65).

SERNAGEOMIN (2019a) (CR, Vol. 3, Annex XIV) have carried out a detailed analysis of the age and stratigraphic relationships of the Ignimbrites and Miocene volcanics that are found outcropping in the area of the Silala ravine in Bolivia and Chile. This work, without doubt, shows that the ignimbrite units defined in Chile, which can be traced northeast into Bolivia up the Silala ravine, are younger than the Miocene Volcanics that form the Silala Chico (Bolivian name) (Cerrito de Silala in Chile) and the small volcanic dome to the north of the Bofedales Norte (Cajones) wetland in Bolivia. These ignimbrite deposits overlie the less permeable Miocene volcanics. These ignimbrite deposits (Nis) and the Miocene volcanics (Nevsch) are clearly shown on the geological map of SERGEOMIN (2003) (reproduced here as Figure 2-1). In contrast, DHI (2018) shows, in pink on their figure, outcrops of "weathered lava flows" of thickness less than 30 m (see Table 2-2 and Figure 2-7) (BCM, Vol. 4, p. 67). Bolivia's hydrogeological map and Bolivia's geological map are compared in Figure 2-8. These weathered lava flows (HGU3) have been defined by DHI as "Chemically and mechanically weathered lava flows (see Table 3, DS-09). Characterized by areas where lavas extruded from the Inacaliri volcano (~1.5 Ma)" (BCM, Vol. 4, p. 65). Whereas the volcanic sequences of the Miocene (HGU4), which are called "Felsic volcanic sequences" by DHI (2018) (up to 600m thick) (see Table 2-2) (BCM, Vol. 4, p. 65), are compacted and of low permeability and considerably older. The area coloured pink on Figure 2-7 does not comprise weathered lava flows, so should not be assigned to HGU 3. Instead, the pink outcrop to the north of the Cajones ravine is a Miocene volcanic dome equivalent to what DHI (2018) calls Felsic Volcanic sequences and should be assigned to HGU 4. The remainder of the pink area on Figure 2-7 comprises outcrops of colluvial or alluvial deposits or is a part of the Miocene volcanic dome that makes up the Silala Chico (Bol) hill and should be assigned to HGU1 and HGU4 (see Figure 2-8). There are clearly errors in interpretation of the geological map, which have resulted in incorrect assignment of hydrogeological units.

These inconsistencies and errors in geological interpretation are in part demonstrated in the cross section at the bottom of Bolivia's geological map (Figure 2-1), presented in Figure 2-9, which shows that SERGEOMIN (2003) interprets the Ignimbrite deposits ("Nis" shown in orange red) as extensively underlying (and therefore older than) the Miocene Volcanics ("Nevsch" shown in beige). The legend from this map, also presented in Figure 2-9, confirms this interpretation. According to the dating work undertaken by SERNAGEOMIN (2019a), this is clearly incorrect.

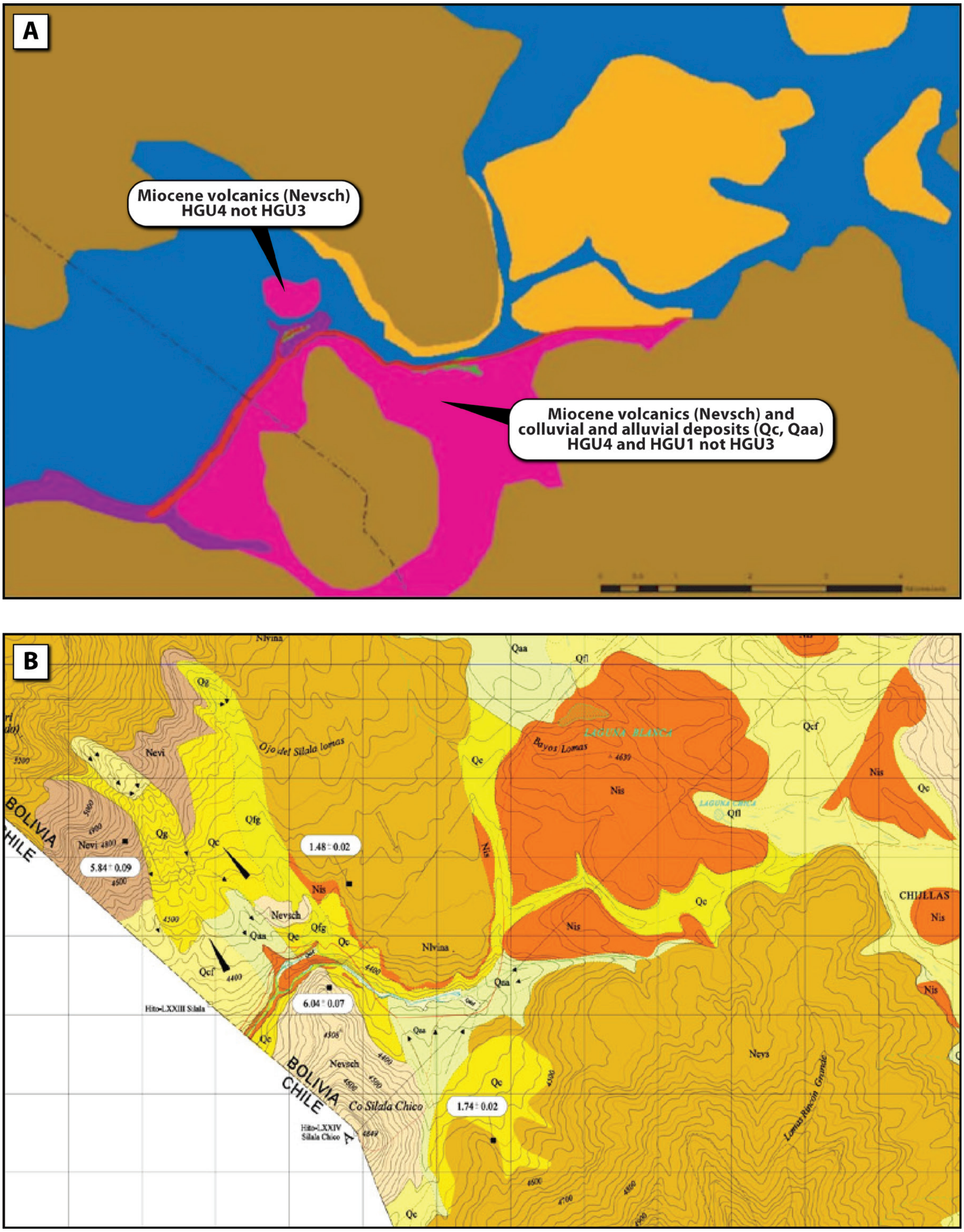


Figure 2-8. Comparison of (A) Bolivia's hydrogeological units (HGUs) (BCM, Vol 4, p. 67) and (B) surface geology in the Silala area. (BR, Complete Copies of Certain Annexes, Vol. 2, Annex 23.5 Appendix a, p. 69).

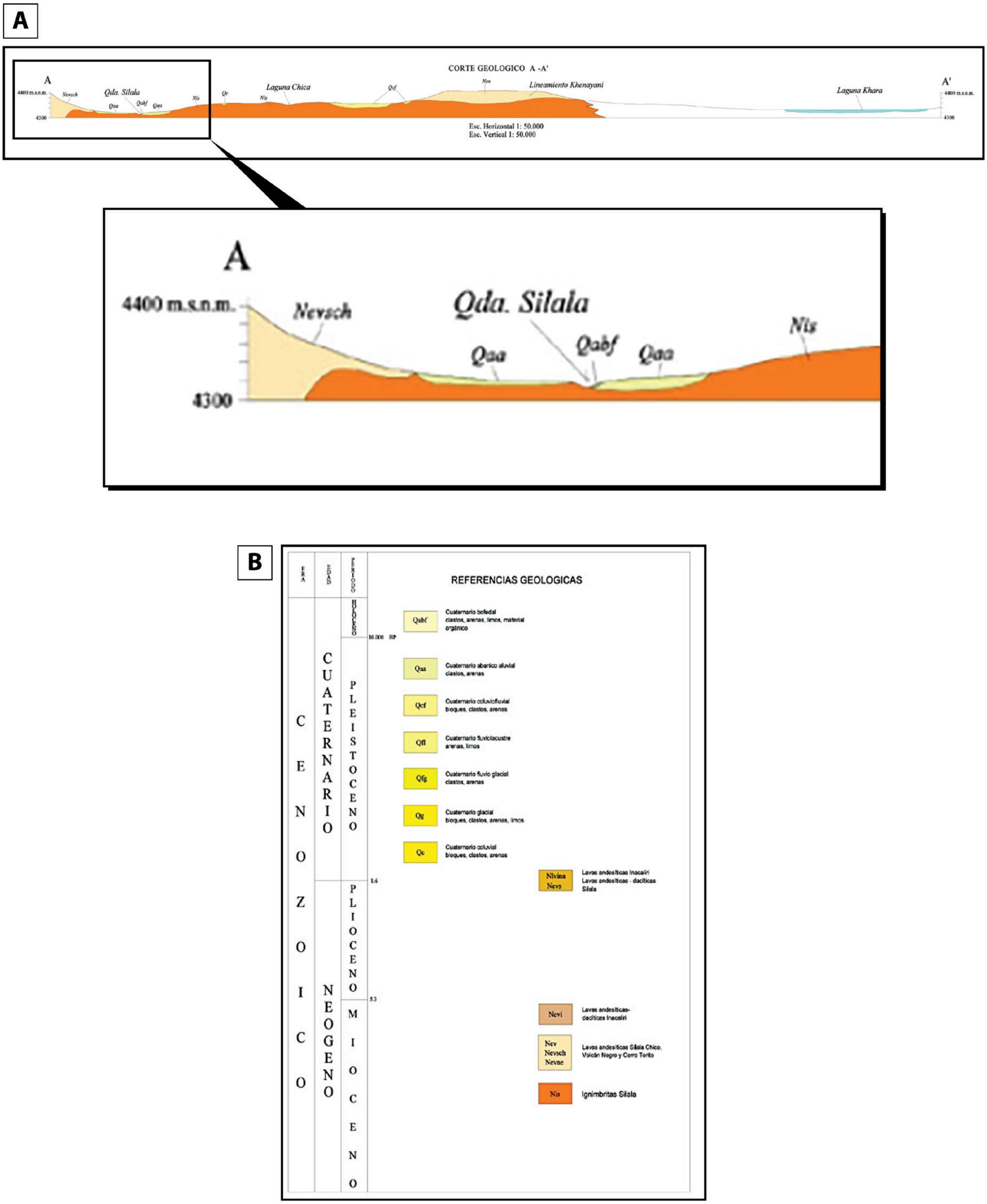


Figure 2-9. (A) Expanded view of the cross section and (B) legend from Bolivia's geological map reproduced at Figure 2-1. (BR, Complete Copies of Certain Annexes, Vol. 2, Annex 23.5 Appendix a, p. 69).

The importance of such errors and inconsistencies in the development of both a conceptual understanding of the hydrogeology and its representation in a numerical model is explained below.

The two ignimbrite units (named Silala (upper) and Cabana (lower) in Chile) are found beneath the Silala River ravine, but SERGEOMIN (Bolivia) (2003) does not recognize these units despite the fact that they occur close to the international border, where they have been observed by SERNAGEOMIN (Chile) (SERNAGEOMIN 2017, 2019b, Arcadis, 2017), the former in outcrop and both at depth in borehole core. The Silala Ignimbrite can be seen to cross the border in continuous outcrop and can be traced on satellite imagery upstream in the walls of the Silala ravine to the confluence of the Cajones and Orientales ravines.

These ignimbrite deposits are constrained by the (older) Miocene volcanics on each side (northwest and southeast) and at some depth (currently unknown). The surface gradient (as well as the ‘dip’ of the formations) changes from being relatively gentle upstream of this pinch-point, to noticeably steeper downstream. This supports the interpretation of the flow which deposited the ignimbrites being constrained by a narrow gap in the Miocene volcanics. This restriction in the cross-sectional area of the main ignimbrite aquifer will clearly impact the permeability and transmissivity distribution in any numerical groundwater flow model and the area where groundwater flow will be focused down-gradient into Chile. Groundwater flow to the south west into Chile will therefore be restricted to this narrow zone, rather than the much wider area shown by Bolivia in their conceptual cross-section (BCM, Vol. 4 p. 88). Since the permeability of the Miocene volcanics is much lower than that of the ignimbrite aquifer, it is unlikely that part of the groundwater flow bypasses the Near Field in the surrounding geological strata, as was modelled by DHI (2018). Figure 2-10 shows the groundwater level map used in definition of the boundary conditions of the Near Field Model. We have added a red arrow representing the implied flow direction; the HGU4 unit is shown by grey hatching. The piezometric contours in this figure, drawn by DHI, indicate groundwater in the ignimbrites flowing beneath the Miocene Volcanic (red arrow), whereas in reality this would not happen because the ignimbrites overlie the Miocene volcanics and groundwater flow would be funnelled through the narrow constriction delimited by the presence of the low permeability Miocene volcanics. This constriction must be taken into account in order to accurately represent the domain of groundwater flow, conceptually, or more pertinently in the construction of DHI’s NFM, or other models.

From experience from recent geological mapping (SERNAGEOMIN (Chile) 2017, 2019b), drilling and groundwater level measurements (Arcadis, 2017) Chile interprets two aquifer systems. One is a shallow aquifer found perched in Alluvial deposits and shallow weathered lavas and a second at depth in the Silala Ignimbrite (Chilean defined) but mostly found in the less welded and more permeable Cabana Ignimbrite (Chilean defined). The upper levels of the Silala Ignimbrite (Chilean defined) are highly welded and represent a confining or semi-confining layer above the Cabana Ignimbrite. It is therefore more appropriate to assess piezometric levels in the shallow aquifer and the deeper aquifer separately. A correct understanding of the hydrogeology leads to differences in the interpolation of the groundwater level data, and hence the current boundary conditions used for the NFM are incorrect.

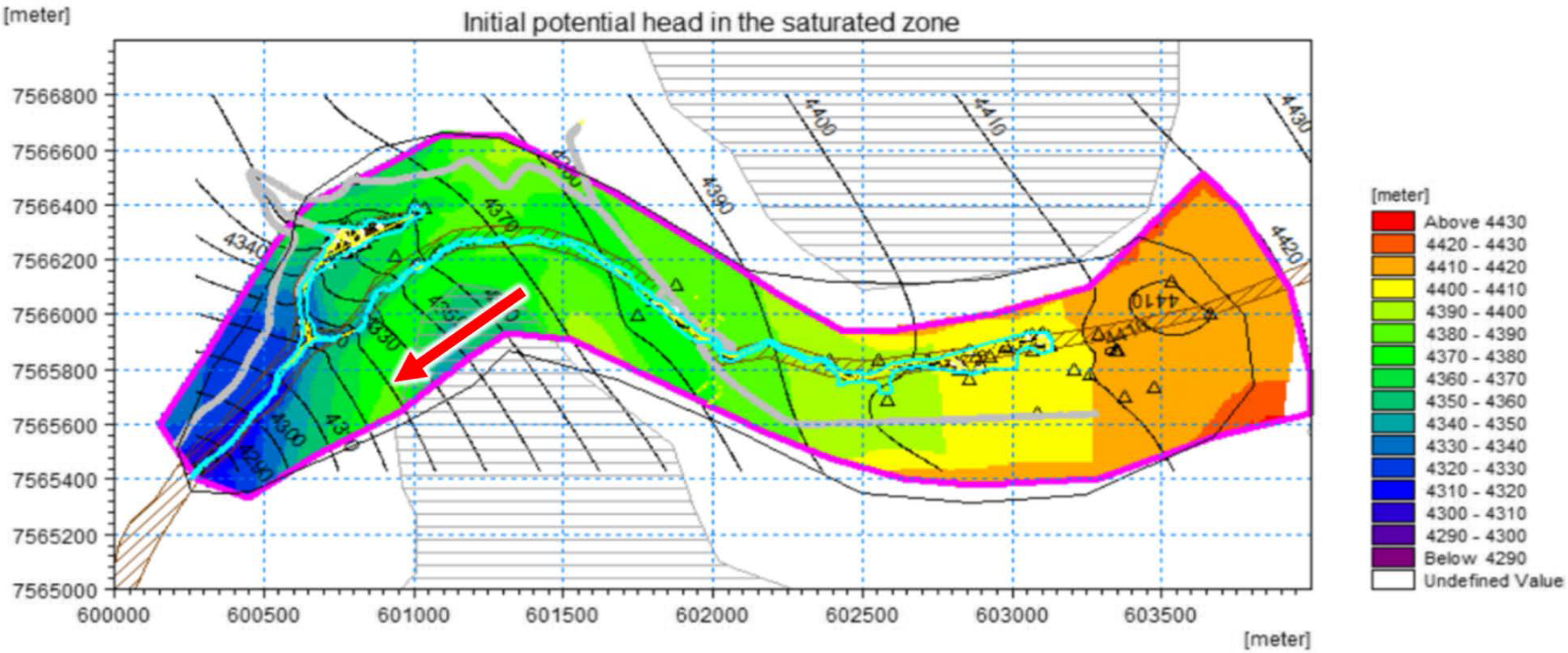


Figure 2-10. "Groundwater level maps used in definition of groundwater component boundary conditions" [Original Caption]. Black lines represent the piezometric contours, the polygons filled with grey lines represent the HGU4 unit. The added red arrow represents the implied groundwater flow through the HGU4 unit. (BCM, Vol. 5, p.19).

3. WATER BALANCE MODEL (WBM)

3.1 Conceptual model

To develop a conceptual model of the Far Field, limited data were available. Data from the Far Field area comprise a surface geology map, a single water level measurement in a borehole located approximately 2 km upstream of the Orientales wetland and soil sample analyses from six locations. According to DHI (BCM, Vol. 3, p. 471) the conceptual model of the Far Field (WBM) considered that groundwater recharge is driven by short-term precipitation events, often separated by long dry periods. And as noted by DHI (BCM, Vol. 3, p. 471), to correctly reproduce the recharge produced in this area, long-term dynamic simulation is necessary[2].

The hydrogeological conceptual model developed by DHI (BCM, Vol. 3, p. 472) considered that the main processes that affect the recharge and the available water resources in the Silala River basin are determined by precipitation, soil evaporation, infiltration and snow processes. The extent of the WBM was defined as the groundwater catchment (defined by DHI as the hydrological catchment) of the Silala River and was delineated using NASA's SRTM digital elevation model. Since the studied area is very dry, evaporation from the soil and infiltration through the upper soils and unsaturated zone of the aquifer to the underlying groundwater table are the main processes that determine the recharge to the catchment.

3.2 Numerical model

DHI's WBM is a transient numerical model that covers the Silala River hydrological catchment upstream of the Orientales and Cajones wetlands (Bolivian wetlands). The main purpose of developing this model was to estimate the overall recharge available to the Silala River basin and its groundwater catchment. This model covers an area of 228.7 km^2 (5,717 active cells of 200 x 200 m (BCM, Vol 3, p. 476)) (note that this differs from the area of 231.5 km^2 quoted in Section 2.2 of Annex E to the DHI (2018) report (BCM, Vol. 3, pp. 472-473)) and simulates the period between 01/02/1969 and 31/12/2016 (17,500 days) (not 1/1/1969 to 31/12/2016 as quoted in Section 2.5 of Annex E to the DHI report (BCM, Vol. 3, p. 477)).

Several versions of the WBM were provided (see Appendix A). The base case of the WBM model is described as "Silala_model_200m_v24.she" and does not include a saturated groundwater flow component. Only two versions of the WBM that simulate saturated groundwater flow as well as recharge were provided by DHI:

[2] We note that DHI's 48 year simulations do not represent the long-term for these groundwater systems. DHI (BCM, Vol.3, p. 491) estimate average groundwater travel times to be 1500 years.

- Silala_model_gw_200m_v12_final.she
- Silala_model_gw_200m_v12_final_tracer.she

In this report we review the first version because the second one was focused on estimating residence time for groundwater in the saturated zone, which is beyond the scope of this report.

3.2.1 Boundary conditions

The boundary conditions used to model the groundwater flow (saturated zone) in the WBM are presented in Figure 3-1. The model was constructed using a no-flow boundary condition across most of the model boundaries, with the exception of a fixed head boundary condition that permits water to exit the model domain towards the Bolivian wetlands (and to Chile). Thus, this fixed head boundary condition is located at the boundary of the NFM. The value of this boundary condition was defined as equal to the initial potential head at that boundary, therefore it is constant in time but it varies in space. It is important to mention that the southwestern no-flow boundary condition is not based on the DHI interpretation of the hydrogeology of the study area. Because the southwestern no-flow boundary condition is near the zone of interest, it is likely that it will have an impact on the simulated flows from the WBM towards the Bolivian wetlands. This issue was not assessed by DHI.

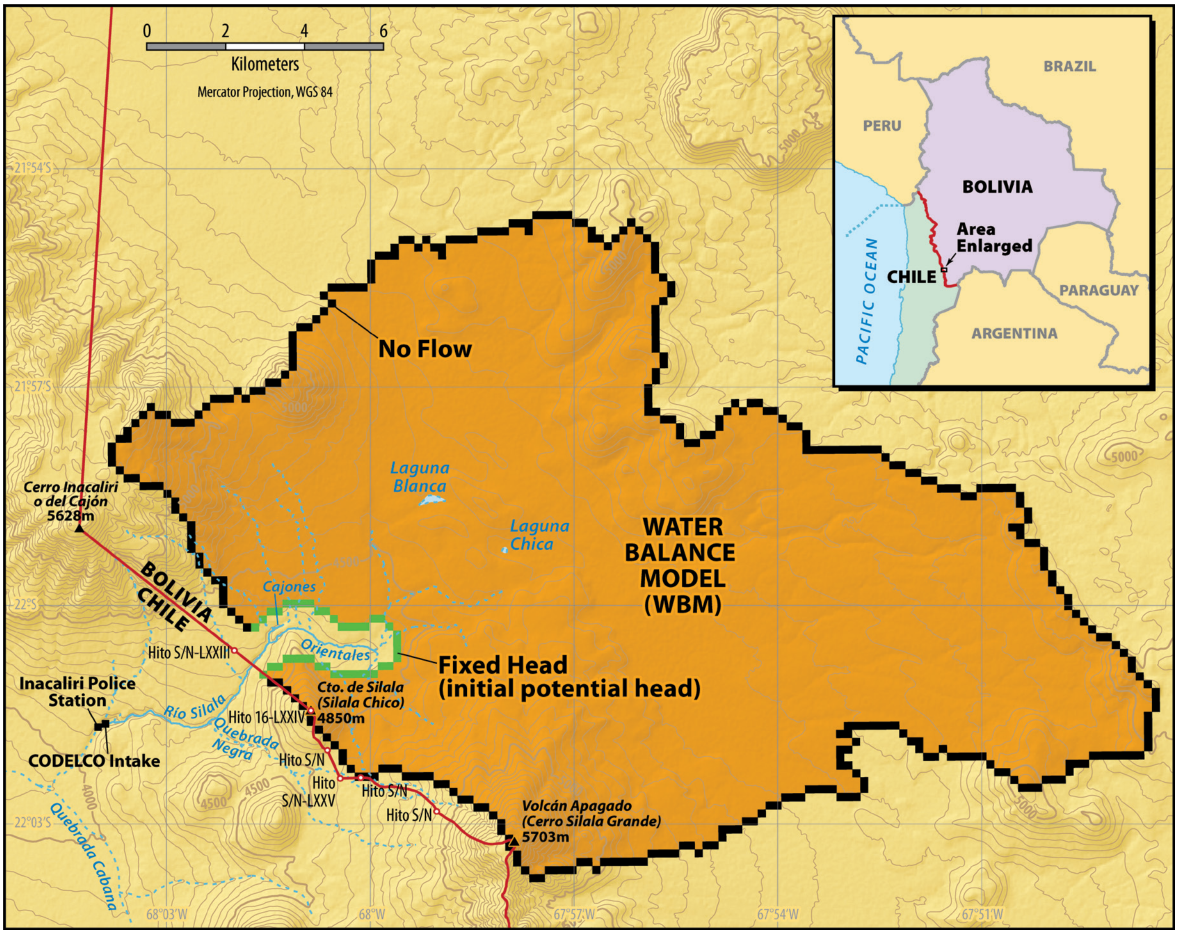


Figure 3-1. Boundary conditions of the "Water Balance Model".

3.2.2 Water balance results

The water balance from the WBM, version Silala_model_gw_200m_v12_final.she, is presented in Table 3-1. This balance in cumulative millimeters was calculated using the water balance module of the MIKE-SHE model. The flows in mm/year and l/s were calculated using the simulation period (17,500 days, or just less than 48 years) and the area of the model's active cells. This table shows that 198 l/s of groundwater exits the model through the fixed head boundary.

	Cumulative water depth (mm)	Average depth rate (mm/year)	Average flow rate (l/s)
Precipitation	-6023	-126	-911
Evapotranspiration	4854	101	734
Recharge (prec.–evap.)	-1170	-24	-177
Total storage change	-170	-4	-26
Net groundwater boundary outflow	1309	27	198
Error	-30	-1	-5

Table 3-1. Water balance from the "Water Balance Model" - Silala_model_gw_200m_v12_final.she version.

The contributions from storage releases shown in Table 3-1 (which are consistent throughout the model period) indicate that the model has not reached a dynamic steady state (i.e. without long-term upward or downward trends in groundwater levels), which means that the model results are therefore still being influenced by the initial conditions and the estimated recharge is also affected by changes in storage. We also note that in DHI's Provisional Report 3, Water balance of the basin and groundwater aquifer and update of measured flow (DHI 2017a, received by Chile in February 2019), recharge using the same model is estimated to be 56 mm/year (instead of the 24 mm/year shown in Table 3-1). No explanation has been provided by DHI for why the estimate was reduced in their final report. This Provisional Report 3 is attached to the present report as Appendix D.

3.3 Main conclusions from the review of the WBM

In this section a limited review of the main configuration of the WBM has been presented, primarily to set the context for the discussion of the NFM. The main conclusions of the review of the WBM are that the model has not reached steady state, so that the water balance is affected by changes in storage, and that the southwestern no-flow boundary condition is not based on DHI's interpretation of the hydrogeology of the study area, instead it seems to be based, at least in part, on the geopolitical boundary between Bolivia and Chile.

4. NEAR FIELD MODEL (NFM)

4.1 Conceptual model

The Silala NFM covers the area immediately adjacent to the Bolivian wetlands upstream of the Chile-Bolivia international border (see Figure 4-1).

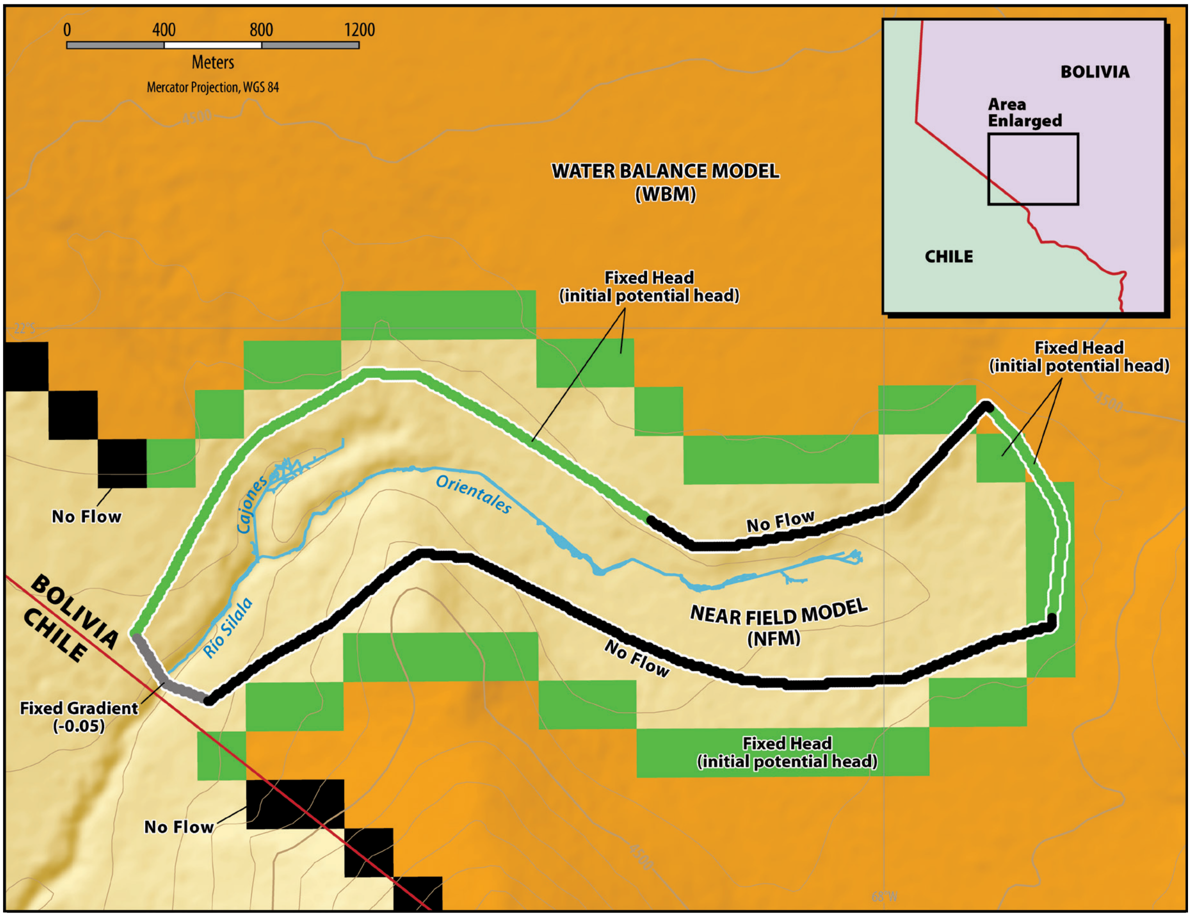


Figure 4-1. The area of Bolivia's Near Field Model. The green color represents Fixed Head boundary conditions, the black color represents No-Flow boundary conditions and the grey color represents Fixed Gradient boundary conditions.

Using the available piezometric information, DHI (BCM, Vol. 4, p. 97) proposed a piezometric map of the Silala Near Field area (see Figure 2-3). Analysis of DHI's piezometric map allows the direction of groundwater flow to be determined (groundwater flow directions are by definition perpendicular to the groundwater level contour lines). These directions are shown by our blue arrows in Figure 4-2A.

DHI's (2018) conceptual understanding of the groundwater system, as illustrated in their BCM figures reproduced in Figure 4-2B and C, shows that the groundwater flow into the Cajones wetland (Bolivia's "northern wetland") comes from the North-North-West, North-West, North-East and South-East, and the flow into the Orientales wetland (Bolivia's "southern wetland") comes from the North-East and the South-East. In contrast, according to their piezometric map, water is entering the Near Field Model mainly through the North-East and is exiting the model through the South-West (see Figure 4-2A). Note that from interpretation of DHI's contours some of the water should also be exiting the Near Field Model through the southern No-Flow boundary of the model, a problem discussed further in section 4.2.3. The piezometric contours and the corresponding flow directions (Figure 4-2A) should be consistent with the groundwater flow directions presented in Figure 4-2B and C. However, when comparing the flow directions derived from Bolivia's piezometric contours and Bolivia's conceptual understanding, the flow directions obtained from DHI's groundwater level map do not correspond to those presented in Figure 4-2B and C. Therefore, the conceptual model of the NFM is based on conflicting interpretations of the data.

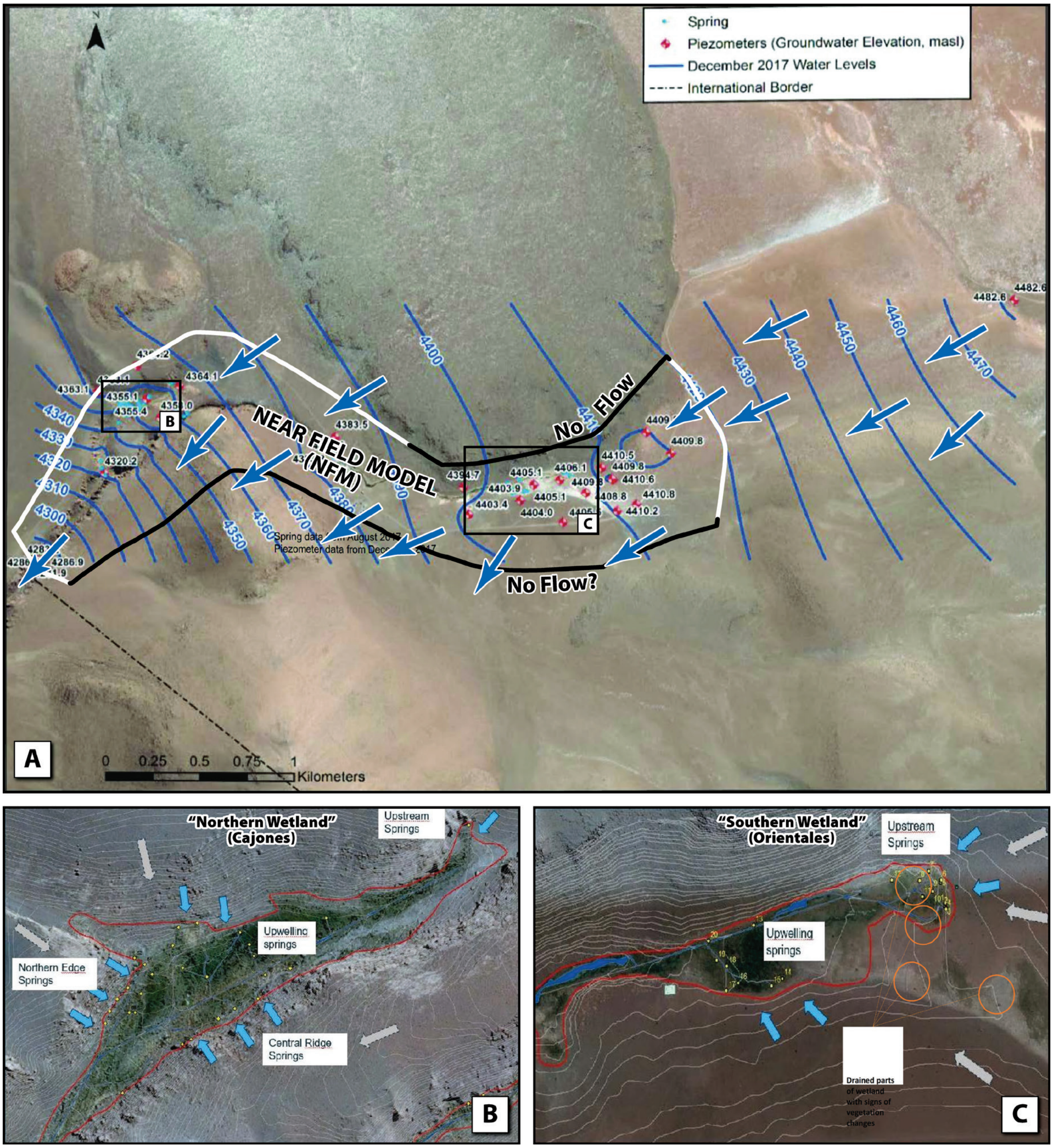


Figure 4-2. A) Groundwater level contours in the Silala NFM, interpolated from piezometer wells, spring elevations, and wetlands excavations for soil sampling (Adapted from BCM, Vol. 4, p. 97). The NFM domain is delimited by the polygon with a black and white border that shows in black the DHI no-flow boundaries and in white the boundaries through which water can pass. The blue arrows represent the direction of groundwater flow interpreted from the contour lines. B) Northern and C) Southern wetlands overall flow directions. (Adapted from BCM, Vol. 2, p. 371). Note: The text in the lower label of panel C is: "Drained part of wetland with signs of vegetation changes" (Muñoz et al., 2019).

Interpretation of the sparse groundwater level data is inevitably subject to uncertainty. However, given the existence of two distinct aquifers, a more realistic interpretation of the groundwater data would use two different piezometric maps, one for the shallow surficial aquifer and one for the deeper ignimbrite aquifer, and include adjustments to take into account the effects of gaining and losing reaches of the river and the presence of the low permeability formations, as discussed above. This more detailed approach would result in contours that are in places very different to those produced by DHI and would result in the definition of markedly different boundary conditions for the NFM.

4.2 Numerical model

DHI's NFM, as described in Annex G to DHI (2018) (BCM, Vol. 5, p. 13), is a transient model but with constant (steady-state) inputs. It covers the area immediately adjacent to the Orientales and Cajones wetlands (Bolivia's southern and northern wetlands, respectively), upstream of the Chile-Bolivia international border. The main purpose of this model was to determine the impacts of channelization on the Silala River flow. This model covers an area of 2.56 km^2 (25,632 active cells of 10 x 10 m) and was run for a period of 91 days.

The representation of the system was developed with the MIKE-SHE and MIKE-11 modelling software, for three scenarios, defined in Annex H to DHI (2018) (BCM, Vol. 5, pp. 67-70):

Baseline Scenario: The "Baseline" model represents the current configuration of the river system, including the historical wetland drainage channels and main river channelization. It includes coupled flow components for groundwater (3-D), unsaturated zone (1-D), evapotranspiration, overland flow (2-D) and channel flow (1-D).

No Canal Scenario: The "No Canal" scenario model is identical to the baseline model except that the 1-D channel flow (i.e. the MIKE-11 model) has been removed from the setup. The "No Canal" model thus includes coupled flow components for groundwater (3-D), unsaturated zone (1-D), evapotranspiration and overland flow (2-D).

Undisturbed Scenario: The "Undisturbed" scenario model[3] is identical to the "No Canal" scenario model but the surface topography and unsaturated soil profile descriptions have been modified to represent the possible long term development of peat soils (of up to 60cm depth). The "Undisturbed" scenario model includes coupled flow

[3] Variously referred to as the "Wetland restoration" scenario (BCM, Vol. 2, p. 303), the "Restored wetland" scenario (BCM, Vol. 5, p. 70), the "Wetland restoration (undisturbed)" scenario (BR, Vol. 5, p. 73), and the "Undisturbed" scenario (BR, Vol. 5, p. 73).

components for groundwater (3-D), unsaturated zone (1-D), evapotranspiration and overland flow (2-D).

The Baseline scenario was modelled using the MIKE-11 model (1D Surface water flow model) to represent the channel flow coupled with the MIKE-SHE model (integrated hydrological and groundwater model). The No Canal and Undisturbed scenarios were modelled using only the MIKE-SHE model. The lack of a MIKE-11 component for the No Canal and Undisturbed scenarios implies that there would be no surface water flow channels if the channelization was removed, which is incorrect. This conclusion has not been justified by DHI. In addition, the MIKE-SHE model is based on a coarser spatial resolution, which means that the routing of flow (as overland flow) in the No Canal and Undisturbed scenarios is not directly comparable to that of MIKE-11 used for the Baseline scenario.

4.2.1 Topography of the NFM

To study the comparability of the three scenarios developed by DHI (2018), a very basic requirement is to review the topography, or ground surface elevation, used in each of them. From this review, it was found that each of the three scenarios uses a different topography, and that the two models used in the Baseline scenario – MIKE-SHE and MIKE-11 – also use different topographies. The DHI (2018) report states that there is a change in topography between the No Canal and Undisturbed scenarios, and some small differences would be expected, given that long term growth of wetland peat soils is included. However there is no mention of differences between the topographies in the Baseline and No Canal scenarios.

For the Baseline scenario, the channel sections' topography (i.e., the Baseline MIKE-11 model) was constructed combining SENAMHI channel dimension surveys and digital surface model (DSM), which allows reference to this discretization as the closest to the real topography in the catchment. The Baseline scenario topography used by DHI (2018) in the Baseline MIKE-SHE model (which is different from the Baseline MIKE-11 topography), was obtained from a high resolution DEM "based on measurements taken during a drone flight in the last half of 2016 (IGM, 2016)" (BCM, Vol. 2, p. 325). Additionally, in both the No Canal and Undisturbed scenarios the topography of the natural terrain was also obtained by DEM data, but it was altered to remove the channel sections. The original files that contain the three MIKE-SHE topographies are:

- Baseline: xxx_topo_5m.dfs2
- No Canal: xxx_topo_5m_adj_v2.dfs2
- Undisturbed: xxx_topo_5m_undisturbed.dfs2

We extracted various cross sections from the MIKE-SHE topographies for comparison. The locations of these cross sections correspond to those used in the Baseline MIKE-11 model, so it is possible to compare the topography from both the Baseline MIKE-11 and the three MIKE-SHE models. Figure 4-3 and Figure 4-4 each show the ground surface elevation of two cross sections from the three scenarios modelled using MIKE-SHE and the ground elevation of the same sections in the Baseline MIKE-11 model. For an appropriate definition of topography, the three MIKE-SHE model cross sections should coincide, except where a small elevation difference (with a maximum of 0.6 m) is created due to assumed peat soil development. The MIKE-SHE model cross sections should also approximate the MIKE-11 cross sections, but with a coarser resolution. For all the cross sections presented in Figure 4-3 and Figure 4-4 and most of the reviewed cross sections, the Undisturbed scenario always overestimates the river bottom elevation. While it was expected that the Undisturbed topography would be higher than the others due to the assumed peat growth, the observed differences are much larger than expected. For example, the topography of the Undisturbed scenario in cross sections no. 3560 and 3370, shown in Figure 4-3, presents differences of almost 7 meters compared to the Baseline MIKE-11 channel bottom (cross section no. 3560) and of 3 meters compared to the Baseline MIKE-SHE topography (cross section 3370). The observed differences show that these three scenarios represent totally different topographies. The same issue is illustrated with the cross sections in Figure 4-4. These should be seen in the context of DHI’s aim to show firstly the effect of the channels (the wetland drainage channels are generally less than 0.5 m deep, and the main channel depths less than 1 meter (see BCM, Vol.5, pp. 32-39)), and secondly, the scenario of peat growth, which increases existing peat depths by a maximum of 0.6 m (BCM Vol. 5, p. 70). The large and unrealistic topographic differences used by DHI are therefore much greater than the small changes to be studied, which indicates that the simulations of the different scenarios are neither equivalent nor comparable.

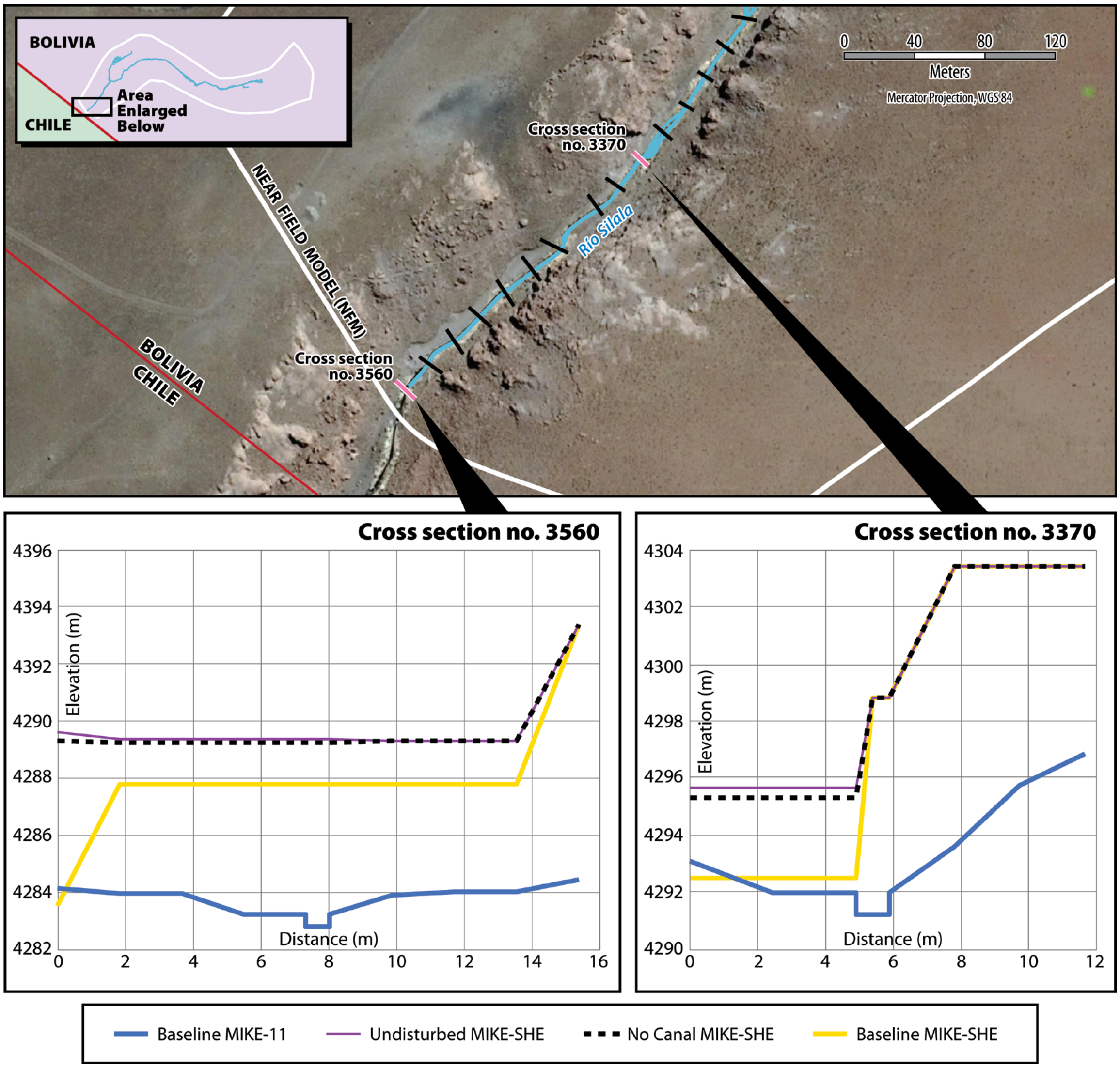


Figure 4-3. Ground surface elevations used in the Bolivian NFM model scenarios compared at two cross sections of the main channel near the international border.

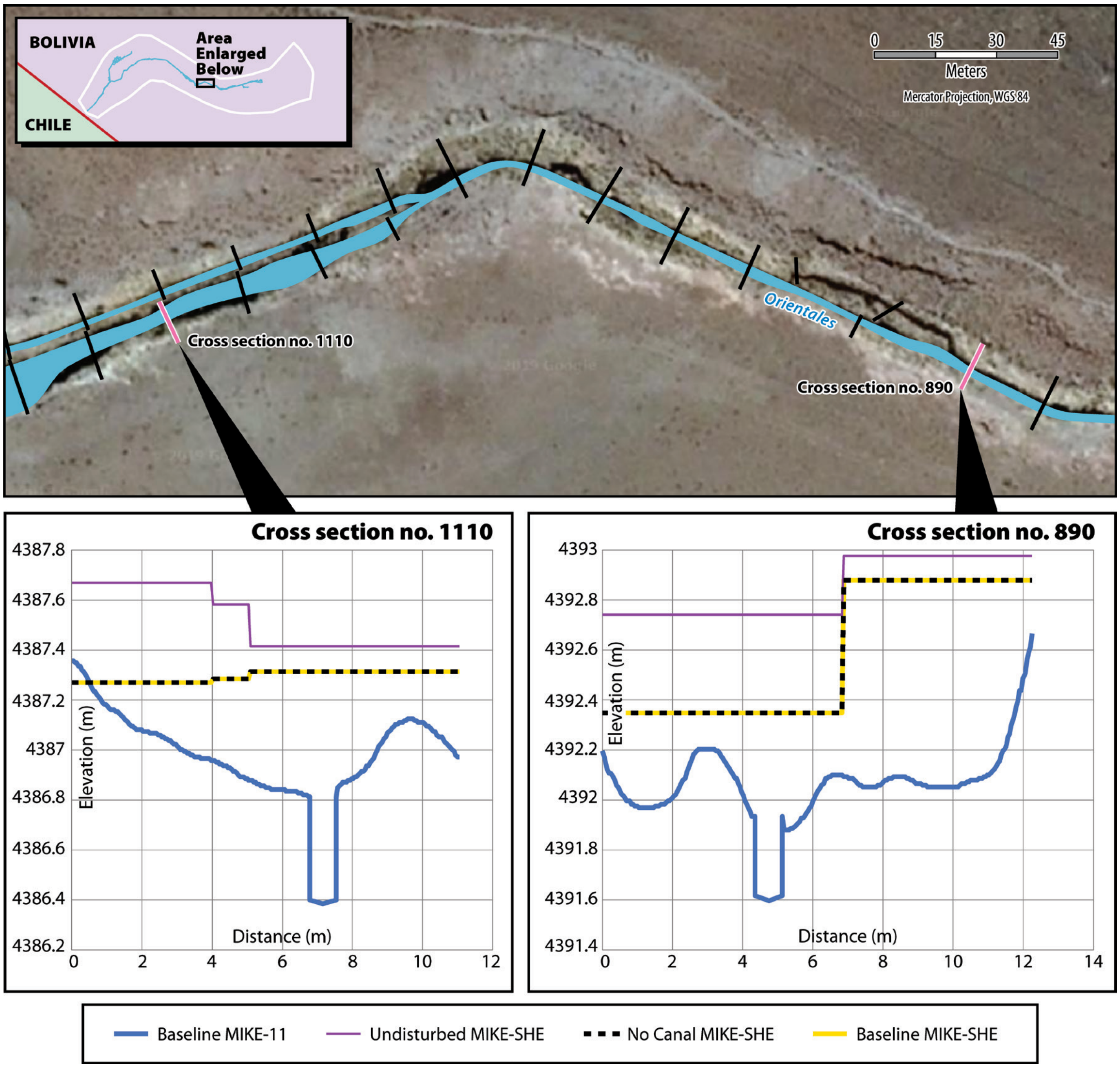


Figure 4-4. Ground surface elevations used in the Bolivian NFM model scenarios compared at two cross sections of the main channel in the Orientales wetland. Specifically, in these cross sections the Baseline and the No Canal topographies from the MIKE-SHE model coincide and the black dotted line obscures the yellow line.

Figure 4-5 shows the difference between the No Canal and the Undisturbed scenarios topographies. Here, differences between 0 and 0.4 meters are noted, which are reasonable and expected given that the scenario represents possible long term peat development.

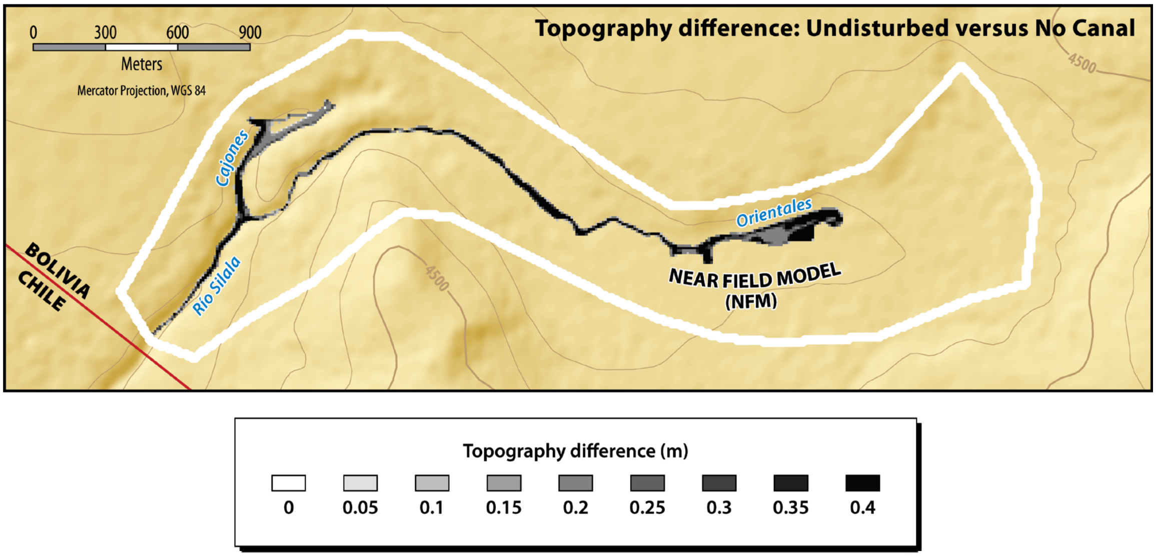


Figure 4-5. Difference between No Canal and Undisturbed model topographies.

Figure 4-6 shows, in plan view, the differences between the topography of the Baseline MIKE-SHE and the No Canal scenario in the NFM. As can be seen from this figure, differences in elevation (mostly over 1.5 m higher in the No Canal scenario) are large in comparison with the depths of the channels (typically 0.3 to 0.8 m). A plan view of the difference between Baseline MIKE-11 topography and any version of the MIKE-SHE topography has not been included because the MIKE-11 topographic information is linear, while the MIKE-SHE information is provided as a gridded digital elevation model (DEM). However, our analysis of individual MIKE-11 cross sections indicates that the differences are substantial (see Figure 4-3 and Figure 4-4).

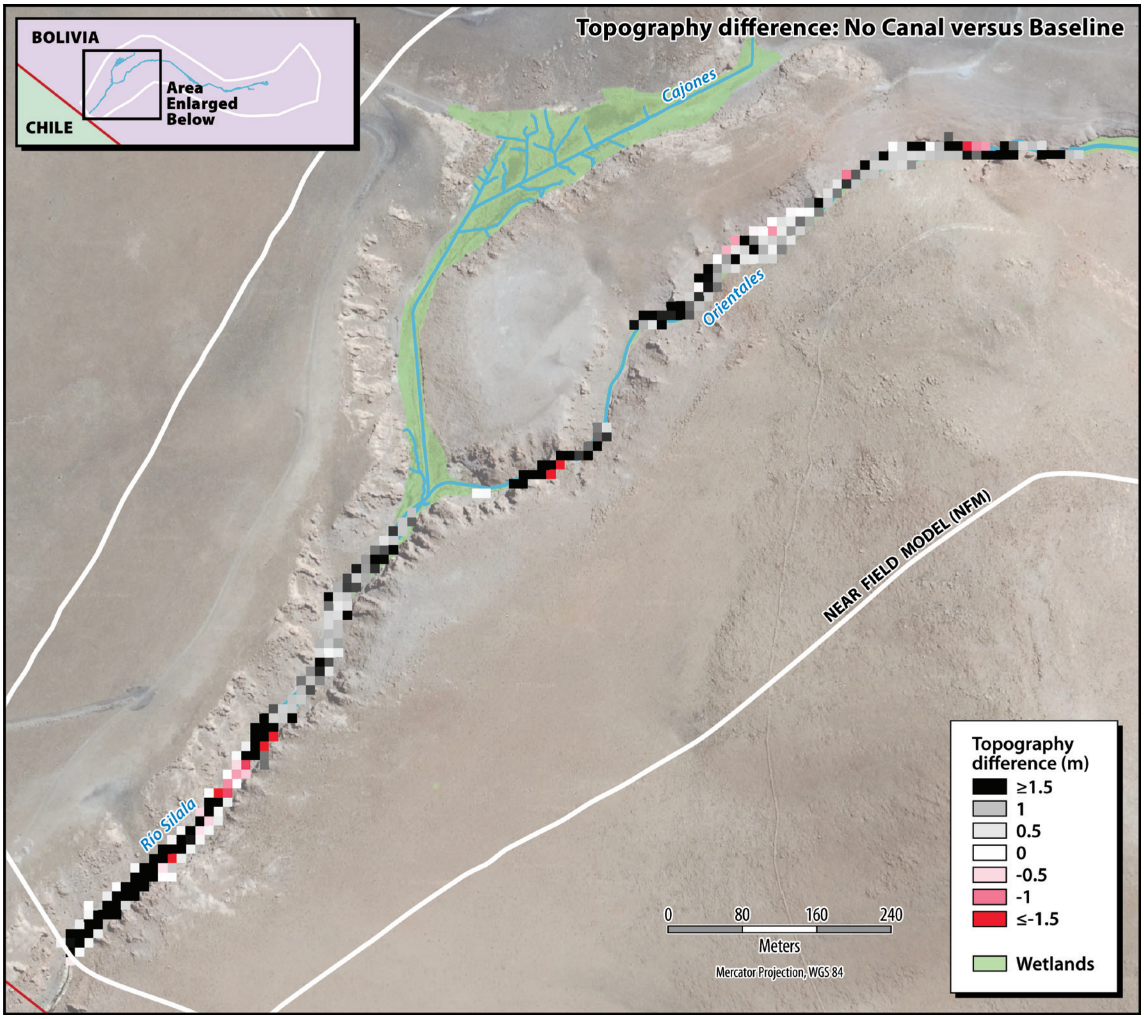


Figure 4-6. Difference between No Canal MIKE-SHE and Baseline MIKE-SHE topographies.

The very large differences between the topography used in the Baseline MIKE-SHE and Baseline MIKE-11 models, on the one hand, and the No Canal MIKE-SHE model, on the other, are not described in the DHI report. These differences, especially the differences of up to 7 m between the Baseline MIKE-11 and No Canal MIKE-SHE topographies shown at the downstream end of the catchment in Figure 4-3, mean that the No Canal scenario is not simply representing the removal of the channels, it also represents an increase in the level of the land surface on the Bolivian side of the border. This is an enormous change in ground level, equivalent to a structure the height of a two-story building spanning the width of the river valley and extending at least 200 m along the river.

Raising the ground surface in this way would reduce the amount of water that would be able to enter the surface water system from groundwater and increase the amount that would leak from the surface water system into groundwater.

In terms of the boundary conditions used by DHI in their model, the dramatic raising of the ground surface would also have the effect of increasing the groundwater heads at the inflow and outflow boundaries, which would in turn reduce the groundwater inflows to the model (from the fixed head boundaries), and increase the groundwater outflows (through the fixed gradient boundaries), leaving less water available to appear as surface water flow in their model.

As DHI's comparison of flows with and without the channels only refer to the surface water component of flow, artificially diverting from the surface water system to the groundwater system in this way gives a false impression of the influence of the channels.

These major differences between the Baseline and No Canal and Undisturbed scenarios are not described in any way in the DHI report. The failure to present this information in the Bolivia's Counter-Memorial leads to a comparison that is unjustified and incorrect, and exaggerates the effects that Bolivia is attempting to prove. At best, therefore, this is highly misleading for the Court.

4.2.2 Steady-state verification

The water balance from the Baseline scenario was examined to see if the model had reached a steady state. This is important as otherwise the model results will be influenced by the initial conditions, and the estimated flows will be affected because the water balance includes unrealistic changes in storage. A steady state condition means that the sum of the inflows is equal to the sum of the outflows, and any changes in groundwater storage should be negligible (i.e., groundwater levels have reached an equilibrium).

Figure 4-7 shows the flow rates to and from groundwater storage over time in the Baseline scenario. By the end of the simulation, there are still significant flows (4 l/s) coming out from groundwater storage. Therefore, the model had not reached a steady state at the end of the simulation period and the simulated flows are influenced by the model initial conditions and an associated error in the water balance.

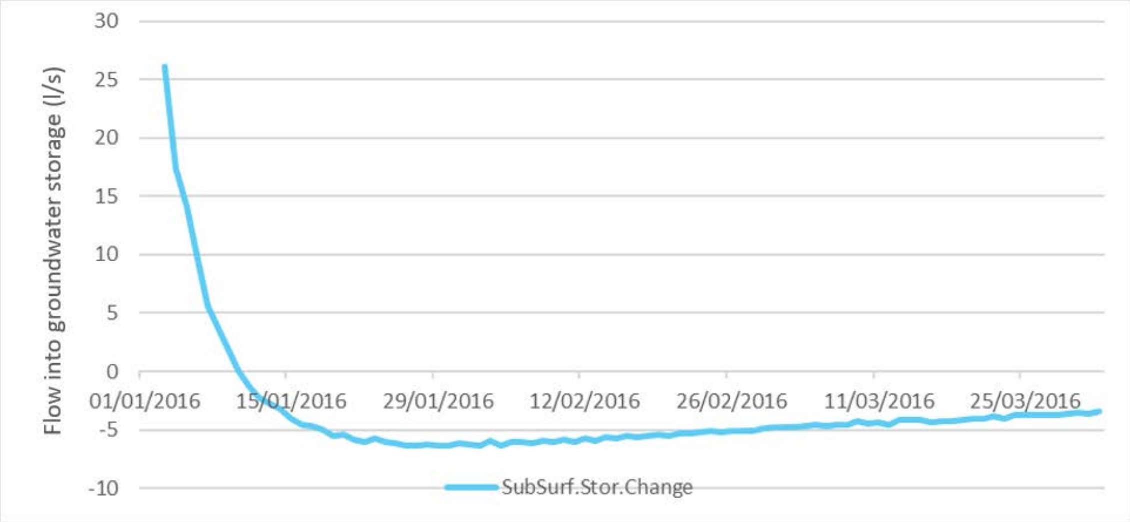


Figure 4-7. Flows into groundwater storage in the NFM, indicating that steady state has not been reached.

4.2.3 Boundary conditions

The distribution of boundary condition types is the same for the three scenarios of the NFM and is shown in Figure 4-8. Note that the NFM comprises three layers with depth (called by DHI in its NFM files Near Surface, Upper Silala Ignimbrite (Bol), and Lower Silala Ignimbrite (Bol))[4]. The same distribution of boundary condition types is used in each layer. Specifically, Figure 4-8 shows the boundary conditions of the Near Surface layer. The DHI model boundary conditions consist of three types (BCM, Vol. 5, p. 18):

- Fixed head: constant in time and equal to the Initial Potential Head (variable in space) in two borders, one at the eastern border and another at the northern border.
- No-Flow: one at the northern border and the whole southern border.
- Fixed gradient: equal to -0.05 at the western border. This gradient was obtained from Arcadis (2017).

DHI defined the boundary conditions using the piezometric map presented in Figure 2-3 (BCM, Vol. 2, p. 293). In Annex G to DHI (2018) (BCM, Vol. 5, p. 18), it is explained that a no-flow boundary is imposed where the head contour lines are perpendicular to the model boundary. Thus, the only flows entering the numerical model should be located where the piezometric lines are not perpendicular to the model borders. However, the boundary conditions are not consistent with the piezometric map presented by DHI (2018) in their conceptual model. As can be seen in Figure 4-2A, there should be flow exiting the model through the southern boundary, but instead, DHI

[4] Note that the three scenarios of the NFM are not to be confused with the three depth layers in the model.

(2018) imposes a no-flow condition at that boundary. Additionally, the no-flow condition imposed on two boundaries of the model is an artificial condition, since there are no impermeable or very low permeability rocks at those boundaries (except where the Miocene volcanics outcrop to the southeast of the Cajones, but this is Chile's interpretation of the Geology, not Bolivia's). Consequently, both the conceptual and the numerical models are incorrect. The numerical model is not only based on a conceptual model that does not represent correctly the reality of the data presented, but also is not consistent with DHI's own conceptual model.

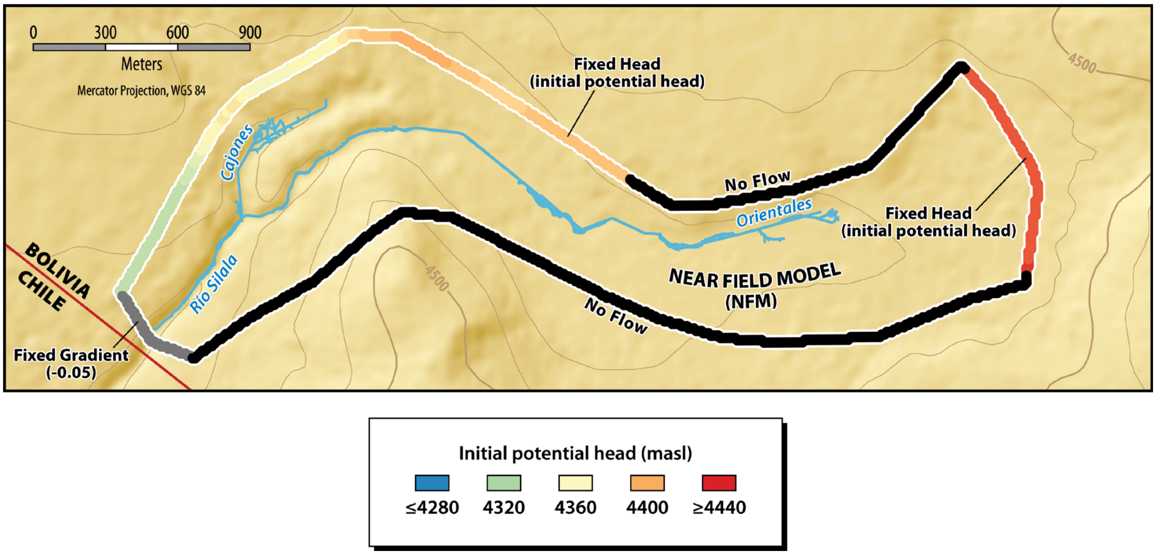


Figure 4-8: Near Field Model boundary conditions of the Near Surface layer. The same distribution of boundary condition types is used in each layer, but the Fixed Head boundary values change between layers. All three scenarios have the same boundary conditions.

4.2.4 Inconsistency between the Water Balance Model and the Near Field Model

Figure 4-9 shows the boundary conditions and the initial potential head contour lines of both the Water Balance Model and the Near Field Model (Baseline and No Canal scenarios). In both models the boundary conditions are shown by colour coding on the model boundary, and for the WBM they are also illustrated with arrows showing flow directions. The head contour lines are different for the two models. Also, when the head contours from the WBM are compared to the NFM boundary conditions, it is observed that there is an outflow from the WBM that should flow into the NFM through the northern No-Flow boundary (black arrow). Additionally, it is observed that a part of the WBM outflow is exiting the WBM model across the international border without entering the NFM model (black arrow). Therefore, there is an inconsistency between the boundary conditions and the groundwater flow directions of the two models.

In addition to the inconsistencies between the flow directions at the boundaries of the two models, there are also inconsistencies between the flow rates. The 198 l/s that leaves the WBM (see Table 3-1) is not the same as the 212 l/s of groundwater flow that enters the Baseline NFM scenario (Table 4-4). Furthermore, the amounts of groundwater flow that enter the No Canal and Undisturbed scenarios of the NFM model (190 l/s and 185 l/s from Table 4-4) are reduced relative to the Baseline scenario. We note that the inflows to the near field model are determined by the model boundary conditions. The effect of this was extensively discussed in Chile's Reply (see Expert Report by Wheater and Peach, CR Vol.1, pp. 85-154) where it was shown that this will have exaggerated the effect of channelization and peat development, perhaps by a factor of 20. We reiterate here that the recharge to the wider groundwater catchment is unaffected by these localized effects, and that there is no explanation given by DHI for where the missing water has gone in these scenarios.

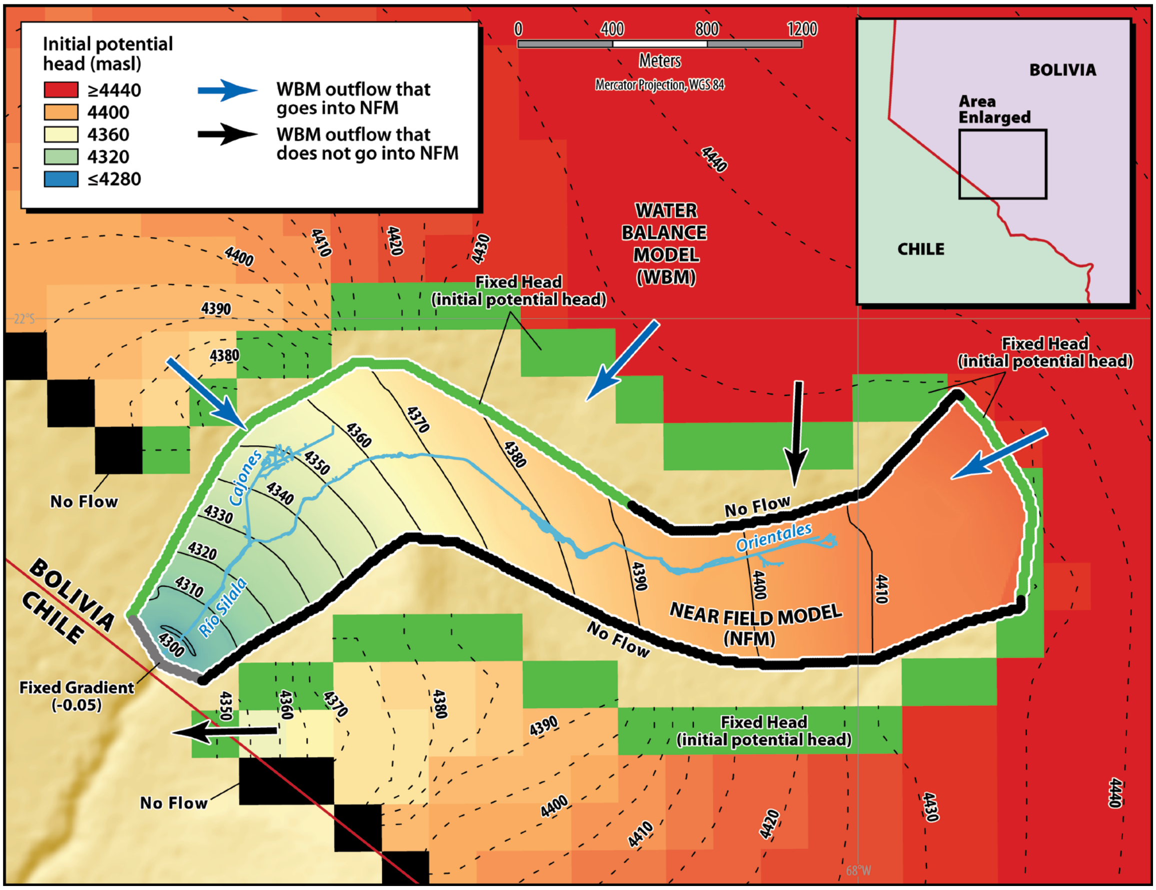


Figure 4-9. Boundary conditions and initial potential head contour lines of both Water Balance and Near Field models. Neither the contour lines nor the flow directions coincide in the two models.

4.2.5 Initial Potential Head of the Near Field – MIKE-SHE model

According to DHI (BCM, Vol. 5, p. 18), the initial potential head map was built using the information obtained in the field from manual measurements. We compared the initial potential heads of the Lower Silala Ignimbrite (Bolivia defined) layer (Computational layer n°3) for the Baseline and No Canal scenarios (which are the same) and the Undisturbed scenarios (Figure 4-10). The initial potential heads used by DHI (2018) in the Baseline scenario are the same as the No Canal scenario, but are different from the Undisturbed scenario. Given that these scenarios are supposed to be steady-state simulations and represent different physical configurations it would be reasonable for them to have different initial conditions. However, there is a methodological inconsistency as the same initial conditions are used for the Baseline and No Canal scenarios but not in the Undisturbed scenario, and there is no explanation given to support these differences. We also note that since none of the three simulations reached the steady-state condition (see Section 4.2.2), the initial groundwater heads influence the results of the simulations.

The differences between the initial potential heads in the Baseline/No Canal and the Undisturbed scenarios are shown in Figure 4-11, and vary between -18 m and +16.5 m. These very large imposed differences in the initial conditions mean that the three simulations are neither equivalent nor comparable. Figure 4-12 shows the difference between the final heads of the Baseline scenario and the No Canal and Undisturbed scenarios.

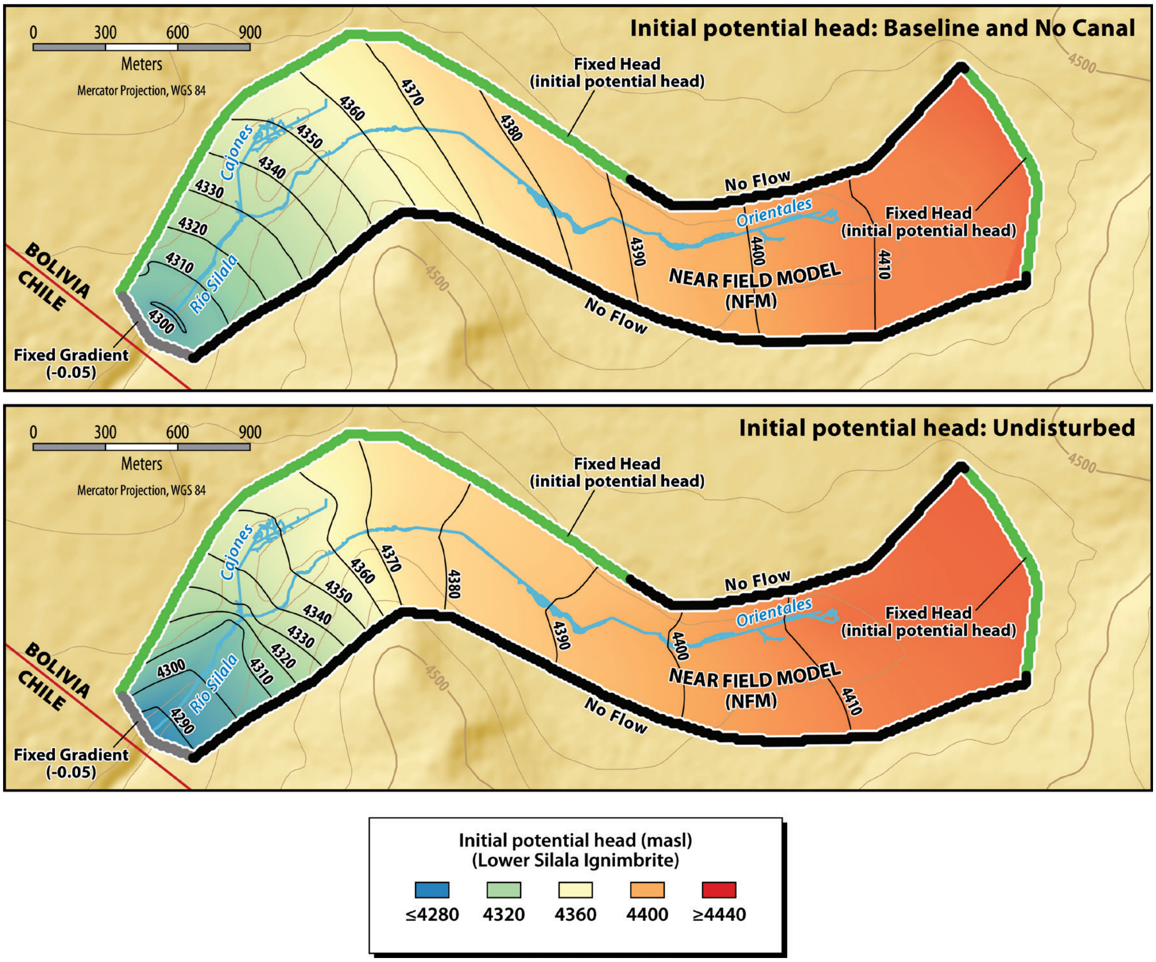
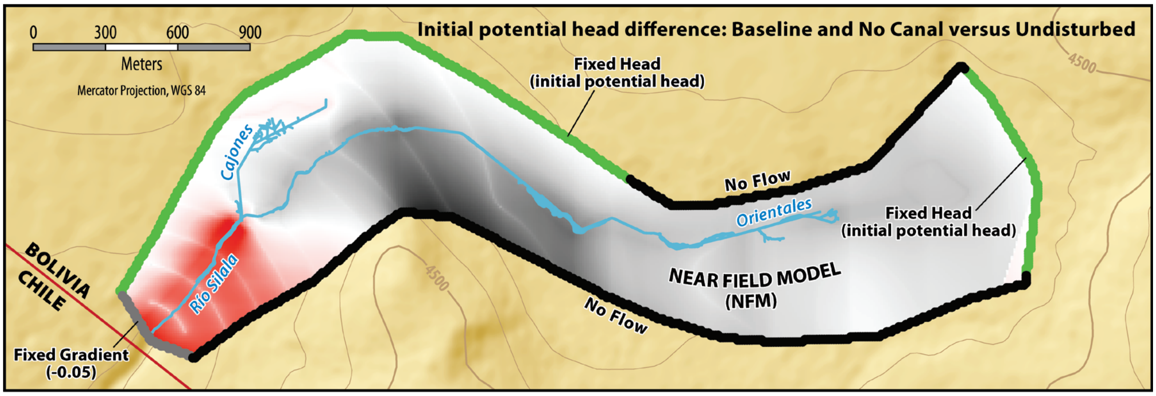


Figure 4-10. Initial potential head map and contour lines in the NFM.



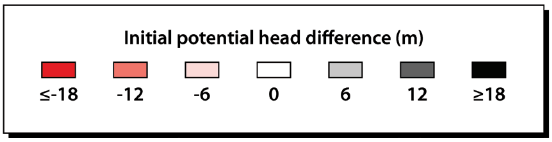


Figure 4-11. Initial potential head difference between the Baseline/No Canal scenarios and the Undisturbed scenario. Positive values correspond to locations where the initial potential head is higher in the Undisturbed scenario.

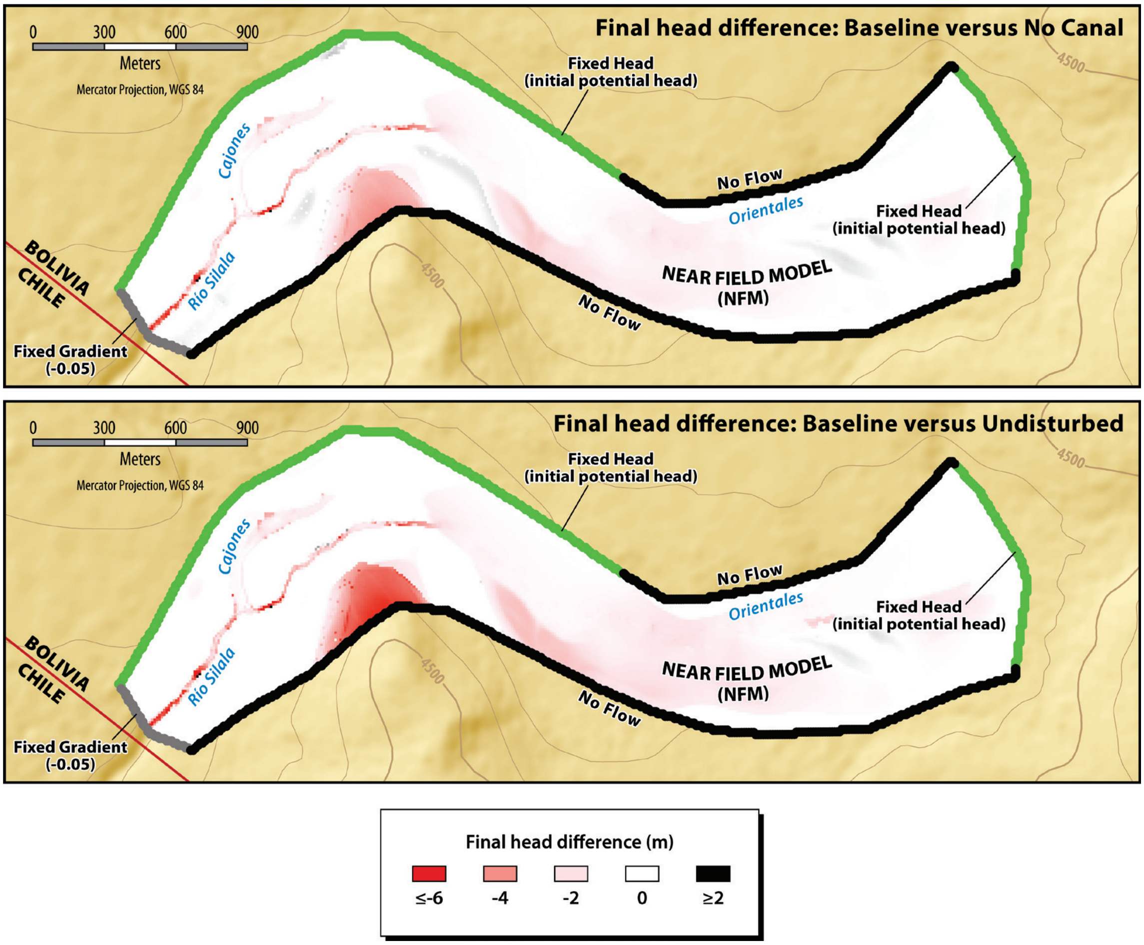


Figure 4-12. Final potential head difference between the Baseline and the No Canal scenarios (upper panel) and the Baseline and Undisturbed scenario (lower panel). Positive values correspond to locations where the final potential head is higher in the Baseline scenario.

4.2.6 Surface water modelling

In the Baseline scenario, the channel sections were represented explicitly in the MIKE-11 model, whereas in the No Canal and Undisturbed scenarios the MIKE-11 component of the model was removed and the natural river sections were not represented explicitly, meaning that the sections for the No Canal and Undisturbed scenarios have no natural channel(s). Figure 4-13 shows the MIKE-SHE and MIKE-11 topographies of the same cross-section. Also, when reviewing the model files, it was found that, to represent the wetland springs, there were local flow injections in all three scenarios. These inflows will hereinafter be referred to as “spring recharge”. This feature is inconsistent with the physical basis of the model, in which groundwater inflow to the Near Field is determined by the NFM fixed head inflow boundary conditions. It appears that additional water has been created arbitrarily. This characteristic of the model is neither explained nor justified in DHI's report.

Table 4-1 summarizes the main aspects of river elements and the way that the "spring recharge" was modelled in the different scenarios.

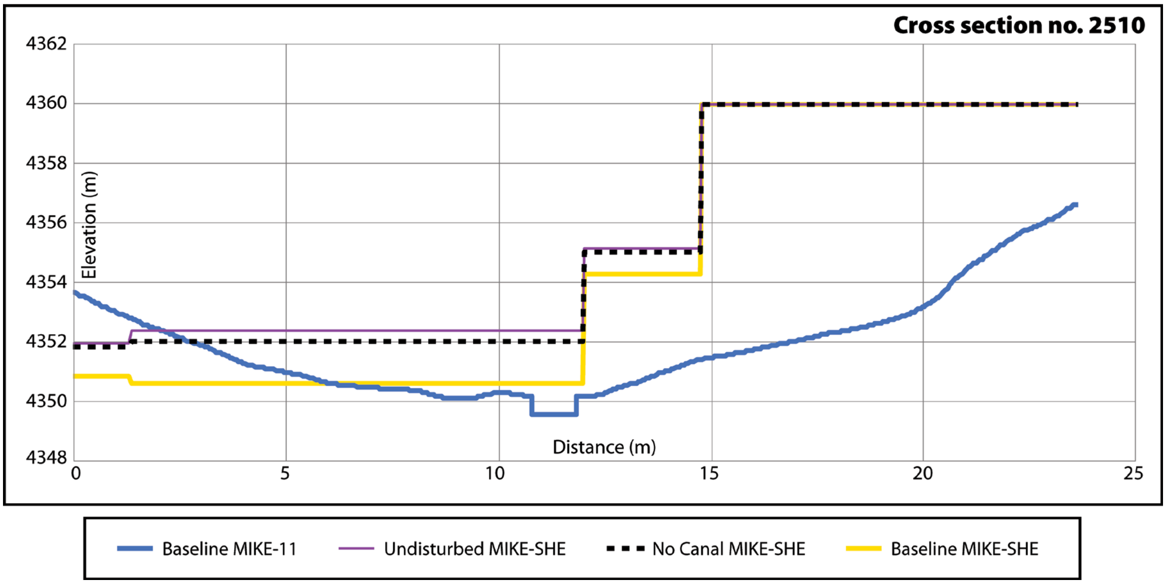


Figure 4-13. Representation of the channels in the different scenarios. The yellow, dotted black and purple lines represent the topography of the Baseline, No Canal and Undisturbed scenarios of the MIKE-SHE model, respectively. The blue line represents the channel section of the MIKE-11 model in the Baseline scenario. In the No Canal and Undisturbed scenarios, these channel sections were not represented explicitly.

Scenario	Hydrological Model	Canal or Natural/Undisturbed river section	River element	Spring Recharge	Elevation
Baseline	**MIKE-SHE+MIKE-11**	modelled by **MIKE-11** – Dynamic Wave	Channel and banks	Local flow at headwaters and springs: 42 l/s	Topographical profiles
No Canal	**MIKE-SHE**	modelled as Overland Flow by **MIKE-SHE** – Diffusive Wave Approximation	Natural sections	Local Precipitation: 31 l/s (95 mm/in 91 days)	First Modification of Digital Elevation Model
Undisturbed	**MIKE-SHE**	modelled as Overland Flow by **MIKE-SHE** – Diffusive Wave Approximation	Restored sections	Local Precipitation: 31 l/s (95 mm/in 91 days)	Second Modification of Digital Elevation Model

Table 4-1. Summary of main aspects of river elements and the way that the spring recharge is modelled in the different scenarios.

As presented in Table 4-1, the spring recharge incorporated in the model is different for each scenario. In the Baseline scenario, a constant flow of 1 l/s at the headwater of each of 32 channels and at 10 springs in the MIKE-11 model is injected (a total of 42 l/s). Figure 4-14 shows the location of these inflows. In contrast, in the No Canal and Undisturbed scenarios, a total of 31 l/s (at 1 l/s or 2 l/s per spring cell) was injected into the MIKE-SHE model as *local precipitation* in a subset of the spring cells (Figure 4-15). The flow injected as precipitation in the No Canal and Undisturbed scenarios not only contributes to the overland flow (68%), but also part of this flow directly interacts with the saturated and the unsaturated zones (31%). This difference between the scenarios, which affects the distribution of surface water and groundwater outflows from the catchment, is not explained or justified by the DHI in its reports. The implications of this for DHI's water balances, and the supposed impacts of channelization, are discussed below in section 4.2.8.

It is important to mention that a sophisticated coupled surface water-groundwater model should be able to represent spring flows as interactions between groundwater and surface water: where the water table comes to surface, springs should appear in the groundwater model, representing discharge points for groundwater, and sources of surface water. It is unrealistic to represent the springs as anything other than interactions with groundwater and representing them as point sources of water injection as DHI have done is simply incorrect.

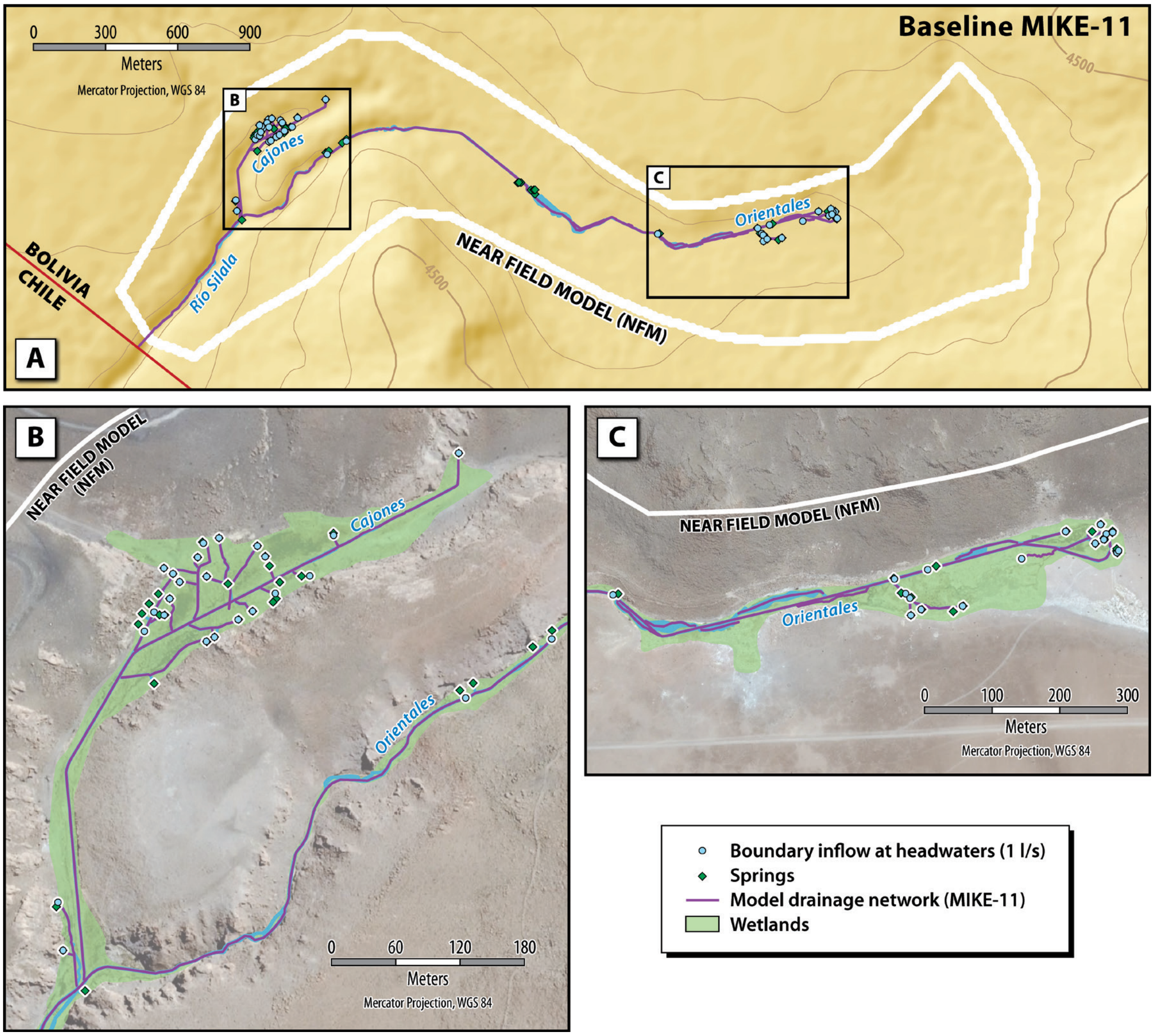


Figure 4-14. Constant inflow at each channel headwater node to model additional spring recharge for the Baseline MIKE-11 scenario, not as a result of interaction between the groundwater and surface water models

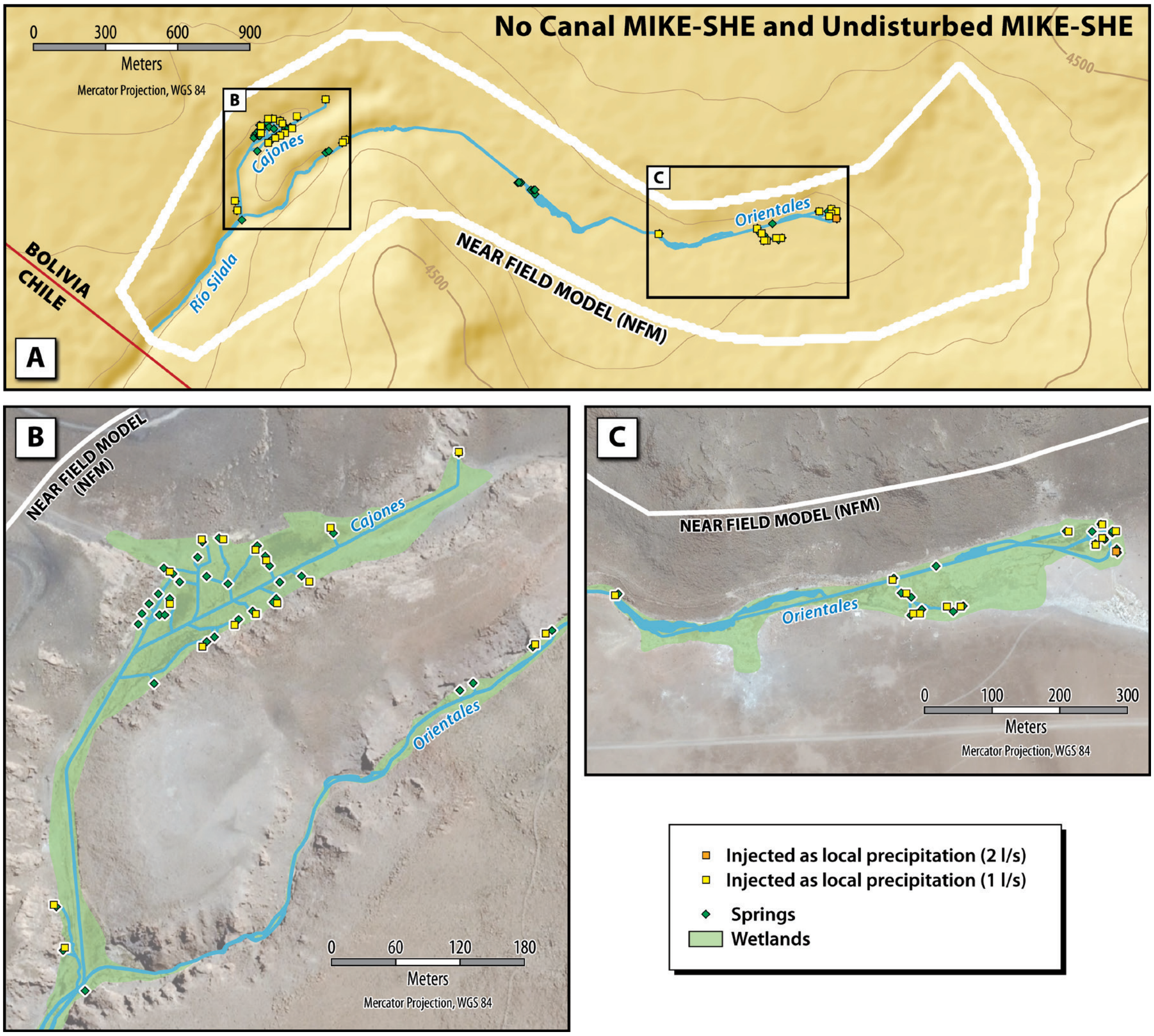


Figure 4-15. In the No Canal and Undisturbed scenarios, additional spring recharge is injected as "precipitation" into the spring cells, not as a result of the interaction between the surface and the groundwater in the coupled model MIKE-SHE.

4.2.6.1 Surface flow calculation in the baseline scenario – MIKE-11

To calculate the surface flows in the channels modelled in the Baseline scenario, the complete 1-D dynamic wave formulation of the Saint-Venant equations is solved using the MIKE-11 model. When coupling the MIKE-11 and the MIKE-SHE models, both the overland flow and groundwater flow modelled in MIKE-SHE are linked directly to MIKE-11 through MIKE-SHE Links (DHI, 2017b).

During a simulation, water levels within the coupled reaches are transferred from MIKE-11 to adjacent MIKE-SHE links. In turn, MIKE-SHE calculates the overland flow to each river link from neighboring grid squares and the river-aquifer exchange. These terms are fed back to the corresponding MIKE-11 as lateral inflows or outflows.

These flow transfers are directly dependent on the topography used for the MIKE-11 sections.

The MIKE-11 model was reviewed in detail. In the following sub-sections we present the results of the main channel reach between the Orientales and Cajones confluence and the last section of the MIKE-11 model (Figure 4-16).

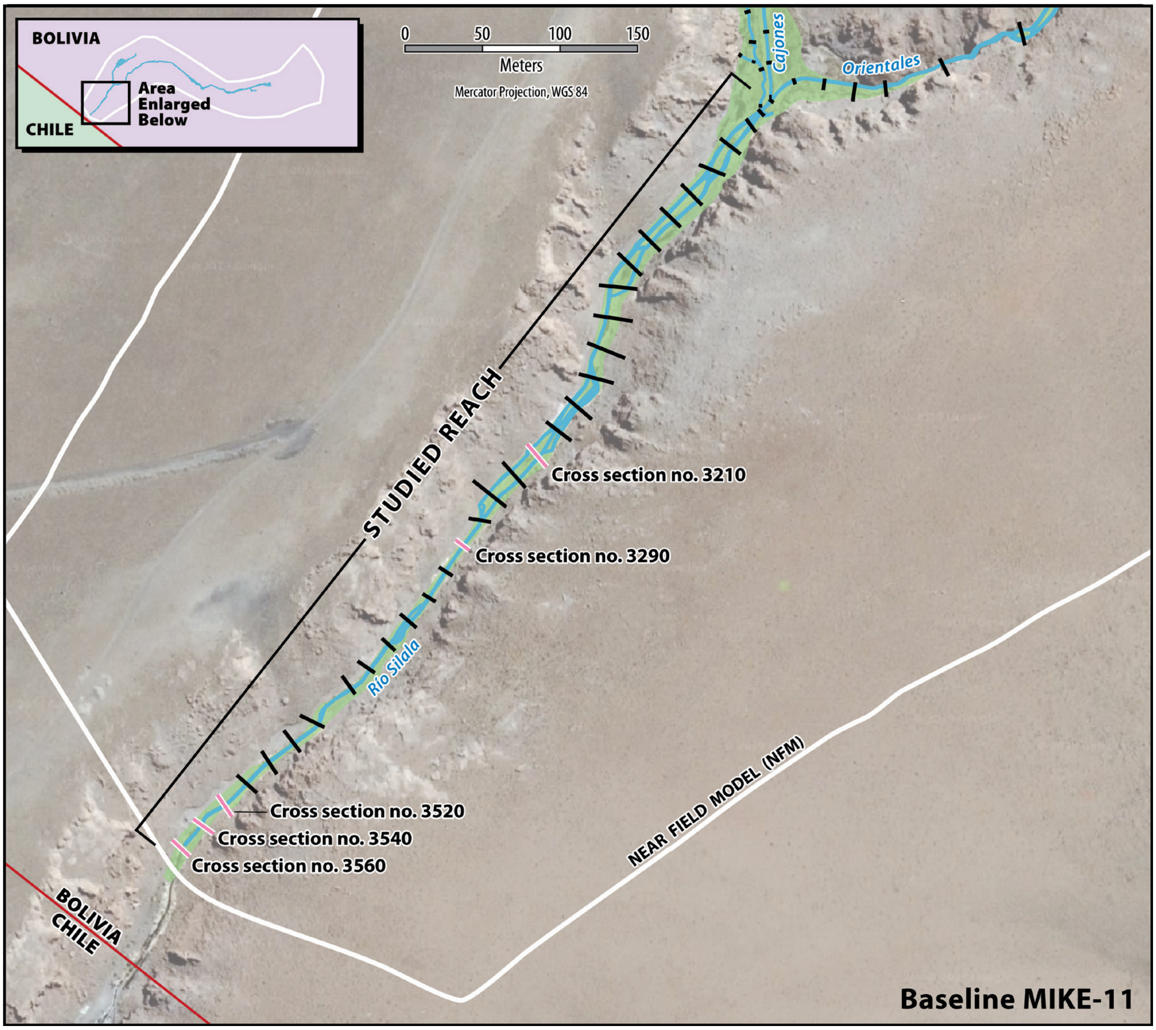


Figure 4-16. Reviewed reach and location of the cross sections (in pink lines) that are presented in the following sub-sections.

4.2.6.1.1 Downstream boundary condition

The discharge at the exit of the MIKE-11 Baseline scenario is calculated using a stage-discharge curve in the last section of the MIKE-11 model (3635, which is located near the international border outside the NFM boundaries), and the slope between the two last cross sections (3560 and 3635) is zero, which is unrealistic (Figure 4-17). This curve was defined to impose a critical flow condition, i.e., Froude number (Fr) equal to 1. The stage-discharge curve is then defined as the one in which Q and h meet Fr = 1:

$$Fr = 1 = \frac{Q(h)}{\sqrt{\frac{g \cdot A(h)^3}{T(h)}}}$$

where T is the width of the channel open surface, A is the cross sectional area of water in the channel and g is the acceleration of gravity.

This feature of the model is not explained or justified in the DHI report. The water level at the exit of the model in the last timestep is 4282.97 m.a.s.l., which corresponds to a flow of 150 l/s. This water depth is obtained after 91 days of simulation, where the steady state has not yet been reached in the integrated MIKE-SHE/MIKE-11 model.

When comparing the flow rates of the MIKE-11 model (150 l/s) with those of the MIKE-SHE water balance (143 l/s), a difference of 7 l/s is obtained (see Table 4-4 in Section 4.2.7), which is attributed to the use of the stage-discharge curve. The most significant aspect of this difference is that it was not reported in the DHI reports and that it results in an additional 7 l/s difference in flow rates between the Baseline and No Canal and Undisturbed scenarios, which is then reported as part of the impact of the channelization, when actually it is due to errors in the MIKE-11 modelling. The logical thing to do would be to compare the results of the MIKE-SHE models, instead of mixing the results of the MIKE-11 model in the Baseline scenario and the MIKE-SHE results in the No Canal and Undisturbed scenarios.

4.2.6.1.2 Manning coefficient and flow conditions

The Manning coefficient, *n*, which represents the hydraulic roughness of the channels, was found to be extremely high (*n* = 0.200).

Table 4-2 shows typical Manning coefficients. In the case of the Silala River, whose water flows through the channel, the expected values would be between 0.017 and 0.035 in the channelized reaches (minimum and maximum values for built masonry channels) and between 0.035 and 0.05 in the natural ones (minimum and maximum values for natural streams). Therefore, using a resistance of *n* = 0.200, which is representative of the highest values recommended for flood plains covered by dense trees, is physically unrealistic.

Type of channel and description	Minimum	Normal	Maximum
B. Lined or Built-Up Channels			
B-2. Nonmetal			
g.- Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
D. Natural streams			
D-1. Minor streams (top width at flood stage 100 ft)			
a.- Streams on plain			
4. Clean, winding some pools and shoals, some weeds and stones	0.035	0.045	0.05
D-2. Flood plains			
d.-Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200

Table 4-2. Typical Manning coefficients, n, for open channel flow for lined or built-up channels, natural streams and flood plains. The complete table is presented in Appendix B. Source: Chow (1959)

As a result of the high imposed value of the Manning coefficient, the normal depth of the channel is increased and the flow conditions are subcritical ($Fr < 1$) in almost all the cross sections, which does not coincide with what is observed in the field, i.e., supercritical flow conditions ($Fr > 1$). Subcritical conditions are observed when the flow is dominated by gravitational forces and behaves in a slow or stable manner, whereas a supercritical flow is dominated by inertial forces, and behaves in a fast or unstable way.

Considering the correct geometry of the last section of the river represented by the MIKE-11 model, i.e. a topographic slope of 5%, and a Manning coefficient of 0.035 (maximum value for built masonry channels), the normal depths of the cross section were calculated for the flow range reported by DHI (between 160 and 210 l/s), obtaining supercritical conditions (see Table 4-3). These results are consistent with field observations. However, DHI results show subcritical conditions (Froude number < 1) for most of the cross-sections, as shown in Figure 4-17. Hence, the results of DHI are unrealistic and conceptually inconsistent with the observed flow regime.

Discharge (l/s)	hc (m)	hn (m)	Froude (-)	Flow conditions
160	0.18	1.57	1.17	Supercritical
210	0.21	1.90	1.16	Supercritical

Table 4-3. Flow conditions in the Silala River at the international border. hc is the critical depth and hn is the normal depth of the Silala River at the international border. As hn is higher than hc, the normal flow condition is subcritical.

The resulting increase in the normal water depth (subcritical flow) due to the high Manning's n and the imposition of a critical flow in the last cross section affect the river-aquifer interactions, for example, more water than is realistic could be expected to infiltrate into the aquifer due to a larger hydraulic gradient between the river and the aquifer.

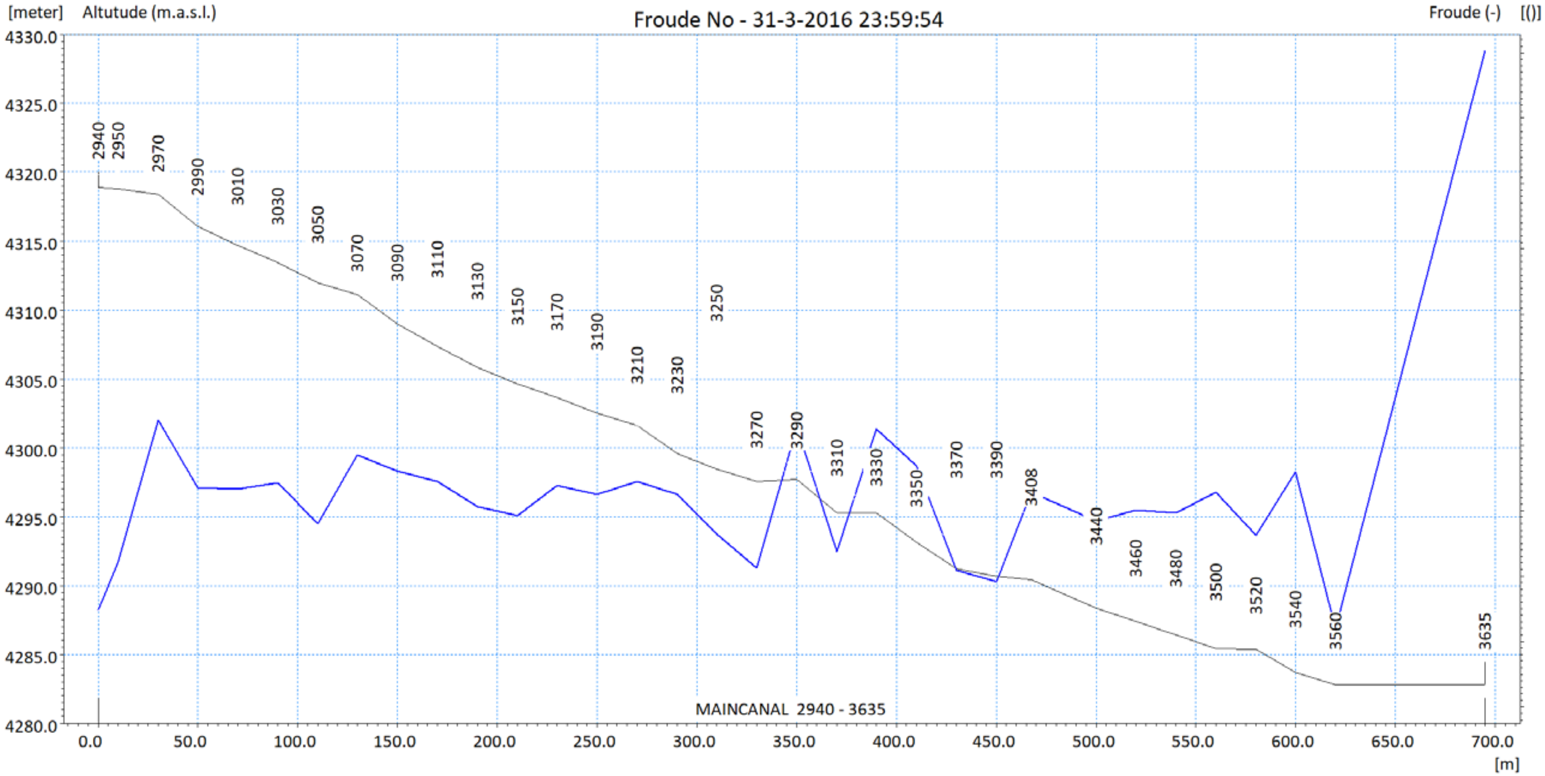


Figure 4-17. Froude number in the reach between the wetland confluence and the last section of the model. The vertical numbers represent the cross-section number, which is also the distance from the beginning of the main channel, located in the headwaters of the Orientales wetland and not shown in this profile. The x axis shows the distance from the beginning of the analyzed reach, which starts at 2940 m and ends at 3635 m of the MAINCANAL in MIKE-11.

4.2.6.1.3 Channel geometry

The channel geometry of the MIKE-11 model was also reviewed in depth. It was found that water at some of the cross sections does not flow through the main channel. Figure 4-18 shows the water level in the reach between the confluence of the Orientales and Cajones wetlands and the last section of the MIKE-11 model. Figure 4-19 shows some of the cross sections where the water does not flow through the main channel and Figure 4-16 shows the location of these sections. DHI (2018) provided no information related to the validity of the topography used in the Baseline MIKE-11 model. For instance, it is unclear why the main channel does not follow the bottom of the valley.

In two cross sections of the studied reach (between sections 2940 and 3625 of the main channel) the channel is simulated as being flooded and the water flows over the river banks (Figure 4-20). This behaviour does not represent the reality, where under an average flow condition the water only flows through the main channel.

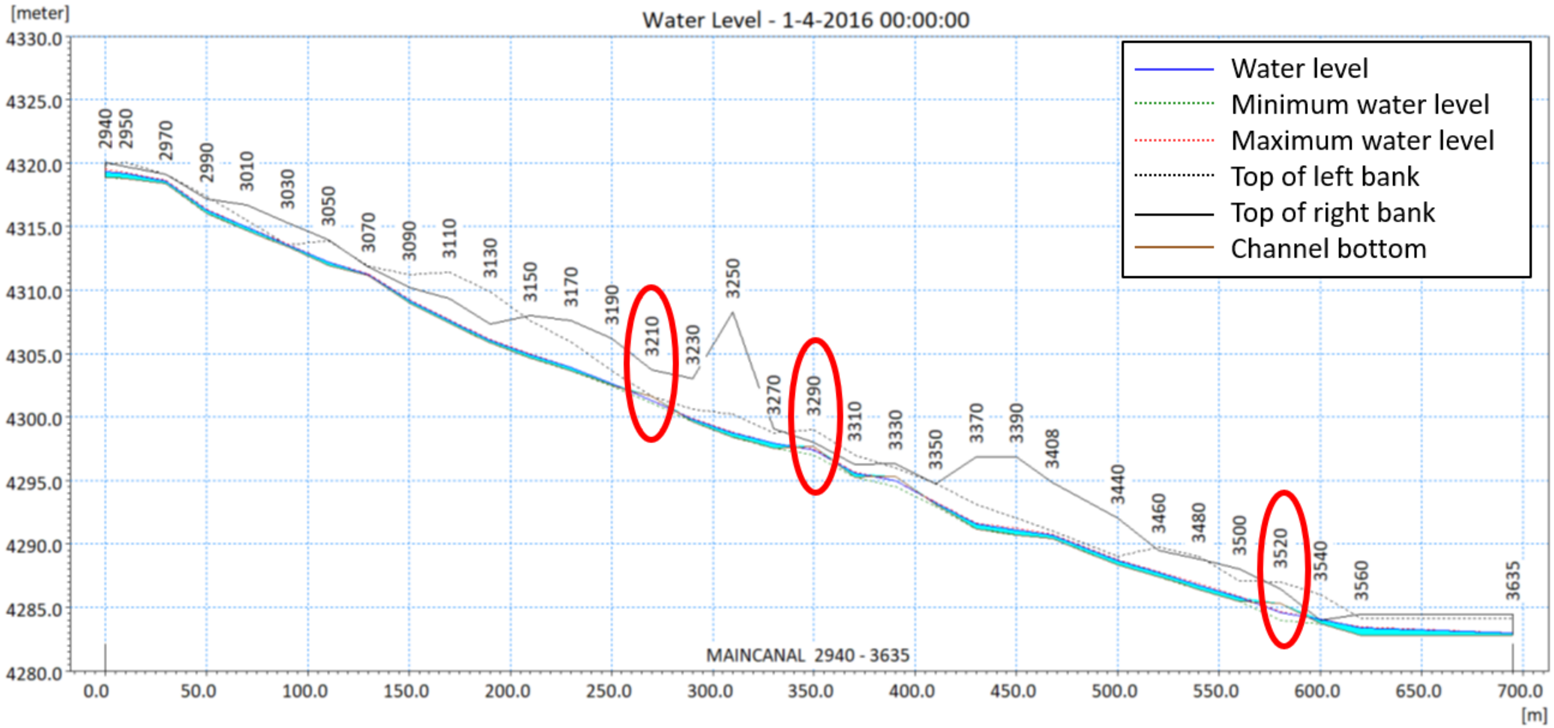


Figure 4-18. Water level in the reach between the confluence of the Orientales and Cajones wetlands and the last section of the MIKE-11 model. Some of the cross sections where water does not flow through the channel are depicted with a red circle (Figure 4-19).

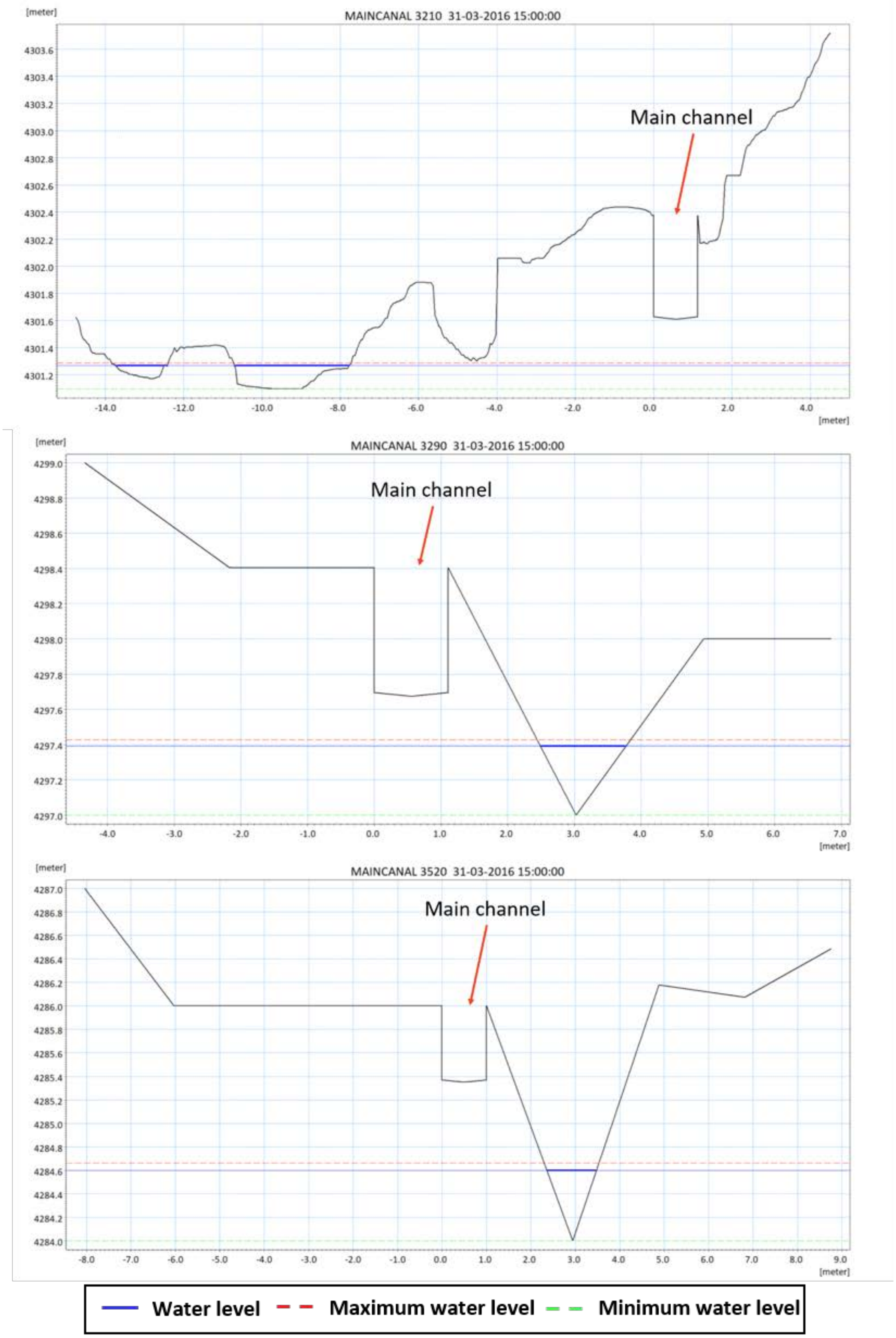


Figure 4-19. Some of the cross sections where the water does not flow through the main channel.

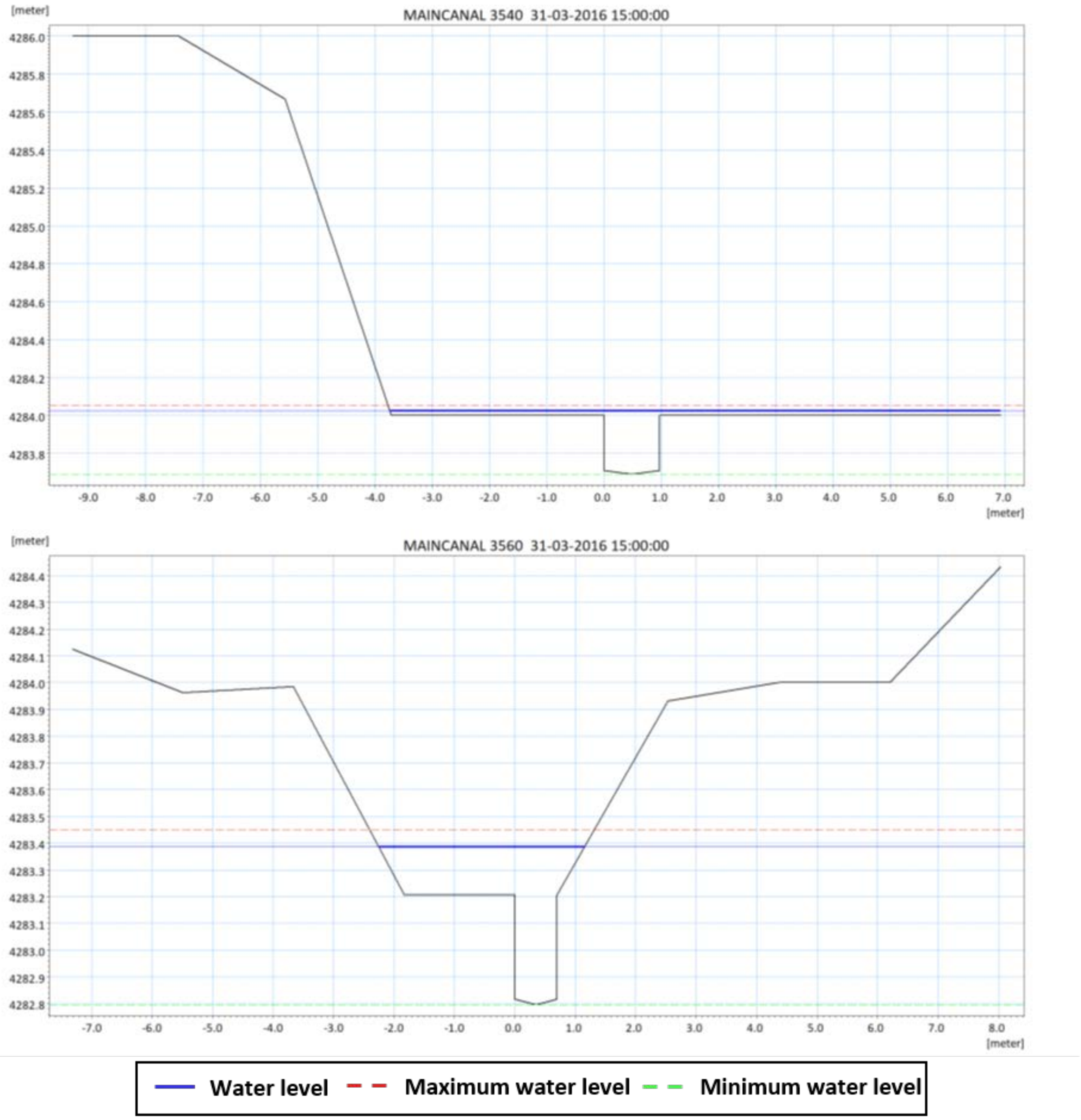


Figure 4-20. Cross sections were the channel is flooded.

4.2.6.1.4 Numerical instability in MIKE-11 model

When reviewing the Baseline MIKE-11 scenario results, errors were found in the DHI's hydraulic modelling:

- Abrupt changes in river flow were found at different points.
- There are flow variations along the river that never stabilize, even at the end of the simulated period. Figure 4-21 shows the flow variations at two points in the river throughout the simulation.

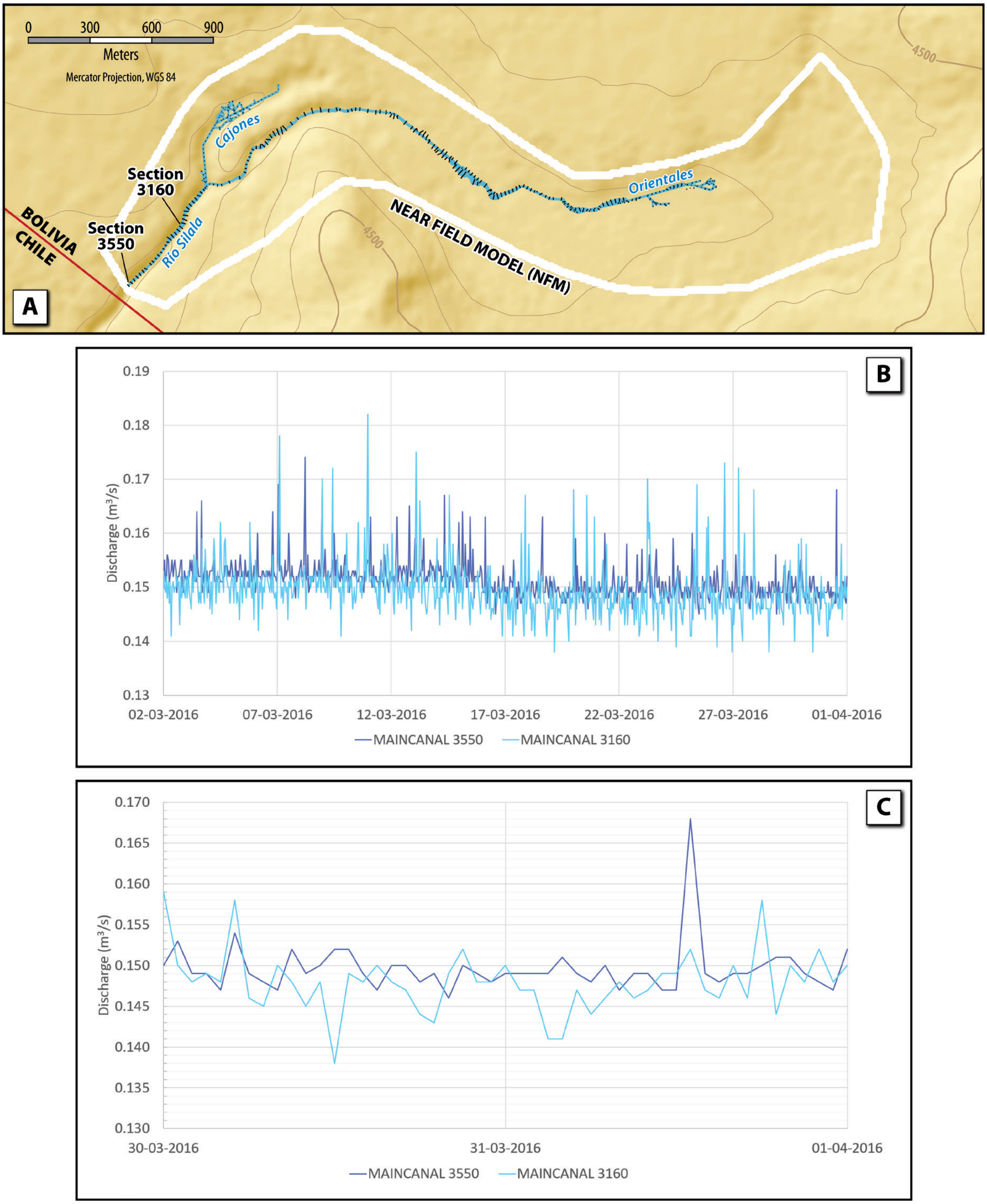


Figure 4-21. Flow variations in different sections of the reach between the Cajones and Orientales confluence and the international border. (A) Plan view of the NFM domain that depicts the locations of the two sections analyzed. (B) Discharge time series of the flow at sections 3550 and 3160. (C) Zoom into the last two days of the flow at sections 3550 and 3160.

4.2.6.2 Surface flow calculation in the No Canal and Undisturbed scenarios – MIKE-SHE Overland flow

The surface flow in both No Canal and Undisturbed scenarios was calculated as overland flow in the MIKE-SHE model: this is a quite different methodology to the Baseline scenario. The overland flow was calculated using the Diffusive Wave approximation of the Saint-Venant 2-D equations (Chow, 2010), and a different numerical scheme, which provides a less precise calculation of the surface flows (compared to the dynamic wave in Baseline scenario). It also uses a much coarser spatial resolution for the flow routing, as noted above. More specifically, in both the No Canal and Undisturbed scenarios there are no river channels identified, as opposed to the Baseline scenario, where the MIKE-11 module is used to transport the flow outside the basin, following the channel and ravine paths existing in the Silala basin. In reality in the absence of channelization, the overland flows would combine into numerous channels, which might change over time, and flow down the topographic gradient to the Silala ravine and thence across the border into Chile. Such braided stream channels are commonly seen in altiplano wetlands (see Figure 4-22). The use of the SHE overland flow algorithms therefore fails to represent the natural channel flow processes, and also provides a very different representation of the possible interactions between surface flow and groundwater, creating further modelling differences to confuse the scenario comparison.

Figure 4-22. Photograph taken at the Quebrada Negra wetland that shows the overland flow combined into numerous channels.

4.2.7 Water balance results of the different scenarios modelled by DHI (2018)

Considering the aspects described in Table 4-1, we have reconstructed the water balance provided in Table 1 of Annex H to DHI (2018) (BCM, Vol. 5, p. 67). Table 4-4 shows the main aspects of the water balance obtained from the result files (.sheres) provided by DHI.

Table 4-5 presents the water balance reported in Table 1 of Annex H to the DHI Report (BCM, Vol. 5, p. 67). Given that the models presented by DHI (2018) are not at steady state (Section 4.2.2), the water balance calculations presented in Table 4-4 were obtained using the difference of the last two-time steps, which are the results that are closest to steady state.

As noted above, while groundwater inflow to the NFM is generated at the model boundaries, thus providing the water that should feed the springs, additional spring flows were represented in the Baseline scenario as point inflows to the channels (spring recharge), modelled using MIKE-11. In the No Canal and Undisturbed scenarios, these extra spring recharge were represented by point-source water injections entered as precipitation rates at each of the spring headwater cells. This precipitation is then processed by the overland flow module and a water balance in each cell is carried out. As mentioned above, none of this spring recharge comes from groundwater interaction, but instead is represented as water apparently created from nowhere, and with no explanation or justification provided by DHI. The discharges obtained by MIKE-11 ("Total river outflow (MIKE-11)" in Table 4-4) and MIKE-SHE ("Total river outflow (MIKE-SHE)" in Table 4-4) are different in part because neither of the two models have reached steady state, but mainly because of the numerical instabilities in the MIKE-11 modelling (see Section 4.2.6.1.4).

		Variables in mm/y			Variables in l/s		
		Baseline	No Canal	Undisturbed	Baseline	No Canal	Undisturbed
Inflow	**Variable description**	**3131**	**2724**	**2656**	**254**	**221**	**216**
Spring recharge	Boundary inflow in MIKE-11/ Precipitation in MIKE-SHE	-518	-382	-382	-42*	-31**	-31**
SubSurf.Bou.Inflow	Subsurface boundary inflow	-2613	-2342	-2275	-212	-190	-185
Storage change		**44**	**5**	**64**	**4**	**0**	**5**
SubSurf.Stor.Change	Subsurface storage change	-44	-5	-64	-4	0	-5
OL Stor.Change	Overland storage change	0	0	0	0	0	0
Total groundwater outflow		**1311**	**1419**	**1442**	**106**	**115**	**117**
SubSurf.Bou.Outflow	Subsurface boundary outflow	1311	1419	1442	106	115	117
Total river outflow (MIKE-SHE)		**1766**	**-**	**-**	**143*** **	**-**	**-**
Baseflow to river	Baseflow to river	1226	-	-	100	-	-
Baseflow from river	Baseflow from river	-112	-	-	-9	-	-
OL->River/MOUSE	Overland flow to river	134	-	-	11	-	-
Spring recharge	Boundary inflow (MIKE-11)	518	-	-	42	-	-
Total overland outflow (MIKE-SHE)		**-**	**1159**	**1113**	**-**	**94**	**90**
OL Bou.Outflow	Overland boundary outflow	-	1159	1113	-	94	90
Total river outflow (MIKE-11)		**1847**	**-**	**-**	**150*****	**-**	**-**
Evapotranspiration		**126**	**150**	**164**	**10**	**12**	**13**
Total outflow		**3283**	**2728**	**2718**	**267**	**222**	**221**
Error		**27**	**0**	**-2**	**2**	**0**	**0**

Table 4-4. Detailed NFM water balance for the three scenarios, obtained from the results file provided by DHI. For the Baseline scenario, the MIKE-11 boundary inflows were considered as spring recharge and included in the Inflow component of the water balance. For the No Canal and Undisturbed scenarios, precipitation was considered as a point-source spring recharge and was included in the Inflow component of the water balance.

*42 l/s input at head waters sections in MIKE-11; **31 l/s injected as point-source precipitation in the MIKE-SHE model.
*** the 143 l/s reported as total river outflow (MIKE-SHE) is not the same as the 150 l/s reported as total river outflow (MIKE-11).

	Variables in mm/y			Variables in l/s		
	Baseline	No Canal	Undisturbed	Baseline	No Canal	Undisturbed
Inflow	3116	2722	2655	253	221	216
Storage change	49	12	64	4	1	5
Total groundwater outflow	1310	1418	1441	106	115	117
Total overland outflow (MIKE-SHE)	-	1159	1112	-	94	90
Total river outflow (MIKE-11)	1846	-	-	150	-	-
Evapotranspiration	125	150	164	10	12	13
Total outflow	3281	2727	2717	266	221	220
Error	25	0	-2	2	0	0

Table 4-5. Detailed NFM water balance for the three scenarios reported in Table 1 of Annex H of DHI's report.

We found an important inconsistency when DHI reported the impact of channelization on surface water flows. In the BCM, DHI states that removing the channels reduces the river flow by 31 to 40% relative to current conditions (BCM, Vol. 2, p. 303). Then, in Bolivia's Rejoinder, DHI reported that removing the channels reduces the river flow by 11% to 33% (BR, Vol. 5, p. 56). The highest values of flow reduction, i.e., the 40% and the 33%, were calculated using the same data from their model runs (Table 4-5), and comparing the Total overland flow (MIKE-SHE) from the Undisturbed scenario with the Total river outflow (MIKE-11) from the Baseline scenario. Nonetheless, the flow reduction percentages are different. The 40% flow reduction can be calculated from the values reported in Table 4-5. However, the 33% flow reduction was only replicated when incorporating 10 l/s of additional surface water flow in the Undisturbed scenario. The incorporation of this additional 10 l/s to the surface water flow was not explained in Bolivia's Rejoinder, but it was included in the Excel spreadsheet named "Water balance tables – Sensitivity Report.xls", which was delivered by DHI along with the files provided to support the Rejoinder modelling (Appendix C). The arbitrary inclusion of this additional surface water flow is wholly unexplained and thus, in addition to all the previous issues described before, the estimations of the impact of channelization on river flow are flawed.

Additionally, we disaggregated the water balance to estimate the groundwater flow that enters at each boundary in the Baseline model scenario. We calculated the water balance using the two sub-catchments that are presented in Figure 4-23. This figure also shows the results of the water balance of each sub-catchment. Taking into consideration the results of this analysis, most of the groundwater inflow comes from the northern boundary. When looking at the groundwater levels and contours presented in Figure 4-2, it would be expected that most of the inflow would come from the eastern boundary.

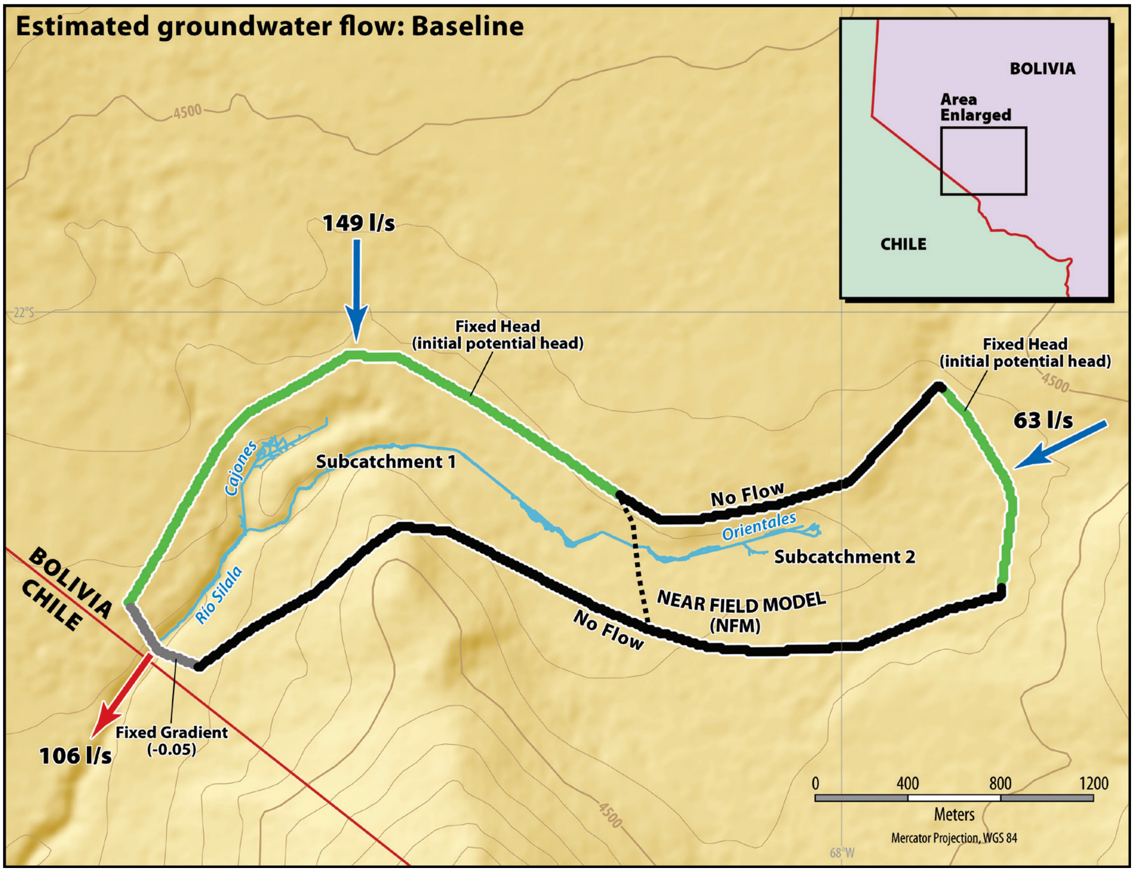


Figure 4-23. Sub-catchments (1 and 2) used to calculate the groundwater inflow from each boundary of the model.

4.2.8 Summary of unreported differences between the DHI scenarios

It can readily be seen from the above discussion that completely different modelling methodologies were used to simulate the scenarios for the evaluation of the impact of the channelization. This constitutes poor scientific practice, at the very least, and means that the results presented to the Court are highly misleading. Broadly speaking, the differences lie in the fact that (vastly) different topographic surfaces, different forms of calculating surface flows and different representations of the springs have been used for the different scenarios.

One of the most significant differences is in the topographies used in the Baseline, No Canal and Undisturbed scenarios. DHI (2018) only mentions changes made to the topography in the Undisturbed scenario, the implication being that there are no differences between the Baseline and the No Canal scenario topographies, other than the removal of the channels. However, examination of the requested model files reveals differences of up to 7 m between the MIKE-11 channel topographies used in the Baseline model and the MIKE-SHE overland flow surfaces used in the No Canal and

Undisturbed scenarios. These differences will have produced a large part of the supposed "impacts due to channelization" presented by DHI in the BCM.

Another incorrect and highly unrealistic aspect of the modelling approach is the addition of external fluxes to represent the springs ("spring recharge"), which should really be a result of groundwater interactions. Despite having an integrated surface-groundwater model, only the diffuse groundwater inflow is solely represented by surface-groundwater interaction: the spring inflows are additionally represented as external inputs to the model (spring recharge), with no justification of where this water actually comes from. In other words, instead of obtaining the spring water flows from groundwater through the hydrogeological model, artificial point flows are introduced.

In the baseline scenario a total of 42 l/s in the form of point injections is introduced into the channel system (distributed at 42 spring locations of 1 l/s each) while in the No Canal and Undisturbed scenarios 31 l/s are introduced via precipitation into the system. First, there is no explanation of where this spring water comes from (it is not from groundwater interaction as it should be). Second, the imposed flow is 11 l/s lower in the No Canal and Undisturbed scenarios than in the Baseline scenario, resulting in a lower outflow, and the reason to artificially impose a difference of 11 l/s is not explained by DHI (2018). Third, the addition of this water is not comparable even if the amounts were equivalent, since the way in which the water is added to the models is different in the different scenarios. There is no reason to assume that the natural springs would no longer discharge to surface if the artificial channelization was removed/restored.

The "spring recharge" flows in the Baseline model go directly into the surface water system, whereas in the No Canal and Undisturbed scenarios 31% of the precipitation representing the "spring recharge" enters directly into the groundwater system. Therefore, the way the different scenarios have been set up results in 9.7 l/s (31% of 31 l/s) being transferred directly from the surface water system to the groundwater system in the No Canal and Undisturbed scenarios. This transfer of water from the surface water to groundwater systems also produces an additional artificial "impact" or apparent increase in flow due to the artificial channels.

We conclude that the apparent impacts of the channelization presented in the BCM are largely a result of the unrealistic way in which the scenarios have been set up, with around 21 l/s of this apparent impact being due to the (unreported) differences in the ways the springs are represented in the scenarios, and the rest being due to the large (unreported) differences between the scenario topographies. Thus, very little of the supposed "impact" of the channelization presented in the BCM, and also in the BR, is actually due to the removal of the channels, and the conclusions of the BCM and BR must therefore be called into question.

We reiterate that the different ways that topographies and the "springs" have been represented in the different scenarios are not described in any way in the BCM. There is no mention of any differences to the topography between the Baseline and No Canal scenarios (only the Undisturbed scenario is supposed to have any topography changes according to DHI's report), and the "spring" flows are presented in Table 1 of Annex H to the DHI Report (BCM, Vol. 5, p. 67) under the same heading labelled as "inflow", with no distinction made at all between the two approaches, implying that this "inflow" is treated the same way in all scenarios. It has only been through detailed examination of the requested model files that these differences between the scenarios have been identified.

5. CONCLUSIONS

This report presents a critical analysis that demonstrates that the methodology used by DHI to estimate the "artificial flow" attributed to the channelization of the Bolivian wetlands is incorrect. The main emphasis of this study is the analysis of the NFM, since it is the main tool that supports Bolivia's estimation of the "artificial flow". Also, a brief analysis of the WBM, used to estimate the recharge of the hydrogeological system, is carried out. The main conclusions from this study are listed below:

Water Balance numerical model

- The southwestern no-flow boundary condition is not based on the geology of the studied area, but rather on a geopolitical boundary.
- The flow directions obtained from the initial groundwater levels do not represent a good approximation of reality since they are influenced by a boundary condition that is based on a geopolitical rather than a physical boundary.
- The no-flow boundary condition located in the western side of the WBM near the fixed head boundary influences the flow direction into the NFM, while it should be exiting the model from east to west.

Near Field conceptual model

- DHI's hydrogeological understanding has been based on an incorrect interpretation of the geology including the stratigraphy and the age relationships of the various deposits, resulting in a flawed conceptual understanding of the groundwater flow regime. This has influenced aquifer delineation, selection of aquifer properties and boundary condition definition in their numerical models.
- DHI (2018) constructed the groundwater level contour map of the Silala Near Field using the levels measured in all the piezometers, making no distinction between piezometers that measure the shallow aquifer groundwater levels and

those that measure the deep aquifer groundwater levels, thus mixing the data from two aquifer systems.

- The groundwater flow directions interpreted from DHI's piezometric level contours do not correspond to DHI's own conceptual model in terms of the flow directions shown on their spring location maps.
- The groundwater level contours do not take into consideration the presence of a low permeability boundary at the south-west of the Orientales stream (Volcanic sequences from the Miocene).

Near Field numerical model

- There is a lack of consistency between the WBM and the NFM:
    - The WBM and NFM groundwater contour lines do not coincide.
    - There is an inconsistency between the boundary conditions and the groundwater flow direction of both models.
    - The 198 l/s that leaves the WBM model is not the same as the 212, 190 or 185 l/s that enter the NFM model scenarios as groundwater flow.
- The boundary conditions used in the NFM are inconsistent with the groundwater flow directions derived from the hydrogeological conceptual model, as well as with the flow directions from the WBM.
- The no-flow boundaries on the north-eastern and southern edges of the model have no physical or geological justification.
- The initial potential head used in the Baseline and No Canal scenarios is different to the one used in the Undisturbed scenario.
- Steady state is not reached after 91 days of simulation, so that there are cumulative systematic errors in the model water balances.
- The model topographies used in the three scenarios are not the same, differing from one another by up to 7 m. These unreported differences are likely to be one of the main reasons for the apparent differences in surface water flow between DHI's Baseline and No Canal and Undisturbed scenarios.
- The method used to calculate the surface flow through the international border in the Baseline scenario is different from that used in the No Canal and Undisturbed scenarios. Therefore, these flows are not directly comparable.
- In addition to the groundwater inflows to the Near Field that arise as a result of the boundary conditions, the springs have been modelled as localized surface water inflows in the Baseline scenario and as a local precipitation in the No Canal and Undisturbed scenarios (spring recharge). Neither of these representations is correct as the spring water should come entirely from interactions with the groundwater system. The amounts of extra spring recharge

added in the models have not been justified, no calculations are shown and no estimation methodology is described.

- The amount of water added as precipitation in the No Canal and Undisturbed scenarios is 11 l/s less than the amount added as surface water inflows in the baseline scenario, thereby artificially producing 11 l/s of apparent increase in flow due to the channels.
- The representations of the springs as surface water sources in the Baseline scenario but as precipitation sources in the No Canal and Undisturbed scenarios results in 31% of the precipitation being transferred directly from the surface water system to the groundwater system. This results in a further 9.7 l/s apparent increase in flow due to the channels.
- Presenting the flow values from the unstable MIKE-11 component of the Baseline scenario, rather than the surface water-groundwater interactions of the more stable MIKE-SHE component, the Baseline scenario results in a further 7 l/s over-estimate of the flows under current conditions. Neither this nor the previously mentioned 11 l/s or 9.7 l/s apparent increases are realistic.
- The differences between the ways the springs were represented in the different scenarios were not described in any way in the BCM and were presented under the same heading in their water balances, implying that they were represented in the same way.
- The downstream stage-discharge curve boundary condition in the Baseline scenario, that imposes critical flow, is not explained or justified in DHI's report.
- The slope between the two last cross sections (3560 and 3635) is zero, which is unrealistic and is not explained or justified in the DHI report.
- The Manning coefficient, *n*, was found to be representative of the highest values recommended for flood plains covered by dense trees (n = 0.200), which is not the case of the Silala River and is physically unrealistic.
- As a result of the high imposed value of the Manning coefficient, the normal depth of the channel is increased and the flow conditions are subcritical ($Fr < 1$) in almost all the cross sections, which does not coincide with what is observed in the field, i.e., supercritical flow conditions ($Fr > 1$). Hence, the results of DHI are unrealistic and conceptually inconsistent with the observed flow regime.
- At some of the cross sections water does not flow through the main channel and in other cross sections the channel is flooded.
- Errors were found in the hydraulic modelling of the DHI:
    - Abrupt changes in river flow were found at different points.
    - There are flow variations along the river that never stabilize.
- Different values for the upper bound effect of channelization on surface flows were reported in the BCM (40%) and the BR (33%) for the same simulations.

Final Conclusions

- The differences between the results obtained using the Near Field Model to represent the effects of channel removal and peat growth are largely due to unreported differences between the models used to represent the different scenarios. These differences were only discovered once the requested model files were examined in detail (and we recall that DHI originally refused to provide these files). The very large number of differences, and the fact that these were not reported, is disturbing, and at best represents very poor scientific practice. The Near Field modelling results presented to the Court in the BCM and BR written pleadings to demonstrate the effects of channelization and peat growth are grossly misleading.

6. REFERENCES

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APPENDIX A.

DATA FILES PROVIDED BY DHI

A-1 MODEL FILES

In the DHI report, three models were used to analyze the hydrological behavior of the basin: Water Balance, Near Field and Near Border. Appendix A details the files provided by Bolivia which could be used to critically analyze these models. Each of these models has variations, marked as different versions, in which the boundary and/or initial conditions change. In particular, 12 configurations are presented for the Water Balance model for water balance and aquifer recharge (Table A-1), and two for the evaluation of groundwater travel times in aquifers (Table A-2).

Annex E Table 3, Line no	Parameter change	Model configuration file name	Directory
1	**Baseline**	Silala_model_200m_v24	WaterBalance
	Rainfall		
2	DGA Laguna Colorada	Silala_model_200m_v26	WaterBalance
3	DGA Linzor	Silala_model_200m_v27	WaterBalance
4	DGA Inacaliri - rainfall-altitude relation	Silala_model_200m_v5	WaterBalance
	Evaporation		
5	Et0 Laguna Colorada	Silala_model_200m_v33	WaterBalance
6	Et0 Sol de Manana	Silala_model_200m_v34	WaterBalance
	Soil parameters		
7	0-10 cm: Ks=9.7E-6 m/s, 10-20 cm: 4.5E-6 m/s	Silala_model_200m_v29	WaterBalance
8	0-10 cm: Ks=1.4E-5 m/s, 10-20 cm: 1.2E-5 m/s	Silala_model_200m_v28	WaterBalance
9	0-10 cm: n=1.619 (theta_FC=0.17), 10-50 cm: n=1.477 (theta_FC=0.19)	Silala_model_200m_v32	WaterBalance
10	0-10 cm: n=1.754 (theta_FC=0.12), 10-50 cm: n=1.699 (theta_FC=0.12)	Silala_model_200m_v35	WaterBalance
11	0-10 cm: theta_r=0.039, 10-50 cm: theta_r=0.042	Silala_model_200m_v36	WaterBalance
12	0-10 cm: theta_r=0.05, 10-50 cm: theta_r=0.132	Silala_model_200m_v37	WaterBalance

Table A-1. Configurations of the water balance and aquifer recharge model in the basin (DHI, 2018).

Task	Model configuration file name	Directory
Particle tracking in Saturated zone	Silala_model_gw_200m_v12_final.she	WaterBalance
WQ tracer in the unsaturated zone	Silala_model_gw_200m_v12_final_tracer.she	WaterBalance

Table A-2. Configurations of the evaluation of groundwater travel times (DHI, 2018).

The Near Field Model has three configurations (Table A-3): the (current) baseline scenario, the no channelization scenario, and the restored wetlands scenario (i.e., without human intervention).

N°	Model setup name	Description
1	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit.she	An integrated hydrological model setup of the Silala Near Field area including canals.
2	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V22_NoCanal_OLexplicit.she	An integrated hydrological model setup of the Silala Near Field area without canals.
3	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V22_NoCanal_OLexplicit_undisturb.she	An integrated hydrological model setup of the Silala Near Field area with restored wetlands and without canals

Table A-3. Configurations of the water balance model in wetlands and springs (DHI, 2018).

The Near Border Model, for which the domain is delimited to study the flow at the international border, has six configurations considering channelization, and six configurations without channelization (Table A-4).

Baseline							Decrease in transborder surface flow	
N°	**Configuration file name with canal**				**N°**	**Configuration file name without canals**	**l/sec**	**Pct**
1	**Silala_NearBorder_grav_v4.she**				**2**	**Silala_NearBorder_grav_nat_v4.she**	**12**	**8**
Sentitivity Analysis							**Decrease in transborder surface flow**	
N°	**Configuration file name with canals**	**Parameters as in**	**Org baseline parameter**	**Scenario Parameters**	**N°**	**Configuration file name without canals**	**l/sec**	**Pct**
3	Silala_NearBorder_grav_v4_5m.she	Silala_NearBorder_grav_v4.she	10 m resolution	5 m resolution	8	Silala_NearBorder_grav_nat_v4_5m.she	14	8
4	Silala_NearBorder_grav_v5.she	Silala_NearBorder_grav_v4.she	M2.5	M=15	9	Silala_NearBorder_grav_nat_v5.she	12	8
5	Silala_NearBorder_grav_v6.she	Silala_NearBorder_grav_v4.she	Kh1=10-4, Kv2=5E-5	Kh1=10-3, Kv2=5E-4	10	Silala_NearBorder_grav_nat_v6.she	23	15
6	Silala_NearBorder_grav_v7.she	Silala_NearBorder_grav_v6.she	Kuz, fine sand=2.74E-5	Kuz, fine sand=10-4	11	Silala_NearBorder_grav_nat_v7.she	24	15
7	Silala_NearBorder_grav_v8.she	Silala_NearBorder_grav_v7.she	Kh2=3E-5	Kh2=10-4	12	Silala_NearBorder_grav_nat_v7.she	39	25

Table A-4. Configurations of the water balance model near the border (DHI, 2018).

To carry out the analysis of the DHI simulations, we studied the model files presented in Table A-5. It was decided to study the WBM version "Silala_model_gw_200m_v12_final.she" because it simulates groundwater flow. The files from the NFM that were studied were the final version of each scenario.

N°	Model	Comments	File name
1	WBM	-	Silala_model_gw_200m_v12_final.she
2	NFM	Baseline scenario	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit
3	NFM	No Canal scenario	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V22_NoCanal_OLexplicit
4	NFM	No Canal Undisturbed scenario	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V22_NoCanal_OLexplicit_undisturb

Table A-5. DHI model files analyzed in this study.

A-2 RESULT FILES

The results of the models developed by DHI, which are presented as text files, are presented in Tables A-6, A-7 and A-8.

	Folder		Text File
Water Balance	1	**Silala_model_200m_v5.she - Result Files**	Chart_wbl Silala_model_200m_v5_PreProcessed_SoilProf Wbl_Chile_sub_total
	2	**Silala_model_200m_v24.she - Result Files**	Chart_Chile Chart_Chile_new Chart_Chile_new_v2 Chart_Chile_short Chart_Chile_sub_wbl Chart_long Chart_wbl Silala_model_200m_v24_PreProcessed_SoilProf
	3	**Silala_model_200m_v26.she - Result Files**	Chart_wbl Silala_model_200m_v26_PreProcessed_SoilProf
	4	**Silala_model_200m_v27.she - Result Files**	Chart_chile_wbl Chart_wbl Silala_model_200m_v27_PreProcessed_SoilProf Total_wbl
	5	**Silala_model_200m_v28.she - Result Files**	Chart_wbl Silala_model_200m_v28_PreProcessed_SoilProf
	6	**Silala_model_200m_v29.she - Result Files**	Chart_wbl Silala_model_200m_v29_PreProcessed_SoilProf
	7	**Silala_model_200m_v32.she - Result Files**	Chart_wbl Silala_model_200m_v32_PreProcessed_SoilProf
	8	**Silala_model_200m_v33.she - Result Files**	Chart_chile_wbl Chart_wbl Silala_model_200m_v33_PreProcessed_SoilProf
	9	**Silala_model_200m_v34.she - Result Files**	Chart_chile_wbl Chart_wbl Silala_model_200m_v34_PreProcessed_SoilProf
	10	**Silala_model_200m_v35.she - Result Files**	Chart_wbl Silala_model_200m_v35_PreProcessed_SoilProf
	11	**Silala_model_200m_v36.she - Result Files**	Chart_wbl Silala_model_200m_v36_PreProcessed_SoilProf
	12	**Silala_model_200m_v37.she - Result Files**	Chart_wbl Silala_model_200m_v37_PreProcessed_SoilProf
	13	**Silala_model_gw_200m_v12_final.she - Result Files**	Silala_model_gw_200m_v12_final_PP_Print Silala_model_gw_200m_v12_final_PreProcessed_SoilProf Silala_model_gw_200m_v12_final_WM_Print Silala_model_gw_200m_v12_final_WQ_Print
	14	**Silala_model_gw_200m_v12_final_tracer.she - Result Files**	Chart_wbl Silala_model_gw_200m_v12_final_tracer_PreProcessed_SoilProf

Table A-6. Results in the form of text files for Water Balance Models.

		Folder	Text File
Near Field	1	**Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit.she - Result Files**	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit_PP_Print
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit_PreProcessed_SoilProf1
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit_PreProcessed_SoilProf4
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit_PreProcessed_SoilProf5
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit_PreProcessed_SoilProf6
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V18_OLexplicit_WM_Print
			wbl_va8_withcanal_OLexp
			wbl_va8_withcanal_OLexp_WBL_POST
	2	**Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V22_NoCanal_OLexp_OL_TopoKorr.she - Result Files**	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V22_NoCanal_OLexp_OL_TopoKorr_PP_Print
	3	**Hot_Silala_10m_withHydrogeologicalModel (MIKE 11)**	Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V3_PP_Print
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V3_PreProcessed_SoilProf1
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V3_PreProcessed_SoilProf4
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V3_PreProcessed_SoilProf5
			Silala_10m_withHydrogeologicalModel_DeepLowK_ModelArea_V3_PreProcessed_SoilProf6

Table A-7. Results in the form of text files for Near Field Models.

	Folder		Text File
Near Border	1	**Silala_NearBorder_grav_nat_v4.she - Result Files**	Chart_wbl Silala_NearBorder_grav_nat_v4_PreProcessed_SoilProf1 Silala_NearBorder_grav_nat_v4_PreProcessed_SoilProf4
	2	**Silala_NearBorder_grav_nat_v4_5m.she - Result Files**	Chart_wbl Silala_NearBorder_grav_nat_v4_5m_PreProcessed_SoilProf1 Silala_NearBorder_grav_nat_v4_5m_PreProcessed_SoilProf4
	3	**Silala_NearBorder_grav_nat_v5.she - Result Files**	Chart_wbl Silala_NearBorder_grav_nat_v5_PreProcessed_SoilProf1 Silala_NearBorder_grav_nat_v5_PreProcessed_SoilProf4
	4	**Silala_NearBorder_grav_nat_v6.she - Result Files**	Chart_wbl Silala_NearBorder_grav_nat_v6_PreProcessed_SoilProf1 Silala_NearBorder_grav_nat_v6_PreProcessed_SoilProf4
	5	**Silala_NearBorder_grav_nat_v7.she - Result Files**	Chart_wbl Silala_NearBorder_grav_nat_v7_PreProcessed_SoilProf1 Silala_NearBorder_grav_nat_v7_PreProcessed_SoilProf4
	6	**Silala_NearBorder_grav_nat_v8.she - Result Files**	Chart_wbl Silala_NearBorder_grav_nat_v8_PreProcessed_SoilProf1 Silala_NearBorder_grav_nat_v8_PreProcessed_SoilProf4
	7	**Silala_NearBorder_grav_v4.she - Result Files**	Chart_wbl Silala_NearBorder_grav_v4_PreProcessed_SoilProf1 Silala_NearBorder_grav_v4_PreProcessed_SoilProf4
	8	**Silala_NearBorder_grav_v4_5m.she - Result Files**	Chart_wbl Silala_NearBorder_grav_v4_5m_PreProcessed_SoilProf1 Silala_NearBorder_grav_v4_5m_PreProcessed_SoilProf4
	9	**Silala_NearBorder_grav_v5.she - Result Files**	Chart_wbl Silala_NearBorder_grav_v5_PreProcessed_SoilProf1 Silala_NearBorder_grav_v5_PreProcessed_SoilProf4
	10	**Silala_NearBorder_grav_v6.she - Result Files**	Chart_wbl Silala_NearBorder_grav_v6_PreProcessed_SoilProf1 Silala_NearBorder_grav_v6_PreProcessed_SoilProf4
	11	**Silala_NearBorder_grav_v7.she - Result Files**	Chart_wbl Silala_NearBorder_grav_v7_PreProcessed_SoilProf1 Silala_NearBorder_grav_v7_PreProcessed_SoilProf4 Wbl_error
	12	**Silala_NearBorder_grav_v8.she - Result Files**	Chart_wbl Cross_sections_main_canal Error_wbl Silala_NearBorder_grav_v8_PreProcessed_SoilProf1 Silala_NearBorder_grav_v8_PreProcessed_SoilProf4

Table A-8. Results in the form of text files for Near Border Models.

APPENDIX B.

VALUES OF THE ROUGHNESS MANNING COEFFICIENT

Type of channel and description	Minimum	Normal	Maximum
A. CLOSED CONDUITS FLOWING PARTLY FULL			
A-1. Metal			
a. Brass, smooth	0.009	**0.010**	0.013
b. Steel			
1. Lockbar and welded	0.010	0.012	0.014
2. Riveted and spiral	0.013	0.016	0.017
c. Cast iron			
1. Coated	0.010	0.013	0.014
2. Uncoated	0.011	0.014	0.016
d. Wrought iron			
1. Black	0.012	0.014	0.015
2. Galvanized	0.013	0.016	0.017
e. Corrugated metal			
1. Subdrain	0.017	0.019	0.021
2. Storm drain	0.021	**0.024**	0.030
A-2. Nonmetal			
a. Lucite	0.008	0.009	0.010
b. Glass	0.009	**0.010**	0.013
c. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
d. Concrete			
1. Culvert, straight and free of debris	0.010	0.011	0.013
2. Culvert with bends, connections, and some debris	0.011	**0.013**	0.014
3. Finished	0.011	0.012	0.014
4. Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
5. Unfinished, steel form	0.012	0.013	0.014
6. Unfinished, smooth wood form	0.012	**0.014**	0.016
7. Unfinished, rough wood form	0.015	0.017	0.020
e. Wood			
1. Stave	0.010	0.012	0.014
2. Laminated, treated	0.015	0.017	0.020
f. Clay			
1. Common drainage tile	0.011	**0.013**	0.017
2. Vitrified sewer	0.011	0.014	0.017
3. Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
4. Vitrified subdrain with open joint	0.014	0.016	0.018
g. Brickwork			
1. Glazed	0.011	0.013	0.015
2. Lined with cement mortar	0.012	0.015	0.017
h. Sanitary sewers coated with sewage slimes, with bends and connections	0.012	0.013	0.016
i. Paved invert, sewer, smooth bottom	0.016	0.019	0.020
j. Rubble masonry, cemented	0.018	0.025	0.030

Type of channel and description	Minimum	Normal	Maximum
B. LINED OR BUILT-UP CHANNELS			
B-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	**0.012**	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
B-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	
d. Concrete bottom float finished with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	.....	0.500

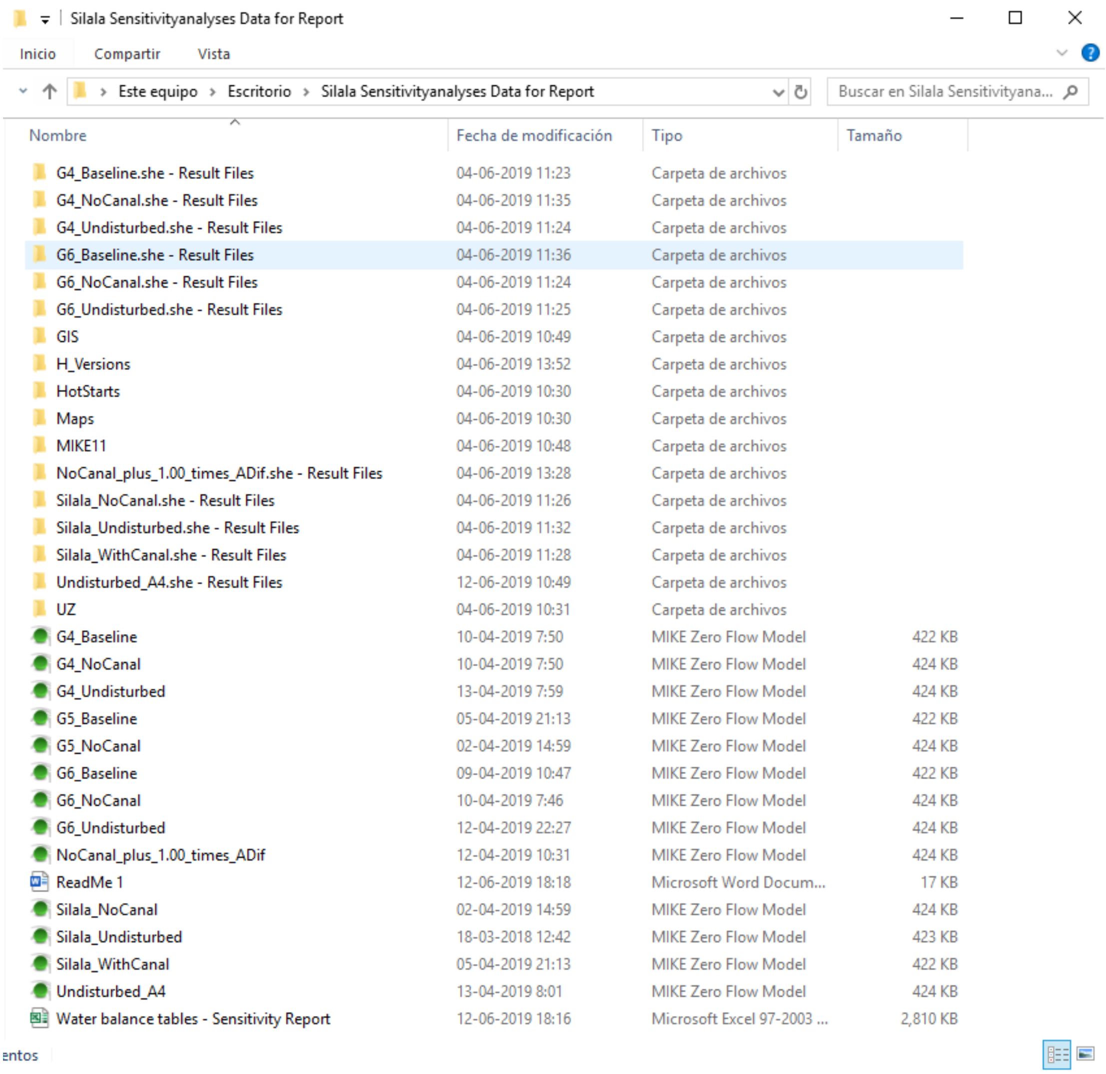
Type of channel and description	Minimum	Normal	Maximum
C. EXCAVATED OR DREDGED			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	**0.022**	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
D. NATURAL STREAMS			
D-1. Minor streams (top width at flood stage <100 ft)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	**0.030**	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools and shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Type of channel and description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
D-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
D-3. Major streams (top width at flood stage >100 ft). The *n* value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	.....	0.060
b. Irregular and rough section	0.035	.....	0.100

Table B-1. Values of the roughness coefficient n (Boldface figures are values generally recommended in design). Source: Chow (1959).

APPENDIX C.

REJOINDER FILES PROVIDED BY BOLIVIA



Nombre	Fecha de modificación	Tipo	Tamaño
G4_Baseline.she - Result Files	04-06-2019 11:23	Carpeta de archivos	
G4_NoCanal.she - Result Files	04-06-2019 11:35	Carpeta de archivos	
G4_Undisturbed.she - Result Files	04-06-2019 11:24	Carpeta de archivos	
G6_Baseline.she - Result Files	04-06-2019 11:36	Carpeta de archivos	
G6_NoCanal.she - Result Files	04-06-2019 11:24	Carpeta de archivos	
G6_Undisturbed.she - Result Files	04-06-2019 11:25	Carpeta de archivos	
GIS	04-06-2019 10:49	Carpeta de archivos	
H_Versions	04-06-2019 13:52	Carpeta de archivos	
HotStarts	04-06-2019 10:30	Carpeta de archivos	
Maps	04-06-2019 10:30	Carpeta de archivos	
MIKE11	04-06-2019 10:48	Carpeta de archivos	
NoCanal_plus_1.00_times_ADif.she - Result Files	04-06-2019 13:28	Carpeta de archivos	
Silala_NoCanal.she - Result Files	04-06-2019 11:26	Carpeta de archivos	
Silala_Undisturbed.she - Result Files	04-06-2019 11:32	Carpeta de archivos	
Silala_WithCanal.she - Result Files	04-06-2019 11:28	Carpeta de archivos	
Undisturbed_A4.she - Result Files	12-06-2019 10:49	Carpeta de archivos	
UZ	04-06-2019 10:31	Carpeta de archivos	
G4_Baseline	10-04-2019 7:50	MIKE Zero Flow Model	422 KB
G4_NoCanal	10-04-2019 7:50	MIKE Zero Flow Model	424 KB
G4_Undisturbed	13-04-2019 7:59	MIKE Zero Flow Model	424 KB
G5_Baseline	05-04-2019 21:13	MIKE Zero Flow Model	422 KB
G5_NoCanal	02-04-2019 14:59	MIKE Zero Flow Model	424 KB
G6_Baseline	09-04-2019 10:47	MIKE Zero Flow Model	422 KB
G6_NoCanal	10-04-2019 7:46	MIKE Zero Flow Model	424 KB
G6_Undisturbed	12-04-2019 22:27	MIKE Zero Flow Model	424 KB
NoCanal_plus_1.00_times_ADif	12-04-2019 10:31	MIKE Zero Flow Model	424 KB
ReadMe 1	12-06-2019 18:18	Microsoft Word Docum...	17 KB
Silala_NoCanal	02-04-2019 14:59	MIKE Zero Flow Model	424 KB
Silala_Undisturbed	18-03-2018 12:42	MIKE Zero Flow Model	423 KB
Silala_WithCanal	05-04-2019 21:13	MIKE Zero Flow Model	422 KB
Undisturbed_A4	13-04-2019 8:01	MIKE Zero Flow Model	424 KB
Water balance tables - Sensitivity Report	12-06-2019 18:16	Microsoft Excel 97-2003 ...	2,810 KB

Figure C-1. Rejoinder files submitted by Bolivia.

APPENDIX D

Contract CDP-I No 15/2017, Study of the Flows in the Silala Wetlands and Springs System

Product No. 3:

Provisional Report 3 – Water balance of the basin and groundwater aquifer and update of measured surface water flow

Foto:SENAMHI 2017, Weir C-2, Southern Wetland

Pluri-national State of Bolivia, Ministry of Foreign Affairs, Diremar

Report

November 15, 2017

The expert in WATER ENVIRONMENTS

This report has been prepared under the DHI Business Management System
certified by Bureau Veritas to comply with ISO 9001 (Quality Management)

Approved by

Oluf Zeilund Jessen, Head of Projects Water Resources

Pluri-national State of Bolivia, Ministry of Foreign Affairs, Diremar

Report

November 15, 2017

The expert in **WATER ENVIRONMENTS**

Contract CDP-I No 15/2017 Study of the Flows in the Silala Wetlands and Springs System.

Product No. 3

Provisional Report 3 – Water balance of the basin and groundwater aquifer and update of measured surface water flow

Prepared for	Pluri-national State of Bolivia, Ministry of Foreign Affairs, Diremar
Represented by	Dr. Emerson Calderón

Foto: SENAMHI 2017: Weir C-2 Southern Wetland

Project manager	Roar Askær Jensen
Quality supervisor	Michael Brian Butts

Project number	11820137
Approval date	November 15, 2017
Revision	0
Classification	Confidential

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1 Executive summary

DHI (the Consultant) has been contracted by the Government of the Pluri-national State of Bolivia (Directorate: Diremar) to execute the technical study: Flow Analysis of the Silala Springs, Canal and Wetland System". The present report constitutes the third deliverable of the second part of the study:" Product No. 3: Provisional Report 3 – Climate data, water balance and measured flows."

The report is divided into three main chapters covering 1) the climate data, 2) water balance and 3) measured flow. We begin with the evaluation of data sources and generation of climate datasets, these areas used subsequently in a model-based groundwater and catchment water balance analysis, which is then evaluated against canal flow measurements.

More specifically, the first chapter describes how climate data from local climate stations have been analysed, processed and combined with local data from satellites to derive long-term spatially distributed time series of precipitation, evapotranspiration and temperature for the Silala Catchment.

In the second chapter, climate data is used in a water balance model covering the delineated catchment to the Silala Springs System (Far Field area of 232 km^2). Due to limitation in the subsurface geological data currently available, a generalised conceptual hydrogeological model has been used. A key output of the water balance model is a distributed estimate of groundwater recharge and the water age that can be compared with field data.

The third main chapter is devoted to Silala Canal flow measurements. Flow data from the two permanent flumes on the Bolivian and Chilean sides of the border, as well as flow data collected by SENAMHI during the May-September 2017 monitoring program have been plotted, analysed and compared. Therefore, the surface flow analyses presented here are based on more flow data than the previous analysis in the project's surface water report from July 2017.

The water balance calculations indicate that the groundwater recharge from the catchment is sufficient to maintain a discharge of 160-200 l/s to the Silala spring and canal system. From particle-tracking simulations, a water age of up to several thousand years from infiltration at the surface to discharge at the springs has been estimated. The results are, however, subject to considerable uncertainty, as demonstrated through a sensitivity analysis.

The flow observations show that the spatial distribution of inflows is approximately constant in time as expected from a groundwater fed stream. In addition to the springs in the Northern and Southern Wetlands, a limited reach of the main canal at the upper part of the ravine contributes to a relatively large inflow to the canal. The recorded fluctuations in flow are likely due to measurement inaccuracies rather than a response to climate events or surface runoff.

The various independently gauged flow series from locations close to the border (three locations in Bolivia and one downstream the border) would be expected to be almost identical. However, these series show significantly different flows ranging from160 to 210 l/s.

The flow data analysis shows that the flows are approximately constant in time and dominated by groundwater discharge. The temporal variation observed in site-specific flow measurements cannot be explained by responses in neighbouring measurement locations or any climate or runoff events.

During the winter period July –Sept 2017, the large base flow component from groundwater is observed to be superimposed by smaller periodic daily flow variations. These cannot be explained by wetland evaporation but may be due to freezing/thawing of the water in the wetlands.

2 Introduction

Through Technical Report Diresilala/DDM Nº 001/2017 of 6 February 2017, the Office for the Protection of Silala Springs, Diresilala, contracted DHI for the realisation of the first part of this technical study of the flows of the Silala Wetland and Springs System. The Silala Springs are located in an arid area of the Potosi Department of Bolivia, close to the border with Chile.

Diresilala was subsequently integrated into Diremar, the Strategic Office for the Maritime Vindication, Silala and International Water Resources. Diremar has signed a new contract with DHI (Contract No. CDP-I 15/2017) for the execution of the second part of the study. The present report constitutes the third deliverable under this second part of the technical study of the flows of the Silala Wetland and Springs System.

2.1 About this report and the following steps of the project

This report documents and analyses climate data, water balance and flow measurements for the Silala Catchment.

The report is organised as a relatively brief main report in which the rationale, analyses and results of each of these three main themes are broadly described in separate sections. The main report also summarises the conclusions on all the themes but does not include all technical details, arguments and references. These are described in the three appendices – one for each main theme - and organised so they may be read in isolation from the main report.

Diremar is in the process of conducting a field study program to supplement the existing information on geology, hydrology, hydrogeology and wetland characteristics. More details on the field survey activities are given in the Field Survey Specifications Report (see Reference 6).

The field survey activities on surface water flows started in May 2017 and are ongoing to capture as much hydrological information as possible. The hydrogeological drilling and testing program as well as the planned campaign for soil sampling and determination of soil hydraulic characteristics in the wetlands and uphill top soils were originally planned to end by August 2017. However, problems in finding and allocating the right teams and equipment have delayed the drilling and soil analysis programs. These programs are not yet finalised at the time of writing (November 2017). This report and the analyses it contains are therefore based on data received from DIREMAR up to October 15th, 2017.

The report forms parts of DHI's deliverable under this project. Further deliverables in the coming project stages are:

- Product 4 Provisional report 4, Subsurface flows
- Product 5 Provisional report 4, Integrated surface and subsurface flows and scenario analyses
- Product 6 Final Report, Summary of findings of the previous reports and project conclusions.

2.2 Project objective and areas of concern

The project objective is to carry out a technical study of the flows of the Silala Wetland and Spring System, quantifying the surface and subsurface flows in their current condition and in their natural state, i.e. the flows without the manmade canal and drainage network. The canalisation was introduced by the Antofagasta Railway Company in the early 20th century to control the flow from the Silala Springs and use it for supply to the steam locomotives on the

Antofagasta-Bolivia Railway. The objective concerns the 'Near Field' area in the Silala Valley from the international border to just upstream the Silala Northern and Southern wetlands (see Figure 1).

A robust assessment requires both data and information of sufficient quantity and quality. It has therefore been agreed between Diremar and DHI to confine the data collection and the flow assessment to the Silala Near Field, where data collection is possible within the time available, and not to extend the field survey to the whole upstream catchment (see Figure 2, the Far Field). The extent of the Far Field groundwater catchment and recharge area is not known in detail and its size and conditions can only be very roughly assessed within the time and resources available to this project. Considerable effort would be required to map the complete hydrogeology and piezometric surface systematically.

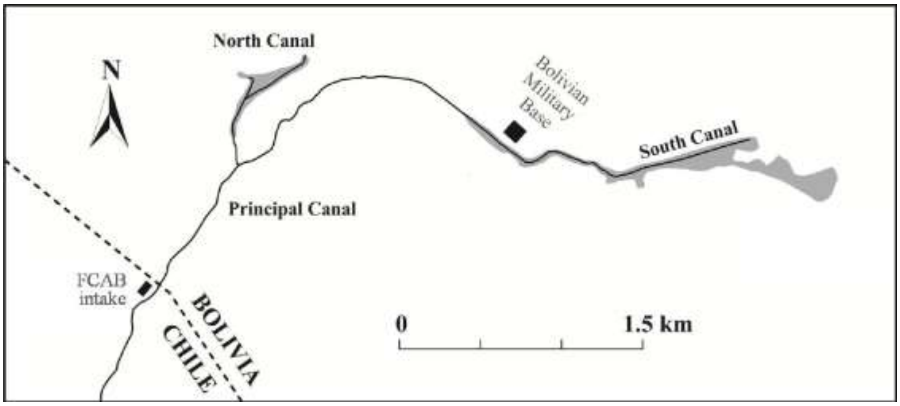


Figure 1 Approximate extent of the Silala Near Field. (Figure from Reference 1)

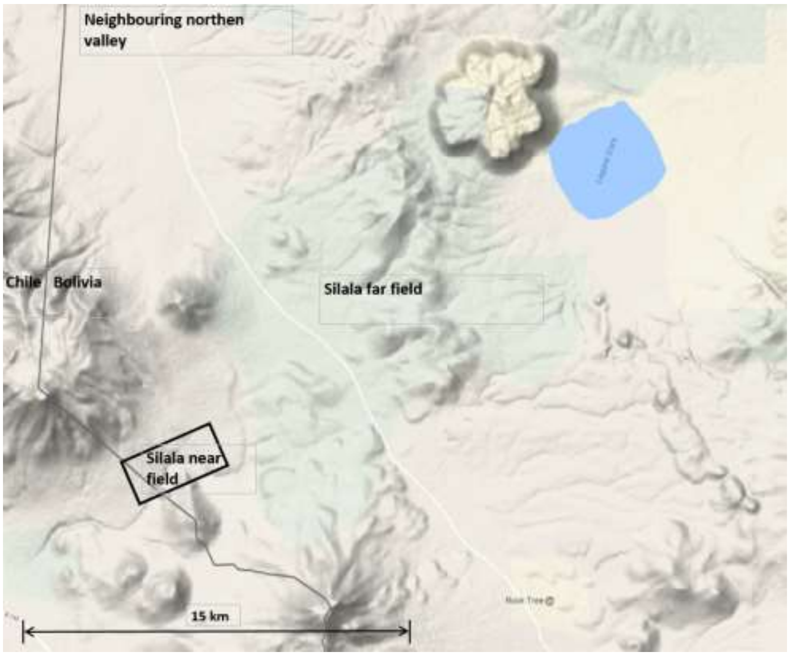


Figure 2 Approximate extents and locations of the Silala Near Field, the Silala Far Field and the neighbouring Northern valley

2.3 Rationale and methodology of the analyses

2.3.1 Climate assessment

Previous analyses (see Reference 10) have indicated large inter annual climate variations in the area and slow response of the Silala Springs System to climate variations. Long-term spatially distributed climate time series are required to understand the local hydrology, to analyse the recharge conditions of the system and the impacts of the manmade canals

Such time series have been generated by combining daily and hourly climate observations from the ground stations within or close to the Silala Springs catchment with satellite data of the *local* area. This approach is deemed to be the best one to compensate for the sparse coverage of climate ground observations in the catchment area.

2.3.2 Water balances and ground water recharge

The Silala Springs System is fed by groundwater originating from the upstream groundwater catchment. Previous isotope analyses of the water in the Silala Springs have indicated water ages in the order of 1,000 -10,000 years. The present aquifer recharge analysis investigates whether the discharge through the Silala Springs System may be in balance with the present climate or the discharge is from slowly depleting aquifers holding fossil water, which has infiltrated during wetter pre-historic periods.

The spatial extent of the supplying groundwater catchment is unknown, but is for the purpose of a water balance analysis, approximated by the Catchment area to the Silala Springs System as delineated from a digital terrain model in our previous surface water report (Reference 10).

A water balance has been established. The main components include precipitation, evaporation, infiltration through the soil, recharge to a groundwater aquifer and groundwater flow. This water balance is then used to assess whether the order of magnitude of upstream recharge is sufficient to sustain groundwater discharge and flow rates at the downstream wetland and border area. Given the approximate groundwater flows, the groundwater travel time and groundwater age are estimated.

2.3.3 Analyses of surface flow measurements

Groundwater feeds the Silala Springs Systems through a number of seepage faces and springs along the edges and underneath the wetlands and canals. The spatial distribution of the groundwater contributions, as well as the magnitude and temporal variation of the canal flows, reveal information on the combined groundwater surface water system, which is important for the subsequent assessment of the flows in the system at present and under natural conditions without the canals.

Data from the project's flow observations campaign has been analysed and evaluated in combination with the longer records from DGA's weir in Chile, just downstream of the border. The flow observation campaign was launched in May 2017 and is still ongoing. Flows are measured at many strategic locations in the system, both as simultaneous spot measurements and in 7 strategic locations as continuous flow records. The analyses are presented in Section 5 of this report and constitute an update of the flow analyses previously presented in the surface water report from July 2017 (Reference 10).

3 Climate data

Climate data from Bolivia, Chile and satellites have been analysed in order to assess the Silala climate variables and produced what is considered to be the most representative climate time series for use in the analysis and models of the Silala Springs System and its catchment. The data sources are presented in this section, including how they were compiled and combined to derive a continuous dataset. The section gives an overall summary of the analyses and findings while further details are given in Appendix A.

3.1 Precipitation data

Daily records of precipitation are available for a number of stations in and around the Silala catchment. The stations are listed in Table 1 and the locations are shown in **Error! Reference source not found.**.

As the stations in Bolivia generally only have a few years of rainfall and several gaps in the observed record, rain gauges at Inacaliri and Silala in Chile operated by Direción General de Aguas (DGA) have been used to analyse the long-term daily rainfall series for the Silala Springs Catchment. The long-term average annual rainfall at DGA-Silala is 87 mm/year compared with 98 mm/year at Inacaliri for the corresponding period from 2001-2017. The rainfall varies considerably over time at both stations with high inter-annual variation. The average rainfall at Inacaliri for the full data period from 1969-2017 is, for example, higher at 122 mm/year due to the large climate variability in the data.

Table 1 Overview of rainfall gauges in Bolivia and Chile

Station	Source	Distance from Silala (km)	Altitude (m.a.s.l)	Period	Years
Silala	Senamhi	0	4402	12/6/2012-30/9/2017	4.5
Laguna Colorada*	Senamhi	28	4278	18/9/2010-25/9/2017	6
Sol de Manana	Senamhi	53	4916	1/1/2012-11/7/2017	5.5
Siloli	DGA	2	4000	25/10/2012-1/8/2017	4.5
Inacaliri**	DGA	6	4040	1/2/1969-28/2/2017	48
Silala**	DGA	2	4305	1/1/2001-28/2/2017	17
Ollague	DGA	90	3707	1/1/1971-28/2/2017	46
Linzor	DGA	25	4100	1/11/1973-28/2/2017	43

*) Very large values in 2016/17 indicate problems with station

**) The DGA gauges, Silala & Inacaliri have identical values for longer periods. - not raw data but it looks like one station may have been gap filled with values from the other station by DGA

Figure 3 Locations of weather stations with rainfall data in Bolivia and Chile (Senamhi stations in green)

3.1.1 Annual and seasonal variation

The inter-annual variation in precipitation is very high. Figure 4 shows the annual rainfall at Inacaliri and Silala. Although the inter-annual variation may have some connection with large-scale atmospheric variations such as the El Niño, its correlation to this phenomenon does not seem to be very strong. It is noteworthy that, after 2001, the dry years seem to be drier and the annual average precipitation at Inacaliri lower than in the previous period. It has not been determined if this is an impact of a general global long-term change in climate or if it is a local decadal variation.

Most of the precipitation occurs during the austral summer months between December and March (see Figure 5). Very little precipitation is observed during the winter months from April to September. Snow has however been recorded and observed in the Silala catchment during the winter during site visits but this may not be captured adequately by the existing weather stations. The stations inspected for the analysis on the Bolivian territory are not equipped with instruments suitable for catching snow.

Daily MODIS satellite data of snow cover over the catchment from 2000 to 2017 confirm that some precipitation falls as snow during the winter months without being recorded at the precipitation gauges. While MODIS provides snow cover, it is not possible to reliably estimate snow depth or snow equivalent from these satellite data alone but they indicate that the gauged precipitation underestimates total precipitation. Further details are provided in Appendix A.

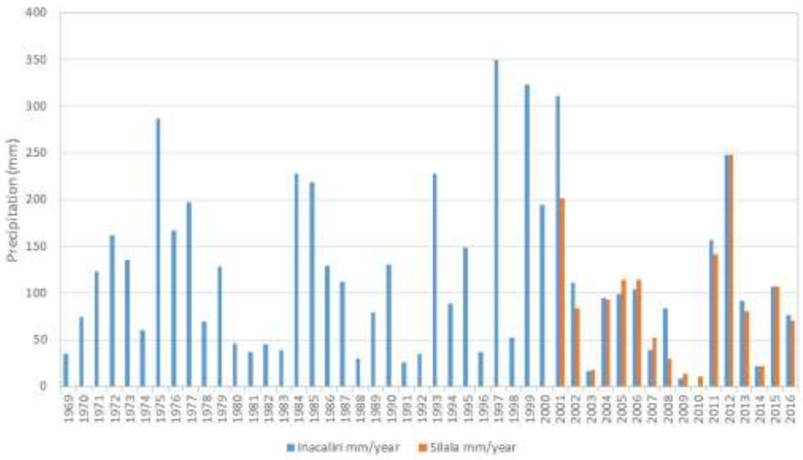


Figure 4 Annual precipitation at the Inacaliri and Silala gauges

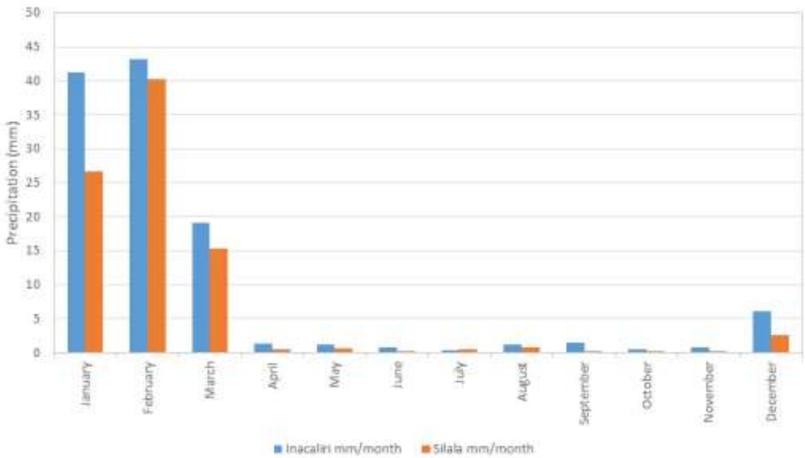


Figure 5 Monthly average precipitation at the Inacaliri (1969-2016) and Silala gauges (2001-2016)

3.1.2 Spatial distribution of rainfall

Rainfall in the area varies with altitude. To establish a reliable and longer data set of spatially distributed rainfall for the Silala catchment, this relationship was analysed using a combination of local ground stations and gridded long-term daily satellite precipitation data (CHIRPS) with a 5-kilometer resolution.

Based on the CHIRPS data within and close to the Silala catchment, a linear relation between precipitation and altitude has be established (see Figure 6). The established altitude relation was combined with the long-term precipitation series from the local weather station, Inacaliri, to estimate the spatial distribution of precipitation across the basin over time. This combination of local ground station data and the altitude variation from the local CHIRPS data provides the best estimate of the daily precipitation over the catchment. The data however does not capture snow events and may therefore underestimate rainfall in some years. The average annual catchment rainfall obtained from the series is 137 mm/year. For comparison, the average annual precipitation, based directly on area weighed CHIRPS data for the Silala catchment, is 146 mm/year. These estimates are of the same order of magnitude as the value of 165 mm/year as derived by Muñoz et. al. (Reference 11) for a smaller Silala catchment but considerably higher than previous estimates around 60 mm/year, which were based on old data from Laguna Colorada.

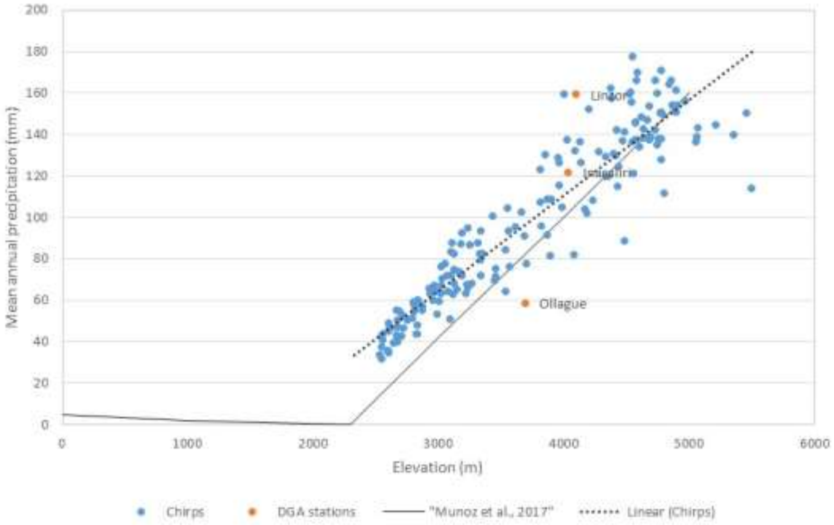


Figure 6 Regional annual average precipitation as a function of altitude based on CHIRPS data from 1981-2017 compared with station data at Silala, Linzor and Ollague and precipitation-elevation relationship derived by Muñoz et al., 2017

3.2 Evapotranspiration

Potential evapotranspiration (Et_0) records have been estimated using the Penman-Monteith equation, at three weather stations close to the site: Silala, Laguna Colorada and Sol de Manana. The method is recognized worldwide for reliable approximations to Et_0 in a wide range of locations and climates.

Figure 7 shows the potential evapotranspiration estimates for the three locations. The average annual Et_0 ranges from 1268 mm/year at Sol de Manana to 1940 mm/year at Laguna Colorada with around 1472 mm/year at Silala. The derived series correspond well with the range of Et_0 from five nearby Chilean DGA stations also shown in the figure.

The altitude dependency of the potential evaporation in the area was found to be negligible. Therefore, the potential evaporation rate is assumed to be uniform over the Silala catchment area. The Et_0 record from the Silala station is assumed to best represent the Et_0 in the catchment and is therefore used in the water balance model. The uncertainty in Et_0 directly affects the range of simulated groundwater recharge. In order to take the large differences between the series from Laguna Colorada, Silala and Sol de Mañana into account, sensitivity analyses have been carried using data from each station as input for the model.

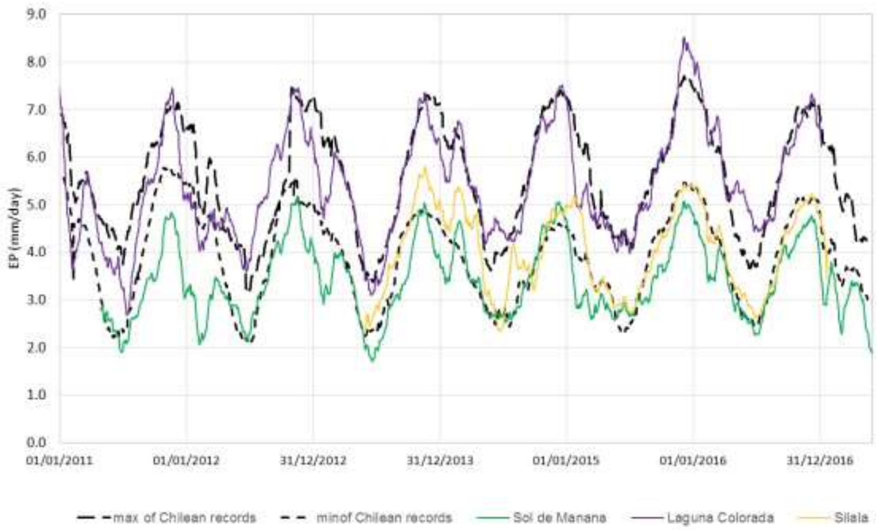


Figure 7 FAO reference Et_0 for Silala, Laguna Colorada and Sol de Manana (30 day moving averages) compared with the range (min to max daly values) of 7 nearby Stations from DGA Chile (Reference 10)

3.3 Temperature

Snowfall has been observed on higher grounds in the catchment also out of the austral winter season. To include the influence of snow on recharge, long-term spatially distributed temperature series with an hourly temporal resolution are required.

Based on the daily time series records from Inacaliri, Linzor, Silala and Laguna Colorada, a long-term time series of daily temperature for the period 1969-2017 has been constructed. A temperature lapse rate of -7.1 °C/km has been derived from these stations, which are all located within or close to the catchment. Hourly variation in the long-term series has been generated from the hourly Silala records.

3.4 Silala climate characteristics and conclusions

Assessment of the recharge conditions in the Silala catchment as well as the detailed analyses of the impact of the manmade canals in the Silala Springs nearfield requires consistent and reliable climate data input, in the form of multi-year time series of precipitation, reference evapotranspiration (Et_0) and temperature.

These time series have been determined specifically for the Silala catchment by combining *local* ground based observations, from within the catchment or very close to it, with the terrain information of the catchment. Where local ground based data have been insufficient to construct a reliable spatial variation satellite, observations of the *local* area have been used.

We find that this combination of ground based and remote sensing observations of the local area gives more reliable estimates for the Silala catchment than trying to correlate observations over long distances for other catchments with different characteristics as presented by Muñoz et al. (Reference 11).

Significant uncertainty in the climate series has been addressed in the water balance model in section 4 by sensitivity runs to assess the range of key model results.

A detailed description of climate data and the generation of the required model input is found in Appendix A.

4 Water balance and groundwater recharge

The Silala Springs and canal flow system is fed almost entirely by groundwater. Groundwater from the upstream catchment area (Far Field) is continuously discharging through the Silala Springs and canals in the Near Field and probably also as trans-border groundwater flow.

It is not clear if the discharge through the Silala Springs System is sustained by:

1. The upstream aquifers being recharged by infiltration of rainfall or melting snow reflecting current climatic conditions,
2. Solely by a gradual depletion of fossil aquifer storage or
3. A combination of 1. and 2.

Groundwater isotope analysis suggests that ancient, fossil water is part of the water discharged at the springs.

The purpose of the water balance analysis is to improve the understanding of the hydrological processes in the catchment and provide an independent estimate of groundwater age to backup this understanding and test if some of the above three explanations of the origin of the Silala flows may be eliminated.

4.1 Recharge estimation approach

A recharge and water balance assessment has been carried out for the approximate upstream catchment of the Silala wetlands. As the hydrogeological data in the area are limited, a conceptual approach has been adopted. It is not possible, with the data available, to determine the source of groundwater but based on generalised climate data, soil properties and overall geological features, the results may provide an indication of whether spring flows at Silala can be explained by a plausible range of recharge rates within the topographical catchment.

Groundwater recharge within the Silala area is driven by short-term precipitation events scattered in time and often separated by long dry periods. To estimate the sustainability of such desert recharge with high variability requires long-term dynamic simulation of the infiltration and evaporation processes, with a daily or finer temporal resolution in order to produce a reliable water balance. This approach constitutes a far better and more detailed analysis than previous simpler water balances for the area such as Reference12, which compares only the average annual precipitation, potential evapotranspiration and surface water canal discharge from Silala.

The topography, soil types and depths, as well as representative precipitation, potential evaporation and temperature are used as input to a distributed hydrological model to produce a water balance for the contributing catchment under historic conditions. A first, rough assessment of travel times in the aquifers is made to ascertain to which extent these match the age of water determined from field measurements.

Dynamic rates of actual evaporation and groundwater recharge are estimated using the distributed integrated flow modelling system MIKE SHE (Reference 14). MIKE SHE is a dynamic flow modelling system, which couples advanced soil moisture and evapotranspiration models with unsaturated zone and groundwater models for describing evaporation from both plants and soils, and recharge/infiltration to the underlying aquifers. The modelling system is described in detail in Appendix B.

4.2 Water balance assumptions

For the catchment upstream of the Silala Springs (the Far Field), the important processes for estimating groundwater recharge are soil evaporation, infiltration and snow processes. Overland processes may play a small role in parts of the catchment, for example on the volcanoes. However, since the areas that could generate overland flow are small as compared to the total catchment area and since the surface runoff seems to re-infiltrate in the foothills of the volcanoes, the overland flow component is expected to be of limited importance for recharge estimation. A number of generalized assumptions, listed below, have been made due to limited data availability and information in the topographic catchment. These assumptions are described in more detail in Appendix B.

- There are no significant surface water bodies or surface water flows within the catchment area.
- There is little or no vegetation to support any significant potential transpiration, i.e. evaporation losses are assumed to be in the form of soil evaporation and a small amount from sublimation from snow at high altitude
- The catchment area (232 km^2) is delineated from the NASA topographical model assuming that the surface water and groundwater catchments coincide
- The soils are generally coarse (sands or gravels), i.e. they are free draining with high permeability and a low capillary rise potential

4.3 Water balance model setup

For estimation of groundwater recharge and water balances for the Silala basin, a MIKE SHE unsaturated zone model was set up. The model has been set up using a grid size of 200 m resulting in a total of 5717 unsaturated zone columns for the catchment. Free drainage was assumed by fixing the water table at a constant depth of 3 m below ground.

Inputs consist of 48 years of daily and hourly climate time series for a period from 1969-2017 (described in section 3 and Appendix A) and estimates of soil properties were based on general literature values for sand and gravel, as no measurements of soil properties are available from the catchment at the time of producing this report. Details of the model setup can be found in Appendix B.

4.4 Water balance results and uncertainty

Based on the model results, the annual average actual evaporation over 48 years has been estimated at approximately 81 mm/year (6% of potential evapotranspiration) with a recharge rate of 56 mm/year corresponding to an outflow rate from the upper catchment of 412 l/s.

Some groundwater flow is expected to bypass the wetland, both below the sediments and in the deeper Ignimbrite aquifer. An old observation borehole in the Silala ravine, located 1.8 km downstream of the border in Chile (Reference 13), indicates artesian conditions and yields a constant rate of 90 l/s (without pumping). It seems plausible that the overall groundwater recharge is somewhat higher than the stream flow and borehole yields combined. Therefore, when compared to the recorded average stream flow at the Silala gauge of 160-210 l/s, our model-based estimate seems realistic.

In order to understand the importance of the model input parameters for the recharge estimates, a sensitivity analysis described in detail in Appendix B was undertaken. The sensitivity analysis looked at the effects of varying soil parameters and potential evapotranspiration rates, as they are associated with high uncertainty. It is clear from the analysis that both soil parameters and evapotranspiration rates have a significant impact on recharge rates. Using potential evapotranspiration from other stations at Laguna Colorada and Sol de Manana has an impact on total recharge in the order of -/+ 20-30%. Soil hydraulic conductivity uncertainty could affect recharge by -/+ 20%. Figure 8 shows daily rainfall, potential evapotranspiration, simulated actual evaporation and estimated recharge over time using the potential evapotranspiration rates from the Silala weather station. This illustrates how high intensity rainfall exceeds daily potential evapotranspiration leading to small amounts of occasional groundwater recharge in Silala. It also shows how actual evaporation and recharge are highly dependent on the variation of daily potential evapotranspiration during the year.

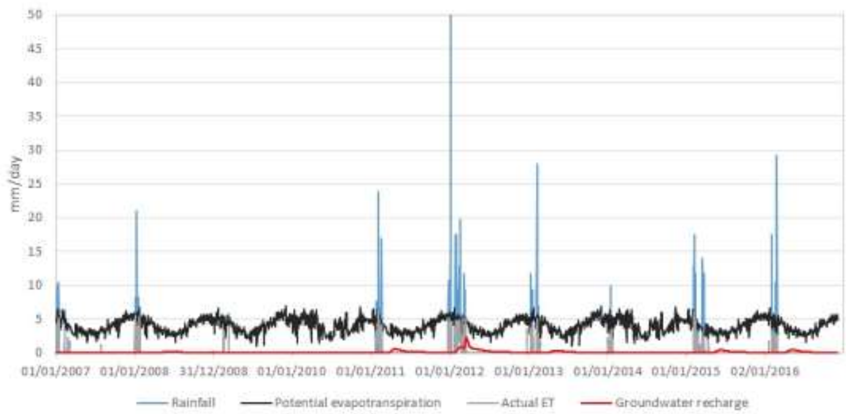


Figure 8 Daily rainfall, potential evapotranspiration and recharge for 2016 3 km north of the Silala wetlands

Based on the sensitivity analysis, the catchment recharge is estimated to be in the range 45-74 mm/year corresponding to 330-550 l/sec. This is consistent with measured flows in the Silala wetlands and the current knowledge of subsurface outflows into Chile. Actual recharge rates could potentially be higher as satellite maps of snow cover indicate that some snow events in the austral winter are not captured in the rainfall station data. Overall, the analysis indicates that it is plausible to assume that the current flows in the Silala Springs system may be sustained by groundwater recharge from the topographic catchment.

4.5 Groundwater flow and age

Groundwater age has been investigated using an extended version of the MIKE SHE integrated unsaturated zone groundwater model with particle tracking. The purpose of the particle tracking analysis was to estimate likely groundwater age of the water recharging the Silala canals and wetlands assuming inflows are from the topographic catchment. This will help ascertain whether the age of the water supports the findings from isotope analysis of water, which suggests that part of the spring water in Silala is fossil water.

The unsaturated model used for recharge estimation was modified for the analysis to include a relatively simple three-layer geological model comprising a lava layer at the top, overlying two Ignimbrite layers. Based on borehole information from the wetland area, the Ignimbrite aquifer was divided into a fractured high permeable top layer with a thickness of 20 m and a lower less permeable layer with a thickness of 250 m. The geological model delineation is described in Appendix B and a geological profile is shown in Figure 9.

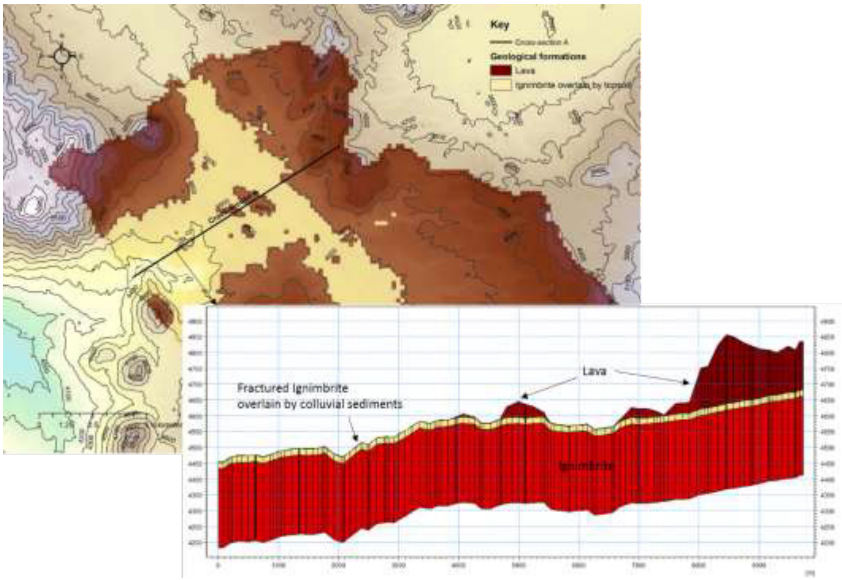


Figure 9 Geological model including cross-section from MIKE SHE model

The particle tracking analysis serves to estimate the origin and travel time of water recharging the Silala canal and springs system. Particles have been introduced at the upper groundwater layer, corresponding to infiltrating water recharging the aquifer. These particles are then displaced according to the simulated flow field until they reach the Silala Near Field area, where the groundwater discharges to the surface. Figure 10 shows the simulated potential head and groundwater flow vectors of the ignimbrite.

The origin, destination and travel time of each particle is registered. The simulated travel time is a proxy of groundwater age. In the Silala Far Field area, the depth to the groundwater table can be up to several hundred meters, especially at higher altitudes. A measure of water age from precipitation on the surface to discharge to the springs would thus have to consider both travel time through the unsaturated zone and through the groundwater aquifer.

Figure 11 shows groundwater age in the catchment based on the particle tracking model. The model results indicate an average groundwater age of approximately 900 years. The age varies with travel times from as little as 25 years in the vicinity of the wetland to up to 4,000 years for water coming from the far end of the catchment. The majority of the water is estimated to be between 400-1,000 years old (see Figure 12) based on groundwater flow transport time alone. Travel time in the unsaturated zone will add to the overall water age, particularly in the areas with volcanoes where the water table is assumed to be as deep as 1,000 m. The travel time in the unsaturated zone has been estimated based on a separate simple transport model run, with a tracer source with a constant concentration applied at the top of a number of unsaturated zone columns in the catchment. This provides a rough estimate of travel time through the unsaturated zone and using this approach, the travel time has been estimated to be between 0-50 years close to the wetland up to over 1,000 years below the volcanoes.

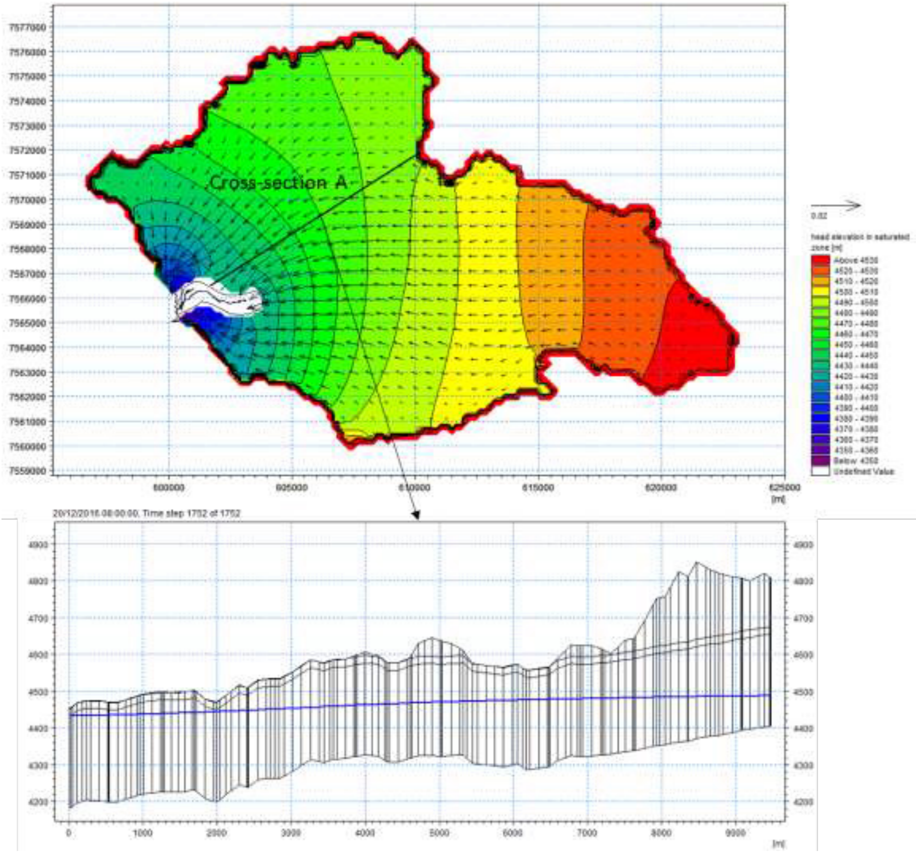


Figure 10 Simulated potential head of the ignimbrite aquifer (above) and in cross section (below)

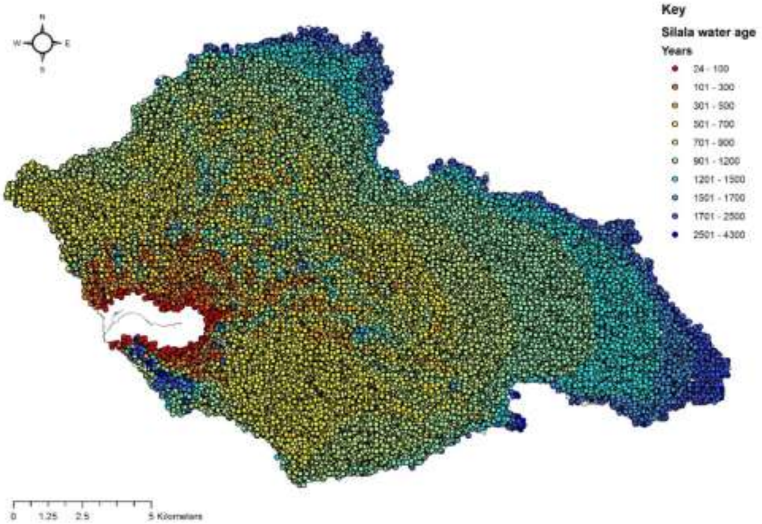


Figure 11 Simulated map of particle travel time and groundwater age

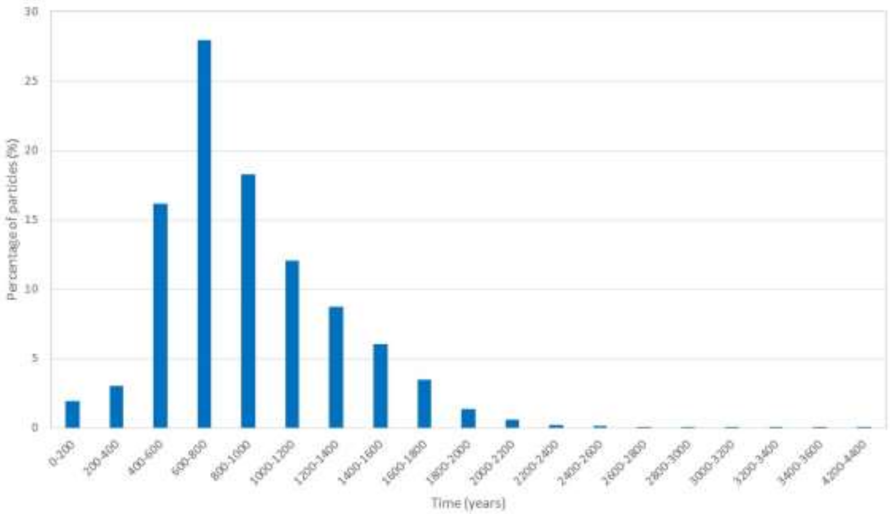


Figure 12 Particle age distribution

4.6 Water balance conclusions

Recharge estimates and water balances have been produced using the best available data for the Silala catchment. The results should be viewed as approximate and should not be interpreted as exact figures due to the scarcity of information on climate, soils and geology in the area. The main findings are summarized below:

- Average recharge for the period 1969-2017 has been estimated to 56 mm/year, which corresponds to a mean groundwater discharge to the Silala Near Field area of approximately 400 l/s. Compared to the recorded average stream flow at the Silala gauge of 160-210 l/s, this seems realistic as some groundwater flow is expected to bypass the wetland, both below the sediments and in the deeper Ignimbrite aquifer.
- Sensitivity runs considering key parameter and inputs indicate a range of recharge of 330-550 l/s. It shows that the recharge by infiltration of precipitation within the topographical catchment can provide sufficient groundwater flow to maintain discharges into the canal and springs system.
- The climate and recharge rate is highly variable with respect to both temporal and spatial distribution
- Overall, the analysis indicates that it is plausible to assume that the flows in the Silala Springs System may be sustained by groundwater recharge from the topographic catchment.
- A particle tracking analysis with the simulated groundwater flow field suggests variable groundwater travel times of up to 4,000 years, with a mean value of 900 years. The simulated travel time is a proxy of groundwater age.
- The age estimates do not include travel time of infiltrating water through the locally very deep unsaturated soil column. Based on average vertical travel time from a simple transport model run with a tracer and simulated depths to the groundwater table, the travel time has been estimated to range from 5-50 years where the groundwater table is closest to the surface by the wetland, to up to over a thousand years with the deepest groundwater table.
- Overall, the analysis confirms a high water age of over 1,000 years as compared to previous Isotope datings of 1,000-10,000 years.
- Given the lack of field data from the Silala Far Field area, the uncertainty and variability of climate data and the model sensitivity, these results should be viewed as indicative only.

A detailed description of the water balances and groundwater age calculations is found in Appendix B.

5 Surface water flow measurements

Groundwater continuously discharges in Silala as surface water through seepage faces and springs. In the present situation, the surface flow is collected by the artificial drainage and canal network and is conveyed through the manmade main canal across the border to Chile.

A key objective of the project is to quantify flows both under current conditions and under natural conditions assuming that the canals are closed and removed. A canal flow measurement campaign has been carried out during May-September 2017. Proven and reliable measurement methods have been applied in order to reduce uncertainties and provide a solid basis for analysing the current Silala surface water flows.

The surface flow measurements are analysed with the purpose of establishing:

- The canal flow rate at the permanent border site including mean rates and temporal variation
- The spatial distribution of canal flows and inflows from the wetlands to the border during the May-September field campaign

- The temporal variation of surface water flows during the May-September field campaign
- Flow measurement and water balance consistency checks
- Interpretation of flow measurement data in the context of a conceptual hydrological model of the Silala near field area

The distributed flow pattern contains information on sub-system contributions to canal flow, which is essential to the understanding, description and simulation of the surface hydrological processes. In later stages of the project, the surface water information will be combined with hydrogeological information collected as part of the groundwater field survey program to form an integrated surface water – groundwater model.

A surface flow measurement program planned by DIREMAR, SENAMHI and DHI was later adjusted during field inspections to pin down the best suitable locations (see Reference 6). SENAMHI has been contracted by DIREMAR to carry out the surface flow measurement program. The surface water flow measurement program was initiated in May 2017. The measurements include simultaneous canal and spring flow measurements, continuous flow records collected at flumes installed during 2017 and the permanent flume flows recorded close to the Bolivian-Chilean border.

Figure 13 shows the flow measurement locations including springs (Ojo de Agua), simultaneous flow measurement locations (S-1 – S-21) and continuous flume flow gauges (C-1 – C-7). Prior to the establishment of the flumes, simultaneous flow measurements have been carried out at both S-1 – S-21 locations and at the locations C-1 – C7 where six new flumes were later installed.

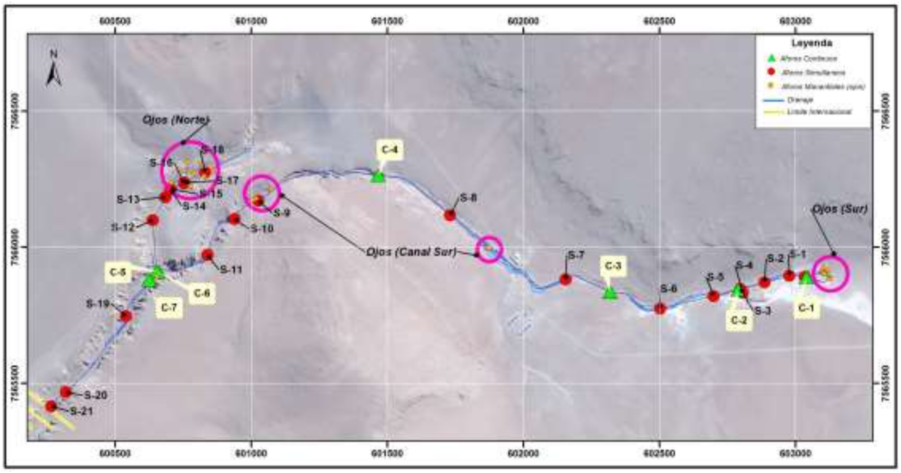


Figure 13 Overview of flow measurement locations (SENAMHI)

A preliminary assessment of measured flows was carried out as part of the Surface Water Report (see Reference 10). In the following sections, the flow data provided by the SENAMHI for the period May-September 2017 are updated, presented and analysed along with the permanent flumes flow records at the Bolivian and the Chilean side of the border.

5.1 Simultaneous canal flow data

The simultaneous flow measurement program is designed to provide a snapshot of flows in many points of the canal network. The measurements have been carried out ten times. Initially at a bi-weekly and later at a monthly frequency, covering all locations within 2-3 days. Micro-propeller measurements in multiple points of the cross section provide a cross-sectional velocity profile, which is integrated to calculate the flow. The profile measurements have been carried out twice at each location to verify results and, if necessary, to take prompt on-site action to prevent errors.

5.2 Simultaneous spring flow data

The program of simultaneous spring-flow measurements was designed to assess flow rates at individual springs and the total spring flow contribution of sub-systems. By comparing measured spring flows and canal flows, a measure of diffuse canal inflows has been derived. Diffuse inflows describe non-point inflows, e.g. seepage faces or groundwater-canal flow exchange.

Spring flows have been measured at the discrete points of spring discharge (Ojo de Agua), which have been mapped across the entire Silala Near Field system. They include free flowing exposed springs, exposed springs with little or no flow and springs covered by soil and visible only by wet soil seepage faces. The first type is suitable for measurement of flow rates which has been carried out by collecting the spring discharge and deriving the flow rate from volume and time. In January 2017, flow rates were measured at the majority of springs while the data collected from May 2017 and onwards only includes 20 high-flow springs approximately. Unfortunately, the spring locations selected for measurement and the applied spring-naming convention are not consistent for all of the 10 measurement rounds during May-September 2017. This means that measured flow cannot be referred to the identical same locations.

Spring flow measurements were carried out for two days. In January 2017, flows at 64 springs were measured, with flow rates in the range of 0 – 11.9 l/s. In the Southern wetland upstream of station C3, 21 springs have been mapped and measured. The total spring flow adds up to approximately 40 l/s with an additional 15 l/s along the lower Southern Canal reach. On the Northern Canal, spring flows adding up to 46 l/s have been recorded. For the entire Silala Near Field area, the sum of spring flows is approximately 100 l/s compared to downstream canal flow measurements in the range of 160-200 l/s, meaning that 60 -100 l/s enters the canal, not as spring point sources, but as diffuse sources.

The canal and springs flow measurements indicate that the Silala canal system receives considerable lateral inflows, which are not accounted for by the spring flow measurements. The canal system gains water from both diffuse sources and spring point discharges, while potentially losing water due to diversion to wetlands, seepage and evapotranspiration. It is not possible to close the canal water balance from the flow measurements but the difference between measured canal flow and measured spring flows indicates a magnitude of diffuse inflows

A total of ten simultaneous flow measurements in 26 locations were carried during May-September 2017. Figure 16 is a longitudinal flow profile along the Southern Canal with measurements from 10 different dates. The flow increases from approximately 20 l/s at the Southern wetland to C-5 at the confluence between the Northern and Southern Canal. The measured simultaneous flow rates are approximately constant in time. Simultaneous flow data are also presented in Figure 17 to Figure 19 and in Appendix C.

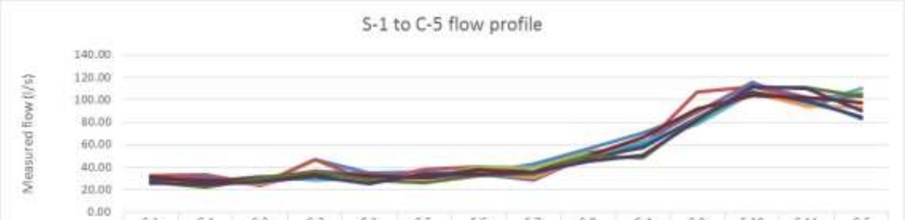
Table 2 shows approximate diffuse net inflows by section of the Silala Canal estimated as the difference between measured mean canal flows and springs flows. At the upstream reaches of the Southern Canal (C-1 – C-3), the measured spring flows are almost equal to the measured canal flow, which implies limited diffuse inflows. However, on the lower section (C4 – C5) where only a few springs have been mapped, a large diffuse inflow indicates significant groundwater discharge to the Silala Canal in the upper canyon/ravine section.

On the Northern Canal, the sum of spring flows accounts for 75-80 % of the canal flow, leaving 20-25 % for diffuse lateral net inflow. Similarly, derived total diffuse net inflows for the Southern Canal are expected to be in the order of 35-45 %

The measurements of simultaneous canal flow and spring flow are associated with uncertainty. The spring flow measurement method is coarse and relies on capturing all of the spring flow within a given time interval, preventing any bypass flow. Measurements of canal flows suggest that the groundwater discharge is approximately constant. Consequently, spring flows should accordingly be approximately constant. However, for the most frequently measured spring, the flows vary between ± 40 % of the average value. The highest relative deviations are found for springs with low flow rates. The variation in measured flow is not consistent across the springs, suggesting that the variations are caused by measurement uncertainty and not hydrological temporal variations driven by, for example, climate.

Section	Measured spring flow (l/s)	Measured Canal Flow (l/s)	Difference, canal-springs (l/s)
C1, springs 1-12 (Zone 2)	23.8	27.8	4.0
C2, springs 1-20 (Zone 2)	41.2	36.7	-4.5
C3, springs 1-21 (Zone 2)	41.2	38.0	-3.2
C4, springs 1-22 (Zone 3)	45.2	59.5	14.3
C5, springs 1-32 (Zone 4)	56.9	97.0	40.1
C6, springs 33-64 (Zone 1)	46.1	56.9	10.8
C5+C6, springs 1-64	103.0	154.0	51.0

Table 2 Canal flows by section, accumulated upstream spring inflows and derived diffuse inflows



	S-1	C-1	S-2	C-2	S-3	S-5	S-6	S-7	S-8	C-4	S-9	S-10	S-11	C-5
May 6-7	25.80	28.35	24.45	47.05	34.95	36.10	34.75	42.95	56.40	70.35	88.45	115.40	96.95	103.65
May 12-14	33.00	33.60	24.50	46.90	28.10	38.30	40.60	35.70	53.10	58.80	107.05	111.65	101.05	105.75
May 15-17	32.50		28.10		31.05	30.30	40.25	39.70	53.10			114.95		
May 27-30	29.05	31.65	23.75	36.90	34.30	30.45	34.35	28.90	49.95	61.90	89.35	113.80	102.15	83.45
June 3-4	31.55	26.90	31.80	28.85	30.05	31.00	36.85	33.50	51.05	62.50	78.65	106.30	95.45	110.30
June 12-14	29.10	27.55	25.75	33.20		32.90	35.20	31.00	49.05	57.35	83.65	106.85	94.55	93.60
June 20-21	29.15	28.6	27.8	33.65	32.25	30.9	37.85	34.1	47.8	58.3	83.75	107.4	98.75	84.8
July 24-25	31.75	26.9	30.9	35.3	32.85	29.9	37.75	35.5	50.15	66.6	92.3	104	102.1	97.65
Aug 25-27	27.45	22.5	30.45	37	28.5	26.4	32.55	33.9	49.85	48.65	83.7	110.6	111.25	103.45
Sep 25-27	26.45	24.45	26.95	31.5	25.35	34.45	33.45	36.15	45.05	50.7	81.65	112.15	109.8	90.3

Figure 14 Longitudinal simultaneous flow profile (Southern Canal)

5.3 Continuous flow data of installed flumes

During May-June 2017, SENAMHI installed six new flumes and V-notch weirs, in accordance with the Final Field Survey Specifications (Reference 6). Once installed, the weirs were calibrated in the field to derive rating curves which describe the relation between water level and flow. Calibration was performed by controlling upstream flows. A number of corresponding values of flow and water level were measured, covering the low to normal flow range at each site. For the low flow ranges, the flow was calculated by collecting the volume in a container for a period of time. For the higher flow ranges, micro propeller measurements were used. The rating curves were approximated by curve fitting to the set of water level and flow data.

All of the weirs are equipped with continuous, automated pressure sensors, which provide continuous records of high temporal resolution

The purpose of this part of the flow observation campaign is to determine the flow rate at strategic locations in the canals of the Silala Springs System as exactly as possible, and therefore:

1. Reveal the temporal variation of the flow rate
2. Evaluate the daily flow variations and detect possible short-term impact of precipitation event. The daily variations are important to evaluate the simultaneous observation taken at more locations and may also open for an independent, although not isolated, evaluation of the evaporation rates
3. Ease the observation of possible surface water impacts from the planned borehole pump tests.

The resulting time series cover the period July –Sept 2017. All series shows a high base flow level superimposed with a smaller periodic daily variation peaking around midday.

Unfortunately, the base flow in all series exhibits abrupt jumps at certain dates and sometimes trends in the intermediate periods. None of these variations can be assigned to climatic events and must therefore be due to malfunctions of the equipment.

Although the daily flow variations may play a role in the uncertainty of the simultaneous observations, they are too small to explain the spread in the simultaneous measurements at the locations. The flows peaks at midday at all stations and daily variations can therefore not be due to evaporation losses that peaks at the same time. Hence, the daily variation is assigned to freezing and thawing of the water in the wetlands.

The results from the two two-week periods, during which the data are most consistent, confirm contributions from the Southern and Northern wetlands to be in approximately 60% and 40% of the confluence flow, respectively and that the flow contribution in the ravine between C4 and C5 is a significant part of the flow at the confluence.

5.4 Permanent Bolivian and Chilean flume flow records

Long-term time series of the flows in the Silala primary canal are available at two locations, one at the old siltation chambers in Bolivia around 700m upstream of the border and the other from Chile’s Direción General Del Agua (DGA), just downstream of the border on the Chilean side. Given the locations and proximity (less than 1 km) of the permanent flumes, no significant differences in canal flows are expected and the same level of flow should be found in both of the two flow time series.

At the Bolivian gauging site, a flume is constructed in a rectangular concrete trench constructed along the old siltation chambers and equipped with a V-notch and automatic (electronic) water level registration by floater with resolution around one mm. Hence, the station should be almost ideal for measuring the narrow flow range of the canal. Water levels are measured both manually (two times a day) by the military personnel and automatically (hourly). Each of the two water level series has been converted to flows by a formula relating specific water level observations to flows. Particularly for V-notch weirs, the standard formula is considered accurate within 3-5 %.

Both manual and automatic water level readings and corresponding flow records exist. A comparison of measured flow time series covering the period August 2013- August 2017 is shown in Figure 15. The series is characterised by a constant base flow of 150-200 l/s, which clearly indicates that the canal is fed almost entirely by groundwater. However, frequent abrupt changes in the calculated flows, sometimes from one time step to the next, are also observed. The rapid fluctuations in flow originate from similar changes in the water level observations. It is, in general, not been possible to relate them to climatic conditions, runoff events or seasonality. It seems likely that these fluctuations must be attributed to uncertainty in water level observations, due to e.g. jamming of the float or sediment deposition in the stilling canal. The automatically gauged water levels include sudden jumps of 0.5 cm or 1 cm although the resolution of the instrument is 1 mm. This also points out to possible errors in the automated sensor registration. In spite of the near ideal flow gauge conditions provided by the weir, the uncertainty is therefore substantial, in the order of 25-30 % of the flow rate.

The Chilean flow time series also includes abrupt changes in flow. The Chilean flow series are generally approximately 15-25 l/s lower than the Bolivian series. A difference in flow of 40-50 l/s is seen in the most recent data from September 2017 (Figure 16). It seems unlikely that local canal losses along a generally gaining canal could explain the recorded differences in flow. Although both series shows significant variations over time, 125-225 l/s for the Chilean series and 160-210 l/s for the shorter Bolivian series, neither shows clear sign of seasonality or a direct correlation with local rainfall. Hence, the variation must be assigned to uncertainty in the measurements.

Figure 15 Long-term series of measured Silala Canal flows close to border, 2013-2017 Blue curve: manual readings C7, yellow curve: automatic floater instrument C7, turquoise curve: daily average from the new pressure sensor C7; red curve daily data from DGA's Siloli station just downstream of the border.

Figure 16 Long-term series of measured Silala Canal flows close to border, May-September 2017. Blue curve: manual readings C7, yellow curve: automatic floater instrument C7, turquoise curve: daily average from the new pressure sensor C7; red curve daily data from DGA's Siloli station just downstream of the border.

5.5 Comparison and analysis of flow data

Figure 17 and Figure 18 show simultaneous flow measurement plotted respectively for the Southern and Northern canal elevation profile, The left axis shows elevations (m) of the canal and the right axis shows flow rates (l/s). In addition, the elevations of springs adjacent to the canal have been marked.

On the Southern canal branch (Figure 17), the mean flow in the Southern wetland increases from 30 l/s upstream at S-1 to 36 l/s downstream at S-6. On the upper canal reaches, the slope is almost constant and from S-6 to C-4, the canal flow increases at an approximately steady rate reaching 60 l/s at C-4. However, from C-4 to S-10, in the upper reach of the ravine, the surface elevation drops and the canal bed slope increases. According to the measurements, a significant inflow to the canal, in the order of 50 l/s, occurs along this section. Since only a few springs have been recorded, the majority of the canal flow increase is due to groundwater discharges through seepage entering the deepest section of the ravine as diffuse discharge to the canal. The spring water level elevations have been plotted as an indication of the groundwater table elevation along the canal. Between S-9 and S-10, the spring elevations are significantly above the canal level. This is indicative of a relatively high water level gradient from the groundwater towards the canal and consistent with the high inflow rates recorded.

The results suggest that the topography is a main controlling factor of groundwater discharges to the canal. As the surface elevations drop, the groundwater table is forced closer to the surface, where it exchanges flow with springs, typically aligned with fractures, or directly to the canal. Larger scale hydrogeological features, such as faults, may play a role with respect to canal discharge patterns. On the steep canal section from S-10 to C-5, the mean flow decreases by approximately 10 l/s, which is attributed to either canal losses or measurement errors.

On the Northern Canal branch (Figure 18), the slope is less variable. The increase in mean flow is relatively high from S-18 to S-13, 5 l/s to 45 l/s. This section is characterized by a dense drainage network distributed across the width of the wetland. This is also the section where the vast majority of the springs of the Northern wetland discharge into the drainage network. From S-13 to C-6, close to the confluence between the Southern and the Northern canals, the wetland is narrowly constrained by the ravine, with an approximately uniform canal bed slope. In this section, only a few springs have been mapped and the mean flow rate increases from 45 l/s to 57 l/s along a distance of approximately 300 m.

Figure 19 shows a map of canal flows and canal net inflows in the Silala Near Field area based on mean simultaneous flow measurements. This figure shows the flow at the continuous measurements stations (C1 – C7), the inflow between the stations and the percentage of flow relative to the downstream measurements, assuming that C7 flow equals the sum of C5 and C6 flows. Approximately 63 % of C-7 flows originate from the Southern canal and wetlands. Most of it enters the canal on the C-3 – C-5 reach. The reach has relatively few mapped springs and the gaining canal flow must thus be attributed to either diffuse seepage sources or groundwater discharging directly through the base of the canal in the deepest section of the canyon. Although not explicitly shown in the map, losses occur on each reach, e.g. by evapotranspiration or canal seepage to the adjacent riparian area.

Figure 17 Southern canal profile (S-1 to C-5) showing canal elevation (m) on the Y-axis and canal chainage (m) on the X-axis

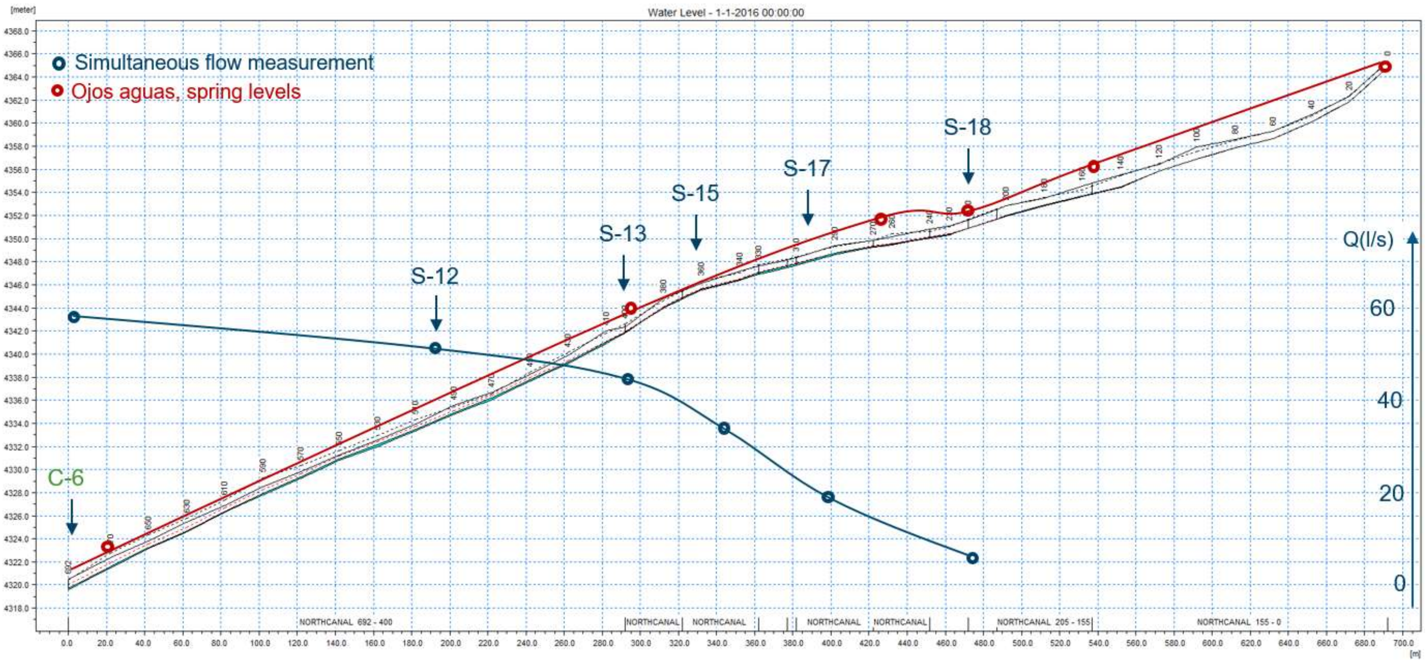


Figure 18 Northern canal profile (S-18 to C-6) showing canal elevation (m) on the Y-axis and canal chainage (m) on the X-axis

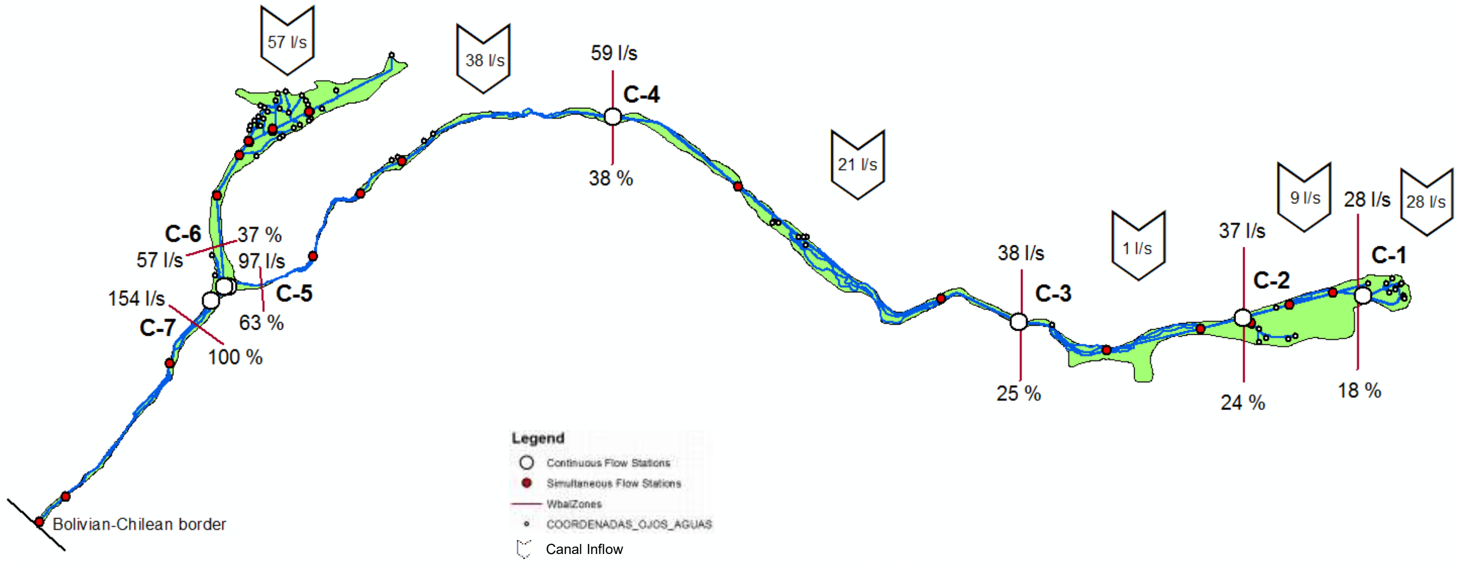


Figure 19 Mapping of flows and net inflows based on simultaneous mean canal flow measurements (in l/s)

5.6 Data consistency and uncertainty

The canal flows have been measured for different periods, at different locations and by different methods. Comparison of the long-term flow records from the permanent flumes in Bolivia and Chile respectively show significant differences in both the mean flow levels and temporal variation.

The shorter term continuous and simultaneous flow measurements carried out in January-September 2017 exhibit inconsistencies both at the individual gauging points but also when cross comparing the data. Figure 20 shows C-5, C-6 and C-7 flow measurements in July-September 2017. The measured continuous flows are significantly higher than the simultaneous flow measurements for all three locations and there are unexplained, but significant differences between the sum of C5 and C6 versus C-7 flows.

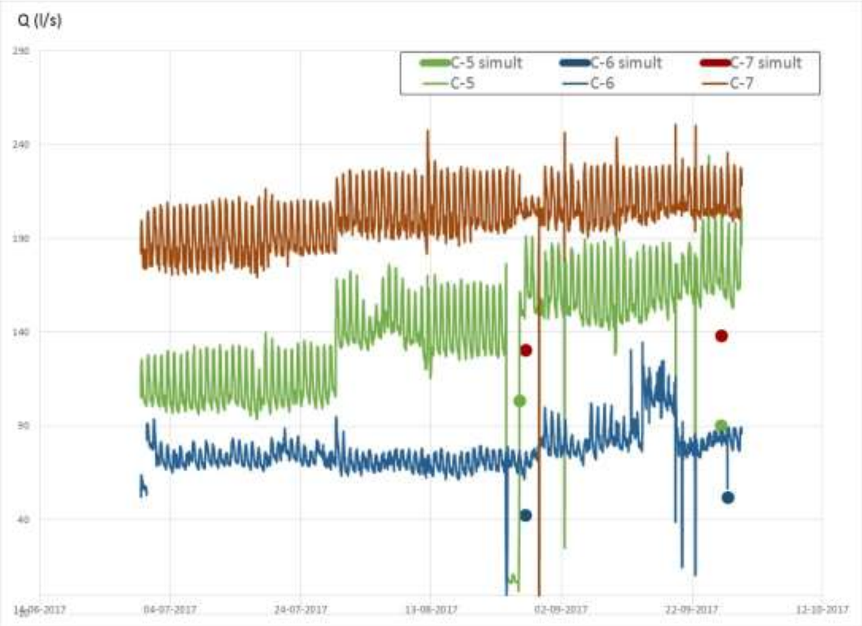


Figure 20 Continuous (shown as lines) and simultaneous (shown as circles) flow measurement data, July-September 2017

5.7 Conclusions on the measured flow data

- The long-term time series from the Bolivian and Chilean permanent flumes show mean flow rates around 160 l/s – 210 l/s with differences between the locations of 15-25 l/s. The temporal variations in flow at both locations are generally not mutually correlated or correlated with seasons, climate or runoff events.

- The flow data collected by SENAMHI during May-September 2017, including both simultaneous and continuous flow measurements, show approximately constant flow rates.
- The measured flows have been used to calculate the spatial distribution of inflows. The spring inflows to the Northern and Southern wetland account for roughly 60 % of the total canal flow at C-7. Diffuse inflows, in particular along the upper ravine reach (C-4 – C-5) of the Southern Canal, account for the remaining 40 %.
- The comparison of flow measurements show significant differences and deviations, under what would be expected to be well-controlled flume measurements. The additional measurements carried out in January-September 2017 have not narrowed the flow range in the downstream reach between C-7 and the border. Despite independent continuous and simultaneous flow measurements on the Chilean and Bolivian side of the border, the actual canal flow remains uncertain (160 -210 l/s).
- Smaller periodic daily flow variations have been detected at all of the seven continuous gauging sites during July-Sept 2017 (winter period). They cannot be caused by wetland evaporation but are likely the effect of freezing/melting of the water in the wetlands.

A more detailed description of flow data and the flow data analyses is found in Appendix C.

6 Summary and conclusions

The hydrology and hydrogeology for Silala is linked with the climate. Flow and water balance estimates thus require reliable distributed climate datasets. These were not available but have been estimated for this project. By combining *local* ground based observations with satellite data and the topography of the catchment, precipitation, potential evapotranspiration and temperature, time series have been established specifically for the Silala catchment.Considering the large spatial climate variability in the Andes This method is deemed to provide better climate datasets than correlating observations over long distances as suggested by Muñoz et al. (Reference 11).

Given the climate variability of the area and the quantity and quality of data, uncertainty must be recognised. Significant uncertainty in the climate series has been addressed in the water balance model by sensitivity simulations and the range of key model results assessed.

A water balance, recharge and flow-tracking model have been set up for the delineated catchment upstream the Silala springs and canal system. It is based on available data, e.g. precipitation and potential evapotranspiration time series and on a number of general assumptions concerning the characteristics and properties of the area.

Results show recharge rates of approximately 56 mm/year in the upstream catchment (232 km^2) corresponding to a total long-term catchment discharge (groundwater *and* surface water) of roughly 400 l/s.

The results indicate that recharge generated inside the topographical catchment under current climate is sufficient to sustain the spring and canal discharges of 160-210 l/s and potentially a cross-border groundwater flow.

The simulated groundwater flow field has been used in a particle tracking analysis in order to map the possible origin and age of water discharging the Silala springs and canal system. The highest age of up to 4,000 years is found for the remote, higher altitude areas with an age of 900 years on average across the catchment. The age estimates do not include travel time of infiltrating water through the locally very deep unsaturated soil column. Based on averaged vertical flow velocities in the unsaturated zone and the simulated depths to the groundwater table, the travel time range from 0-200 years, where the groundwater table is closest to the surface (3-4 m below surface at the downstream boundary) and up to several thousand years with the deepest groundwater table.

Overall, the analysis indicates a water age within the range of previous Isotope datings of 1,000-10,000 years.

Given the lack of field data from the Silala Far Field area, the uncertainty and variability of climate data and the model sensitivity, the results should be viewed as indicative only.

The continuous Silala canal flow measurements at the two permanent gauging stations on Bolivian and Chilean territory immediately upstream and downstream of the border have been supplemented by new measurements carried out by SENAMHI during January-September 2017. SENAMHIs field program includes simultaneous micro-propeller flow measurements (21 locations), spring flow measurements (20-33 Ojos De Agua) and six continuous flume water level recorders converted to flows.

The flow data analysis shows that the flows are dominated by groundwater discharges and approximately constant in time. The temporal variation observed in site-specific flow measurements cannot be explained by responses in neighbouring measurement locations or any climate or runoff events.

The flow measurements have provided valuable information regarding the spatial distribution of inflows and allowed a breakdown of water balances by reach. Although considerable flows (approximately 95 l/s) enter through the springs at the Northern and Southern wetlands, a large groundwater inflow contribution has been identified along the Southern Canal between C3-C5, especially along the upper reaches of the ravine, coinciding with a locally steep drop in topography and canal levels.

The different flow measurements around C5-C7 just upstream the border revealed inconsistencies between the flow records and have not contributed to narrowing the canal flow range.

Smaller periodic daily flow variations have been detected at all of the seven continuous gauging sites during July-Sept 2017 (winter period). They cannot be caused by wetland evaporation but are more likely due to freezing/melting of the water in the wetlands.

The continuous flow measurements have confirmed that the Northern and Southern wetlands contribute to respectively around 40% and 60% of the confluence flow and that a significant part of the flow in the Southern canal enters along the ravine upstream of the confluence. The uncertainties for assumingly well controlled flume measurements appear high and the data available up to the deadline of this report do not further constrain the wide flow range of 160-210 l/s measured at the border.

7 References

Reference 1

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Reference 2

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APPENDICES

APPENDIX A

Climate data

A Climate data analysis

This appendix documents a climate and hydrological analysis of the Silala Springs system in Bolivia close to the Chilean border. The purpose of the analysis was to develop an understanding of the hydrological processes in the spring catchment, with the aim to produce a water balance for the upper part of the catchment.

The appendix presents the available climate data for the area including precipitation, evapotranspiration and temperature, and our analyses of their spatial and temporal variations. It gives our best estimates of long-term distributed climate series, to be used in the catchment water balance studies in this report and in the detailed integrated groundwater –surface water studies of the Silala Nearfield to be established later in the project.

A.1 Precipitation

Daily records of precipitation are available for a number of stations in and around the Silala catchment in both Bolivia and Chile. Senamhi has provided data for three stations in Bolivia and station data has been extracted for six stations operated by Direción General de Aguas (DGA) in Chile. The stations are listed in Table A-1 and the locations are shown in Figure A-1. Historical data for Laguna Colorada is also available for a period from 1980-2000. However, this data set looks erroneous, with repeating patterns of rainfall for longer periods. It has therefore not been used in the analysis.

Table A-1 Overview of rainfall gauges in Bolivia and Chile

Station	Source	Distance from Silala (km)	Altitude (m.a.s.l)	Period	Years
Silala	Senamhi	0	4402	12/6/2012-30/9/2017	4.5
Laguna Colorada*	Senamhi	28	4278	18/9/2010-25/9/2017	6
Sol de Manana	Senamhi	53	4916	1/1/2012-11/7/2017	5.5
Siloli	DGA	2	4000	25/10/2012-1/8/2017	4.5
Inacaliri**	DGA	6	4040	1/2/1969-28/2/2017	48
Silala**	DGA	2	4305	1/1/2001-28/2/2017	17
Ollague	DGA	90	3707	1/1/1971-28/2/2017	46
Linzor	DGA	25	4100	1/11/1973-28/2/2017	43
Caspana	DGA	40	3246	12/6/2012-30/9/2017	4

**) Very large values in 2016/17 - problems with station*
***) Identical values for longer periods - not raw data but it looks like one station may have been gap filled with values from the other station by DGA*

Figure A-1 Locations of weather stations with rainfall data in Bolivia and Chile (Senamhi stations in green)

As the stations in Bolivia generally only have a few years of rainfall and also have several gaps in the records, some of the stations from Chile have been used for analysing the long-term variations in rainfall and for looking at long-term annual average rainfall for the Silala catchment. The DGA rain gauges at Inacaliri and Silala (hereafter named DGA-Silala) are located closest to the study area and both have long records. However, it was noted that, for some years after 2010, the rainfall is identical at the stations, which could indicate that one of the stations may not have been operating properly and some gap filling was undertaken. The long-term average annual rainfall at DGA-Silala is 87 mm/year compared to 98 mm/year at Inacaliri for the period from 2001-2017. The average rainfall at Inacaliri for the full data period from 1969-2017 is 122 mm/year.

A.1.1 Annual and seasonal variation

The inter-annual variation in precipitation is very high, as illustrated in Figure A-2**,** which shows the annual rainfall at Inacaliri and Silala. The calendar years 2003, 2009 and 2010 were particularly dry years. Although the inter-annual variation may partly be explained by large scale atmospheric variations such as the El Niño effect, all three years are only moderate El Nino years. On the other hand, 2015 was very strong but was not particularly dry in the records. Hence, the inter-annual variation in precipitation does not seem to have a very strong El Niño correlation. A similar inter-annual pattern is observed at the other DGA stations. It is also interesting to note that the dry years seem to be drier after 2001 than for the previous period. Whether this and the detected generally lower average precipitation at Inacaliri is due to a general global long-term change in climate or whether it is a local decadal variation cannot be determined from the available data.

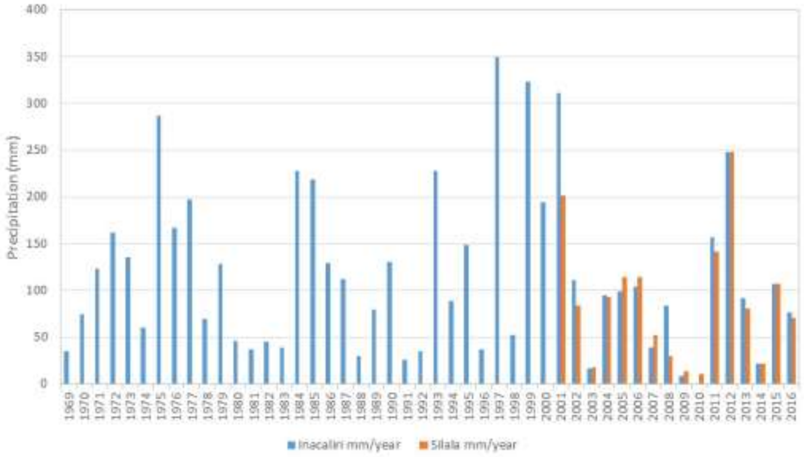


Figure A-2 Annual precipitation at the Inacaliri and Silala gauges

Most of the precipitation in the Silala catchment occurs during the austral summer months between December and March (Figure A-3). Very little precipitation is observed during the winter months from April until September. Snow has been recorded and observed in the Silala catchment during the winter but this may not be captured adequately by the weather stations. In fact, the stations inspected on the Bolivian territory were not equipped with instruments suitable for catching snow. The station data from Inacaliri and DGA-Silala has some minor precipitation events during the winter month for some years but no precipitation has been observed at the two stations after 2005.

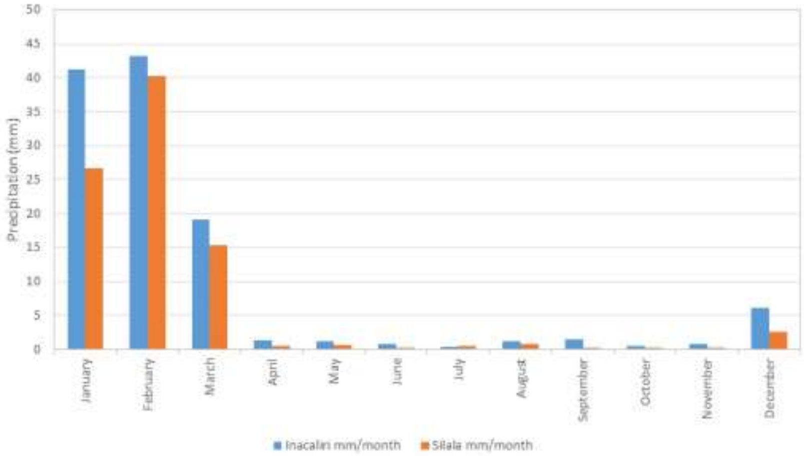


Figure A-3 Monthly average precipitation at the Inacaliri (1969-2016) and Silala gauges (2001-2016)

A.1.2 Snow formation

In order to investigate the importance of snow events in more details, MODIS satellite data was acquired, with a spatial resolution of 500 m showing the snow cover of the catchment on a daily basis from 2000-2017. Percentage snow cover in the Silala topographic catchment area indicates that some precipitation falls as snow during the winter months. Particularly large snow (wet) events were observed in July 2002, August 2011 and June 2013 (see Figure A-4 and Figure A-5). However, this was not observed in any of the rain gauge data. Only a small amount of precipitation was recorded at the Inacaliri station in 2002 and none during the other periods. While MODIS provides snow cover, it is not possible to reliably estimate snow depth or snow equivalent from the data alone but they indicate that the gauged precipitation underestimates total precipitation.

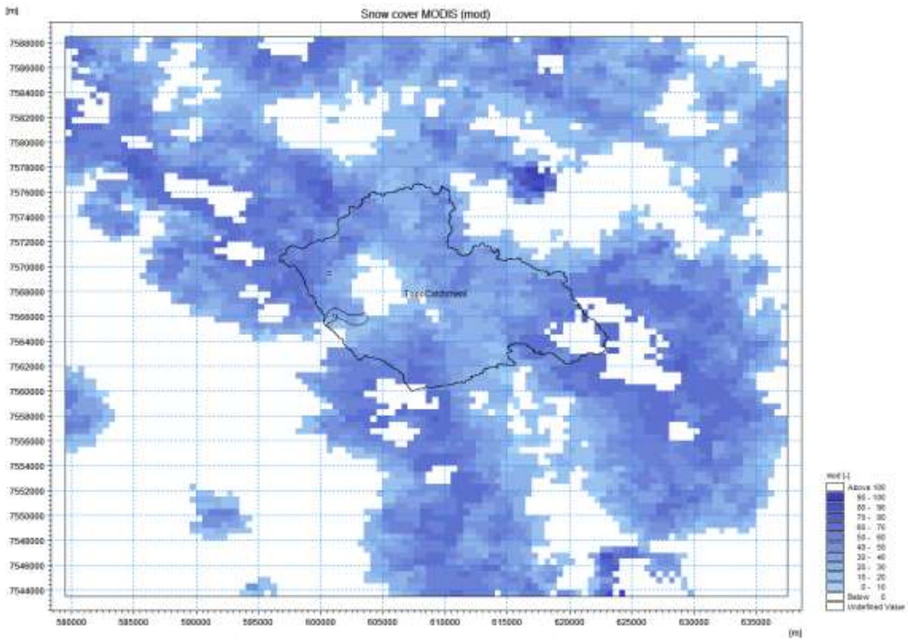


Figure A-4 MODIS satellite snow cover in the Silala catchment in June 2013

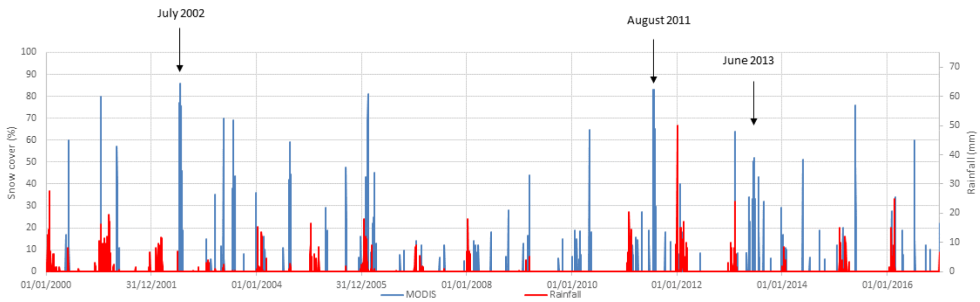


Figure A-5 Comparison of satellite snow cover (blue) to the north of the wetland on the ridge with rainfall daily recorded at Inacaliri (red).

A.1.3 Spatial distribution of rainfall

Due to the limited number of rainfall station with longer-term rainfall records in the Silala catchment area, it is difficult to make a reliable assessment of the spatial distribution of rainfall. Muñoz et al., 2017 (Reference 11) has, based on long-term rainfall records at a large number of DGA stations in Chile, developed a simple rainfall-altitude relationship and used it, combined with local elevation data, to make an assessment of the annual average rainfall for the catchment delineated by them. However, there is a large spread in the rainfall data at heights above 3,500 meters. It was therefore decided to look at satellite data to see if a more reliable relationship could be established from local data.

Climate Hazards Group Infrared Precipitation with Station data (CHIRPS) was used for the analysis. The data consists of daily gridded values with a resolution of 0.05 degrees or approximately 5 km, covering a 30-year period starting in 1981. Other gridded remote sensing rainfall series were also considered for the analysis but since these (TRMM and GPM, Reference 15 and 16) have a much lower spatial resolution (0.25° and 0.1° compared with 0.05°), the CHIRPS is considered the best source of distributed precipitation available for the Silala catchment. Furthermore, GPM data is only available for 2015-2017.

Like the ground station records in the area, the CHIRPS data does not show precipitation outside the austral summer months. Hence, CHIRPS does not capture any snow events in the winter months. The spatial variation of long-term annual average rainfall indicates that the highest amount of rainfall is seen in the North-Eastern part of the Silala catchment, reducing towards the South-West. This is consistent with the fact that precipitation in the basin is mainly caused by convective activity in a North-East South-West direction. More than 90% of the precipitation in the basin occurs between January and March, as a result of the significant atmospheric pressure coming from the East. During the rest of the year, the atmospheric moisture in the air decreases due to dry winds from the West.

Based on the CHIRPS data within and nearby the Silala catchment, a linear relation between precipitation and altitude has be established (Figure A-6 below). There is some scatter at the higher elevations and in general the curve is not as steep as the one derived by Muñoz et al., 2017.

As input to the water balance modelling, local gridded elevation data has been combined with the derived altitude/precipitation relation and long-term station data from the Inacaliri weather station to generate spatial precipitation distribution estimates across the basin over time. This combination of local ground station data and the altitude variation from the local CHIRPS data is deemed to give the best estimate of the daily precipitation over the catchment.

The average annual rainfall obtained from the series is 137 mm/year. This is lower than the value derived by Muñoz et al., 2017 of 165 mm/year, which was based on Chilean data from a larger area. It is also assumed that the Silala catchment area was smaller than the area used in this study. For comparison, the average annual precipitation based directly on area weighed CHIRPS data for the Silala catchment is 146 mm/year, less than 7% higher than what we consider the best estimate. The three estimates are within the same order of magnitude and considerably higher than previous estimates of around 60 mm/year, which were based on data from Laguna Colorada.

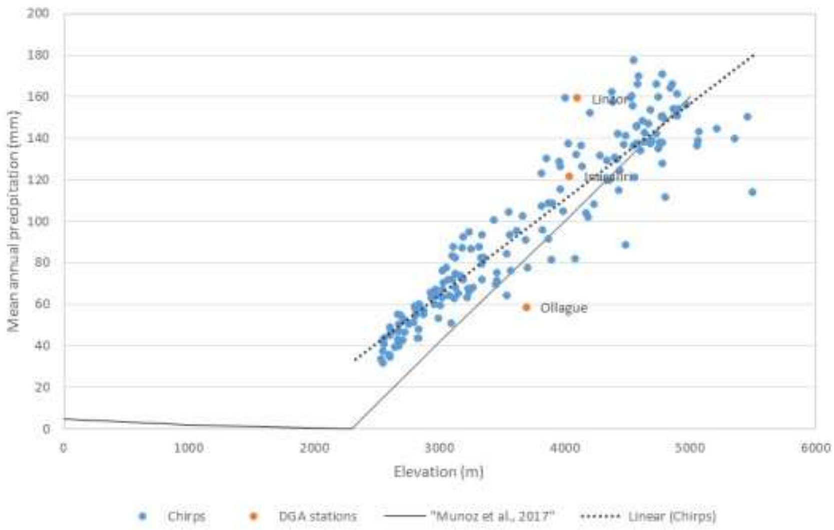


Figure A-6 Regional annual average precipitation as a function of altitude based on CHIRPS data from 1981-2017 compared with station data at Silala, Linzor and Ollague and precipitation-elevation relationship derived by Munoz et al., 2017

A.2 Evapotranspiration

Potential evapotranspiration records have been calculated for three weather stations: Silala, Laguna Colorada and Sol de Manana. Estimates have been derived using the Et_0 calculator, a software tool developed by the Land and Water Division of FAO (Reference 17), which calculates reference evapotranspiration (Et_0) according to FAO standards based on temperatures, solar radiation and wind speed using the Penman-Monteith equation. The method is recognized worldwide for reliable approximations of Et_0 over a wide range of locations with different climates. It is physically based and explicitly incorporates both physiological and aerodynamic parameters.

Figure A-7 shows the potential evapotranspiration estimates for the three locations. For Silala, the evapotranspiration is higher in 2013/14 than later years, which is due to an abrupt change in average wind speeds in 2014, from around 12 m/s to less than 5 m/s. This indicates some problems with the station. Unfortunately, it has not been possible to establish what has caused the change. For Laguna Colorada, reference evapotranspiration is generally higher than for the other two stations, which is mainly due to high average wind speeds of 15 m/s. At Sol de Manana, the average wind speed is less than half (7 m/s). This indicates that the potential evapotranspiration is highly sensitive to wind speeds in this region. The average annual Et_0 ranges from 1268 mm/year at Sol de Manana to 1940 mm/year at Laguna Colorada with around 1472 mm/year at Silala. Compared to the range of Et_0 from seven nearby Chilean DGA stations (Figure A-7), these values seem reasonable.

The relationship between elevation and average annual evapotranspiration rates for the three Bolivian stations and five DGA stations is shown in Figure A-8. Although a downward trend in evapotranspiration with elevation is detected, it is small (-100mm/1000m) corresponding to less than 7% change in EP rate of the Silala station, over the whole altitude range of the Silala catchment. Furthermore, the slope of the trend line is uncertain due to the large spread in the data.

Consequently, the potential evaporation has been assumed to be uniformly distributed over the catchment. Since the Silala station is located inside the catchment, the series from this station are deemed to be the most representative for the catchment conditions. This series has been repeated to form a long multiyear time series. To account for the uncertainty illustrated by the rather big difference in EP levels between the three Bolivian stations, sensitivity analyses of the impact on the modelled groundwater recharge from the EP rates has been made. This was done by substituting the Silala series with the series from respectively Sol de Mañana and Laguna Colorada.

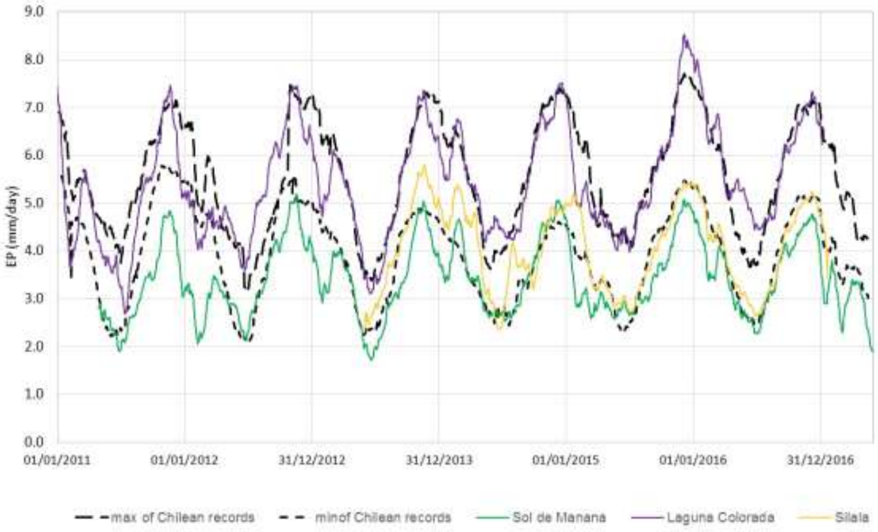


Figure A-7 FAO reference Et_0 for Silala, Laguna Colorada and Sol de Manana (30 day moving averages) compared with the range (min to max daily values) of 7 nearby Stations from DGA Chile (Reference 10)

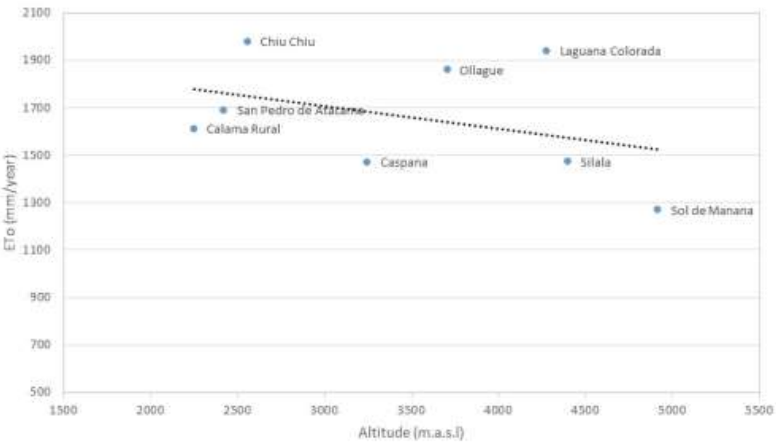


Figure A-8 Regional annual reference Et_0 as a function of altitude

A.3 Temperature

Daily temperature records are available for three Bolivian weather stations in Table A-1 and longer-term records have also been collected from two Chilean DGA stations: Inacaliri and Linzor. The annual average temperature varies considerably between stations, with an average temperature at Inacaliri of 5.71°C compared with 1.49 °C at Silala. The temperature gradient based on this dataset as a function of elevation is illustrated in Figure A-9. It should be noted that the average temperature was calculated for different time periods. However, the gradient is still quite clear from the graph. At an altitude between 4 and 5 kilometers, this corresponds to a reduction in temperature of 7.1 °C/km compared to 4.6 °C derived by Muñoz et al., 2017 who used station data for a larger region. 7.1 °C/km is also high compared to general global numbers of 4-6 °C/km but the regression of the nearby stations in Figure A-9 seems to strongly support this lapse rate.

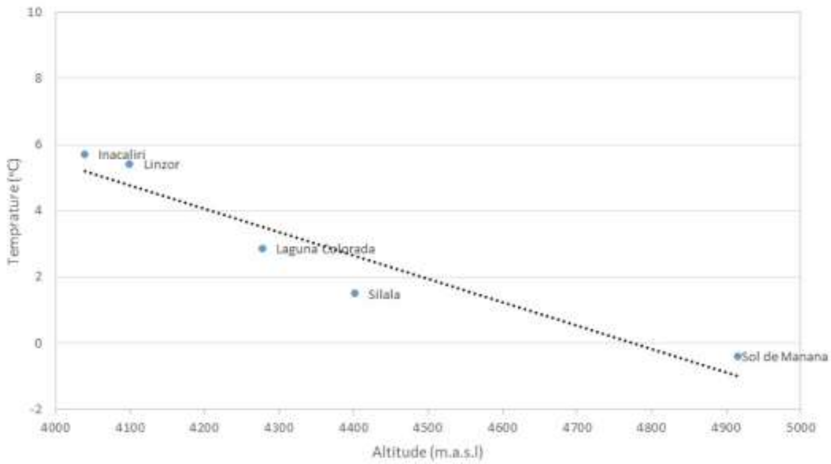


Figure A-9 Annual mean temperature gradient as a function of altitude

Based on the daily time series records from Inacaliri, Linzor, Silala and Laguna Colorada, a long-term time series of daily temperature for the period 1969-2017 has been constructed. However, data for the period 1986-2010 is not available and has therefore been gap-filled with data from Laguna Colorada and Silala from 2011-2016.

In order to be able to model snow formation and melting as accurately as possible, hourly temperature data was also acquired. Hourly data for Laguna Colorada for the period 2011-2016 was used for testing a diurnal model developed by De Wit et al. (1978) (Reference 18). Based on average, minimum and maximum daily temperature can be used for generating hourly data. This method was then used for converting daily data at Silala for 2016 into hourly data. As minimum and maximum values were not readily available for the Chilean stations, the hourly data from 2011-2016 based on Laguna Colorada and Silala data have been used for long-term water balance calculations.

An analysis of the temperature data shows that the annual average temperature is 2.2 °C with a minimum annual average temperature of 1.9 °C and maximum of 3 °C. Maximum daily temperatures are in the range 17.3-21.5 °C with an average of 19.6 °C. Minimum temperatures vary more between -24 °C to -16 °C with an average of -19.6 °C. Overall, the inter-annual temperature pattern is fairly similar. It was therefore assessed reasonable to repeat the data for the period from 1969-2010 in order to generate a long-term temperature time series. Some variation in temperatures for specific years will not be captured and this could have some impact on snow formation for the earlier period. However, as some of the snow events in the austral winter months are not captured in the rainfall data, this is more of an issue and may mean that infiltration rates using the rainfall data may be slightly underestimated for some years..

APPENDIX B

Water balance

B Water balances

Appendix B describes a water balance analysis undertaken for the Silala River basin located in Bolivia. The purpose of the analysis was to develop an understanding of the hydrological processes in the catchment, with the aim to produce a water balance for the upper part of the catchment feeding the Silala wetlands.

The Silala springs and canal flow system is fed almost entirely by groundwater. Groundwater from the upstream catchment area for the wetlands is continuously discharging the springs and canal of the Silala wetlands. In order to sustain the groundwater flow, the groundwater aquifer must be either:

1. Recharged by infiltration of rainfall or melting snow reflecting current climatic conditions,
2. Associated with a gradual depletion of groundwater storage or
3. A combination of 1. and 2.

Groundwater isotope analysis suggest that ancient fossil water is part of the water discharged at the springs.

B.1 Recharge estimation approach

As the hydrogeological data from the area is limited, a conceptual approach has been adopted for estimating recharge and water balances. With the data available, it is not possible to determine the source of groundwater. However, based on generalized climate data, soil properties and overall geological features, the water balance estimates as presented in this appendix confirm that flows at Silala *may* be sustained by plausible infiltration and groundwater recharge rates occurring within the topographic catchment.

Groundwater recharge in the Silala area is driven by short-term precipitation events scattered in time and often separated by long dry periods. Correct reproduction of such desert recharge requires long-term dynamic simulation of the infiltration and evaporation processes with a daily or finer temporal resolution. This simulation approach has been adopted in the analyses and constitutes a far better and more detailed approach than previous simpler water balances for the area such as Arcadis (2017) (Reference 13), which compares only the average annual precipitation and surface water canal discharge from Silala.

The MIKE SHE hydrological modelling system (DHI, 2012) (Reference 14) has been selected for this analysis. The rationale behind this selection is that this modelling system is one of the most advanced and well-proven spatially distributed modelling systems available. It incorporates and dynamically links all the relevant hydrological processes for the analyses. The process representations are all physically based, which makes it possible to fill in information not measured in the field with generally accepted estimates, without sacrificing the transparency of the analysis.

MIKE SHE includes a soil moisture model by Kristensen and Jensen (Graham and Butts, 2006) (Reference 12) combined with an unsaturated zone flow model (Richard's equation) for describing evaporation from plants and soils and recharge/infiltration to the underlying aquifers. The model has a snow module, which accounts for the formation of snow based on diurnal variations in temperature and snow melt, including sublimation from dry snow. The evapotranspiration module accounts for evaporation from plant interception, ponded water, soil evaporation as well as transpiration from plants. Surface runoff processes are also included using a simple diffusive wave model. Finally, the model includes a 3D-groundwater flow model coupled with the surface water and unsaturated flow modules.

A schematic of the MIKE SHE flow modelling system illustrating the different flow processes included in the system is presented in Figure B-1. Detailed descriptions of the different modules and equations can be found in the MIKE SHE documentation.

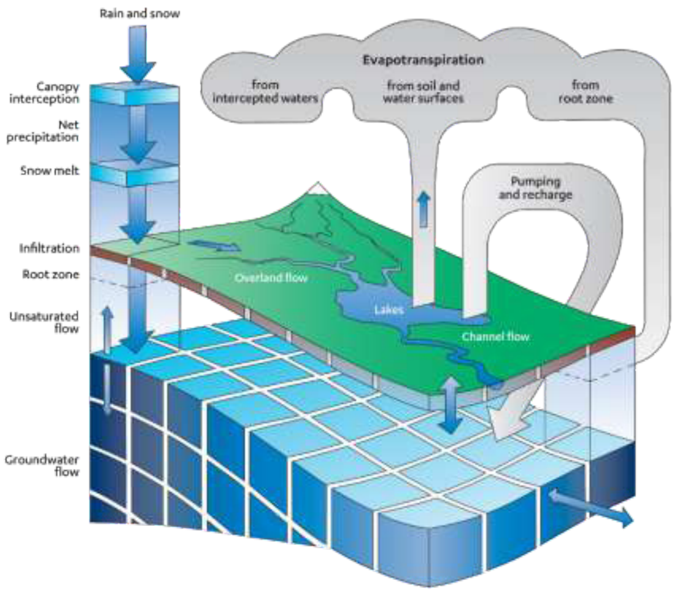


Figure B-1 MIKE SHE flow and transport modelling system

B.2 Water balance assumptions

For the Silala catchment, the important processes for estimating groundwater recharge are soil evaporation, infiltration and snow processes. Overland processes may play a small role in parts of the catchment, for example on the volcanoes. However, since the areas that could generate overland flow are small compared to the total catchment area and since the surface runoff seems to re-infiltrate in the foothills of the volcanoes, the overland flow component is expected to be of limited importance for recharge estimation. The topographic catchment area has been delineated based on a NASA digital elevation model (DEM) and covers an area of 231.5 km^2 excluding the wetlands. The catchment area contributing to recharge is uncertain due to limited information on the underlying geological aquifers. However, it is reasonable to assume, as a first assumption, that the groundwater divide coincides with the topographic divide.

The catchment is characterized by being very dry with very limited vegetation outside the wetland areas. Soils consist of sandy gravels with very little evidence of surface runoff or ponding near the surface. Soil evaporation is therefore the main process for removing water. Some evaporation also takes place from snow through sublimation but, as little information is available on rates and literature is sparse on this subject, this is assumed to be limited. A small sublimation factor of 5% of the potential evapotranspiration rate has been assumed reasonable.

Soil evaporation typically takes place from the upper 2 cm of soil (Xiao et al., 2011) (Reference 19) and will depend on soil properties such as hydraulic conductivity and capillary effects as well as the location of the water table. The recent drilling of boreholes by SERGEOMIN indicate depths to the water table of approximately 4 meters immediately upstream of the wetland, with a likely increasing depth of several hundred meters moving away from the wetland into the lavas. For recharge estimation, it is therefore assessed reasonable to assume that outside of the wetland areas all soils across the catchment have free drainage conditions.

Limited information is currently available on soil properties in the basin. However, based on observations during site visits, top soils consist of mainly coarse sand and gravels with no indication of surface runoff or water ponding. On some of the volcanoes, there is some evidence of old flow pathways but runoff has not been observed in recent time. Investigations by Arcadis (2017) (Reference 13) in Chile indicate fairly sandy gravelly soils with hydraulic conductivities in the order of 0.1-2 m/day. However, this may not apply inside the Silala catchment and requires further investigations. Capillary effects are also of importance and will depend on grain size distribution, with limited capillary rises of 15 cm for coarse sands and up to 0.5 m for finer sands (Kasenov, 2001) (Reference 20). For soils with lower hydraulic conductivities, capillary forces will tend to be higher.

B.3 Water balance model setup

For an initial estimate of groundwater recharge and water balances for the Silala basin, a MIKE SHE unsaturated zone model was set up. The model has been set up using a grid size of 200 m resulting in a total of 5717 individual unsaturated zone columns for the catchment. Free drainage was assumed by fixing the water table at a constant depth of 3 m below ground.

Long-term daily and hourly climate time series for a period from 1969-2017 (described in Appendix A) was used as input for the model. Daily station rainfall from Inacaliri was used as input in the model along with a precipitation lapse rate to account for variations in rainfall with altitude. A daily potential evapotranspiration time series at Silala was constructed based on 4 years of data from 2013-2016 and assumed to apply for the whole the catchment. Some variation will occur with altitude and varying wind speeds but no clear correlation could be found in the data. In terms of temperature, an hourly record of temperature generated from hourly values at Laguna Colorada (2011-2015) and daily values at Silala (2016) was used as input for the model, combined with a temperature lapse factor of -0.71 ^{o}C/100 m derived from station data. Snow formation has been included using a standard melting threshold temperature of 0 ^{o}C and a sublimation factor of 0.05.

Soils were assumed to be homogeneous with a saturated hydraulic conductivity of $1.4 \cdot 10^{-5}$ m/s (~ 1.2 m/day) corresponding to sand (Freeze and Cherry, 1979) (Reference 21) and capillary parameters were set using standard empirical Van Genuchten parameters of α = 0.05 and n = 3 corresponding to well graded sand. The unsaturated zone model input parameters are summarized in Table B-1 below.

Table B-1 Overview of unsaturated model parameters

Model component	Parameters	Values
Unsaturated zone	Saturated conductivity Ks	1.4 x 10^{-5} m/s
	Saturated water content Θ_s	0.37
	Residual water content Θ_r	0.03
	Water content at wilting Θ_{wp}	0.03
	Water content at field cap. Θ_{fc}	0.044
	Van Genuchten α	0.05
	Van Genuchten n	3

B.4 Water balance estimates and uncertainties

Based on the model results, the annual average evaporation over 48 years was estimated to 81 mm/year with a recharge rate of 56 mm/year corresponding to an outflow rate from the upper catchment of 412 l/s. The recharge varies considerably in space as illustrated in Figure B-2 below. Compared to the recorded average stream flow at the Silala gauge of 160-210 l/s, this seems realistic. Some groundwater flow is expected to bypass the wetland both below the sediments and in the deeper Ignimbrite aquifer. An observation borehole downstream of Silala located in Chile (Arcadis, 2017) (Reference 13) indicates partly confined conditions and currently yields a constant rate of 90 l/s. It seems plausible that the overall groundwater recharge is somewhat higher than the stream flow and borehole yields combined.

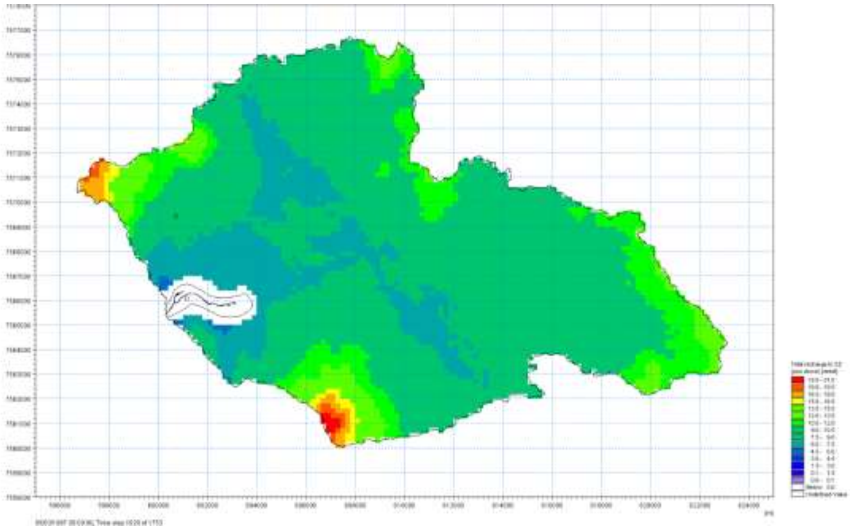


Figure B-2 Estimated groundwater recharge across the catchment on 5/3/1997

In order to understand the importance of the soil properties and potential evapotranspiration estimates for the recharge estimates, a sensitivity analysis was undertaken. Due to large run times, a representative unsaturated zone column located 3 km north of the wetland was selected for the analysis. Model runs were undertaken for a shorter period from 1998-2017 (~19 years). The column was selected as it has approximately the same precipitation as the catchment being located at an altitude of 4660 m close to the average for the catchment of around 4,700 m. Precipitation for the shorter period is slightly lower with an average of 131 mm/year. Evaporation is higher than for the full catchment. Baseline recharge from the column is therefore lower, 48 mm/year compared with 56 mm/year for the full catchment. The results of the sensitivity analysis are summarized in Table B-2.

It is clear from the analysis that both soil parameters and evapotranspiration rates have a significant impact on recharge rates. The potential evapotranspiration has a particular impact on total recharge. Interestingly, the annual average potential evapotranspiration at Sol de Mana is only 15% below the annual average at Silala but this results in a 33% increase in recharge. Conversely, the average potential evapotranspiration at Laguna Colorada is 32% higher than at Silala but only results in a reduction in recharge of 8%. An analysis of the daily potential evapotranspiration records at the three stations show considerable variations during the periods of rainfall, which explains the differences in impact on recharge. The graph in Figure B-3 below shows daily rainfall, potential evapotranspiration and estimated recharge over time. It illustrates how high intensity rainfall exceeds potential evapotranspiration rates leading to small amounts of groundwater recharge in Silala. Soil parameters also have an impact on soil evaporation. Particularly saturated hydraulic conductivities affect evaporation with an increased evaporative loss for less permeable soils.

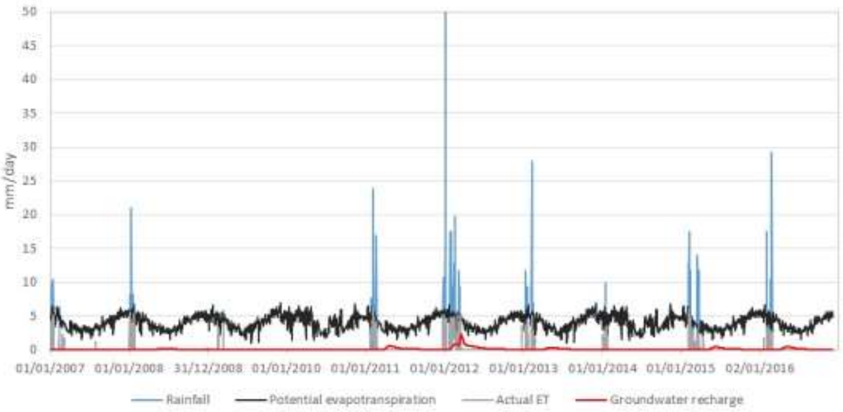


Figure B-3 Daily rainfall, potential evapotranspiration and recharge for 2016 3 km north of the Silala wetlands

Based on the sensitivity analysis of groundwater recharge, taking into account the fact that the column model has lower recharge than the full catchment, the catchment recharge is estimated to be in the range of 45-74 mm/year corresponding to 330-550 l/sec. This is consistent with measured flows in the Silala wetlands and current knowledge of subsurface outflows into Chile. Actual recharge rates could potentially be higher as satellite maps of snow cover indicate that some snow events in the austral winter are not captured in the rainfall station data. It may be possible to reduce the uncertainty of the recharge estimates if more information on soil properties become available but potential evapotranspiration rates remain uncertain. Overall, the analysis indicates that it is plausible to assume that the wetland is fed by groundwater recharge from the topographic catchment.

Table B-2 Sensitivity analysis of recharge estimates to soil parameters and potential evapotranspiration

Sensitivity run	Parameter	Rain mm/year	Evaporation mm/year	Recharge (mm/year)	Recharge (l/sec)	Change from baseline (%)
Baseline	See Table 1	131.2	83.8	47.4	348.1	-
1	Ks=1.4E-4 m/s	131.2	75.5	55.7	409.1	17.5
2	Ks=1.4E-6 m/s	131.2	92.8	38.4	281.6	-19.1
4	Van Genuchten α = 0.2	131.2	74.5	56.7	416.1	19.5
5	Van Genuchten α = 0.1	131.2	78.9	52.3	384.0	10.3
6	Epot -	131.2	87.6	43.6	319.9	-8.1

	Laguna Colorada					
7	Epot - Sol de Manana	131.2	67.8	63.4	465.5	33.7

B.5 Groundwater flow model and age

Groundwater age has been investigated using an extended version of the MIKE SHE integrated unsaturated zone groundwater model with particle tracking. The purpose of the particle tracking analysis was to estimate likely groundwater age of the water recharging the Silala canals and wetlands assuming inflows are from the topographic catchment. This will help ascertain whether the age of the water supports the findings from isotope analysis of water suggesting that part of the spring water in Silala is fossil water.

The unsaturated model used for recharge estimation was modified for the analysis to include a relatively simple three-layer geological model comprising a lava layer at the top, overlying two Ignimbrite layers. Based on borehole information from the wetland area, the Ignimbrite aquifer was divided into a fractured high permeable top layer with a thickness of 20 m and a lower less permeable layer with a thickness of 250 m. The extent of the lava deposits was delineated based on both a geological map provided by SERGEOMIN reproduced in Figure B-4 below and another updated map: SEARGEOMIN: PROYECTO MAPEO GEOLÓGICO ESTRUCTURAL ÁREAS CIRCUNDANTES AL MANANTIAL SILALA, La Paz, 2017 in Figure B-5. The applied delineation is fairly simple and does not represent the lava deposits very precisely, particularly in the Eastern part of the catchment. Outside the areas covered by lava, the Ignimbrite aquifer is assumed to be covered by colluvial/glacial topsoil of 1 m thickness. A geological profile of the model layers is presented in Figure B-6.

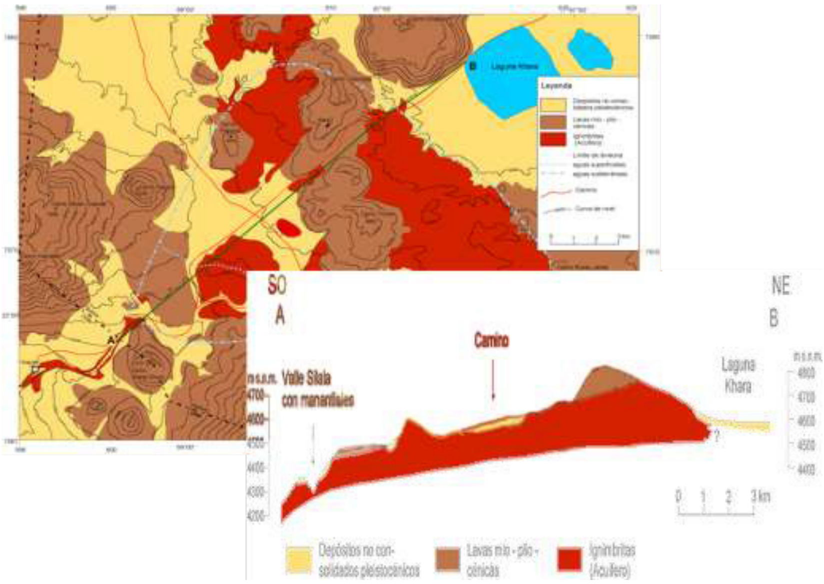


Figure B-4 Geological interpretations provided by SERGEOMIN (from Powerpoint)

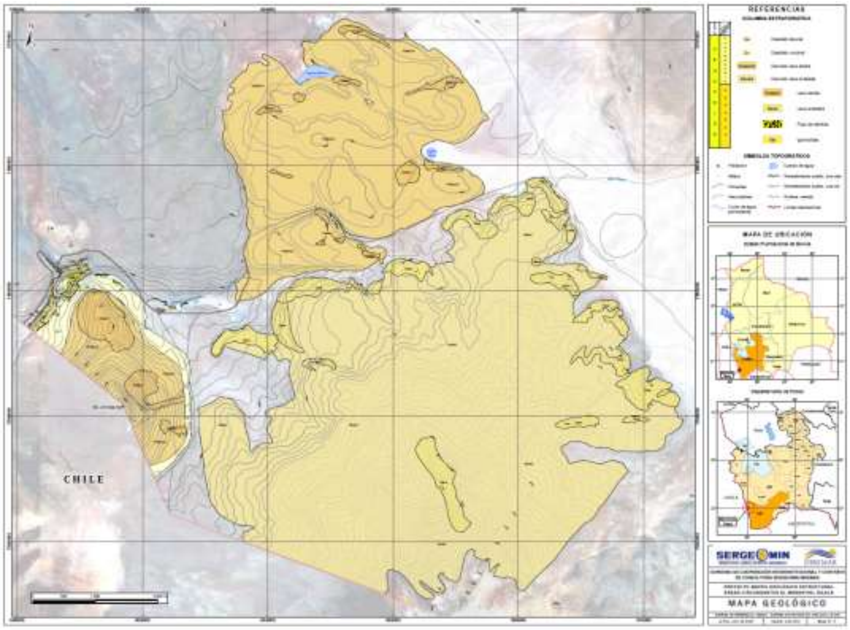


Figure B-5 Updated geological map provided by SERGEOMIN, 2017

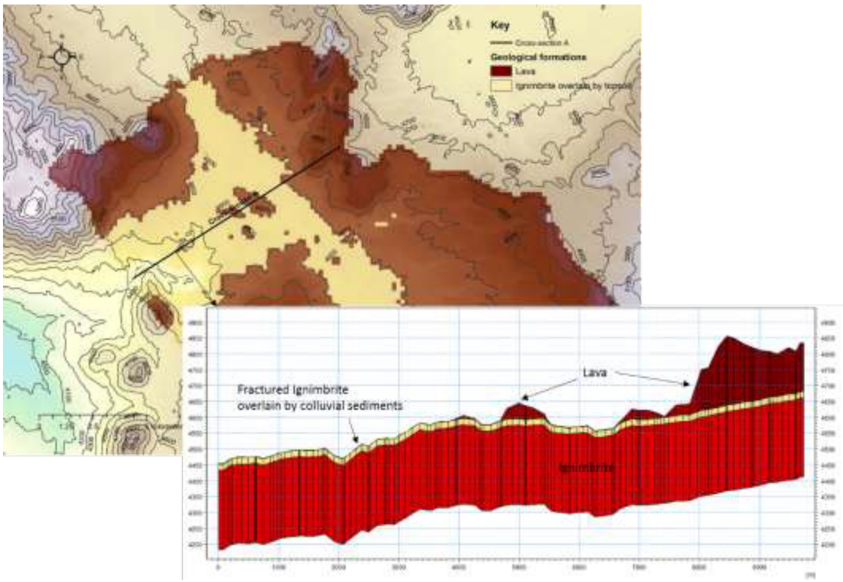


Figure B-6 Geological model including cross-section from MIKE SHE model

In terms of aquifer properties, the Ignimbrite aquifer has been assumed to have fairly high horizontal hydraulic conductivities in the order of 10^{-5} - 10^{-4} m/s. The lava deposits have been assumed to have lower saturated conductivities than the underlying Ignimbrite. Currently, there is no borehole information on aquifer properties in the catchment but pumping tests across the border in Chile (Arcadis, 2017)[1] indicate values for Ignimbrite in this range. One borehole also indicates partly confined conditions in the lower Ignimbrite but this has not been possible to confirm in the Silala catchment. It is likely that parts of the aquifer could be semi-confined but for the purposes of this analysis the aquifer has been assumed to be unconfined in the topographic catchment.

In the particle tracking model the unsaturated zone parameters were modified slightly compared to the values in Table B-1 using a higher α value of 0.15 to reduce the capillary effects. Currently, there is very limited information on soil parameters but the nature of the deposits do seem to indicate sandy gravel with low capillary effects. Using the modified parameters, the modelled recharge increases to 63.6 mm/year compared with the previous 56 mm/year, which is at the higher end of the range of recharge from the sensitivity analysis above. Table B-3 provides a summary of the saturated zone model input parameters.

Table B-3 Overview of geological units and parameters

Soil name	Horizontal K (m/s)	Vertical K (m/s)	Specific yield (-)	Specific storage (-)	Porosity (-)
Weathered Ignimbrite	0.0001	1.00E-05	0.15	0.0001	0.2
Ignimbrite	2.50E-05	2.50E-06	0.15	0.0001	0.2
Lava	1.00E-06	1.00E-07	0.15	0.0001	0.2
Colluvial/Glacial top soil	1.40E-05	1.40E-06	0.3	0.0001	0.2

Modelled groundwater levels at the end of 2016 are shown in Figure B-7 both as contours with flow vectors and along a cross-section. The results are presented at the end of the simulation in December 2016. Since recharge rates are small and the unsaturated is very deep, in some places between 500-800 m, limited annual fluctuations in the groundwater table are observed. The location of the water table in the middle of the catchment is approximately between 20-50 m below ground. This seems reasonable, as the area is very dry with no indication of a shallow groundwater table. There are three small dry lakes in this area, which indicates that locally the groundwater table may occasionally be higher but, with the regional model using a 200 m grid, it has not been possible to capture it in the model.

[1] Arcadis, 2017. Memoria, Volume 4, Annex 2. Detailed Hydrogeological Study of the Silala River

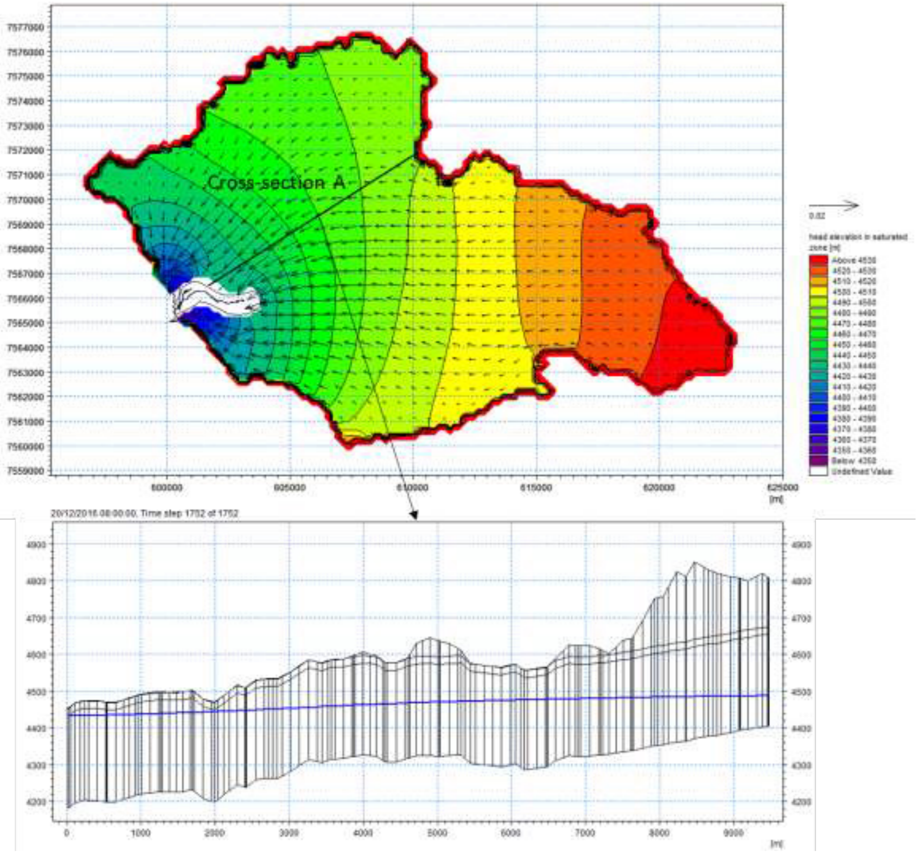


Figure B-7 Simulated potential head in the Ignimbrite aquifer including flow vectors (layer 3) and profile of water table on 20/12/2016

The combined unsaturated zone and saturated zone flow model has been used for a particle tracking analysis. The particle tracking analysis serves to estimate the origin and travel time of water recharging the Silala canal and springs system. Particles have been introduced in the upper groundwater layer, corresponding to infiltrating water recharging the aquifer and subsequently displaced step by step according to the simulated flow field until reaching the Silala wetland area, corresponding to groundwater discharging into the surface water system or leaving the area as sub-surface flows.

The origin, destination and travel time of each particle are registered. The simulated travel time is a proxy of groundwater age. In the Silala Far Field area, the unsaturated zone, i.e. the depth to the groundwater table, can be up to several hundred meters, especially at higher altitudes. A measure of water age from precipitation on the surface to discharge to the springs would thus have to consider both travel time in the unsaturated zone and groundwater.

Figure B-8 shows groundwater age in the catchment based on the particle-tracking model. The model results indicate an average groundwater age of approximately 900 years. The age varies with travel times from as little as 25 years in the vicinity of the wetland to up to 4,000 years for water coming from the far end of the catchment. The majority of the water is estimated to be between 400-1,000 years old (Figure B-9) based on groundwater flow transport time alone.

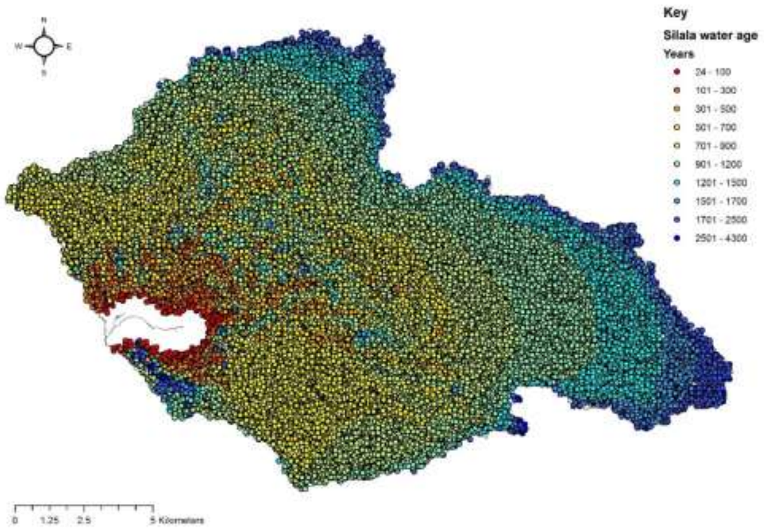


Figure B-8 Simulated map of particle travel time in the saturated zone

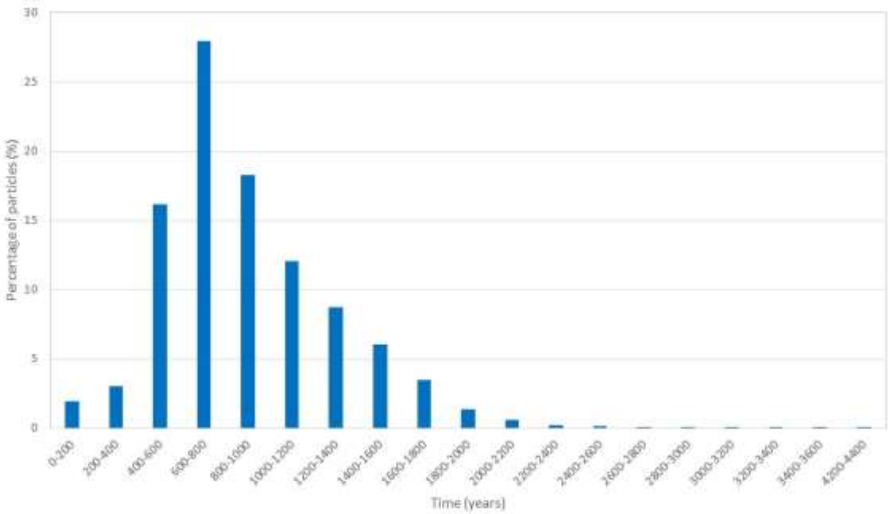


Figure B-9 Particle age distribution

Travel time in the unsaturated zone will add to the overall water age, particularly in the areas with volcanoes where the water table tends to be very deep, down to 1,000 m. The travel time in the unsaturated zone has been estimated based on a separate simple transport model run with a tracer source with a constant concentration applied at the top of a number of unsaturated zone columns scattered across the catchment. Four columns with different depths to the groundwater table were selected and travel times were found to be approximately 1 m/year. Combined with the modelled depth to the water table, this provides a very rough estimate of travel time through the unsaturated zone presented in Figure B-10. In the model, it has been assumed that the flow through the unsaturated zone takes place as matrix flow through a highly porous medium. Flow is more likely to be a combination of fracture and low permeable matrix flow at depth but as no information is available on the unsaturated zone properties, this could not be modelled at this time. The travel time in the unsaturated zone using this approach has been estimated to be between 5-50 years close to the wetland up to over 1,000 years below the volcanoes.

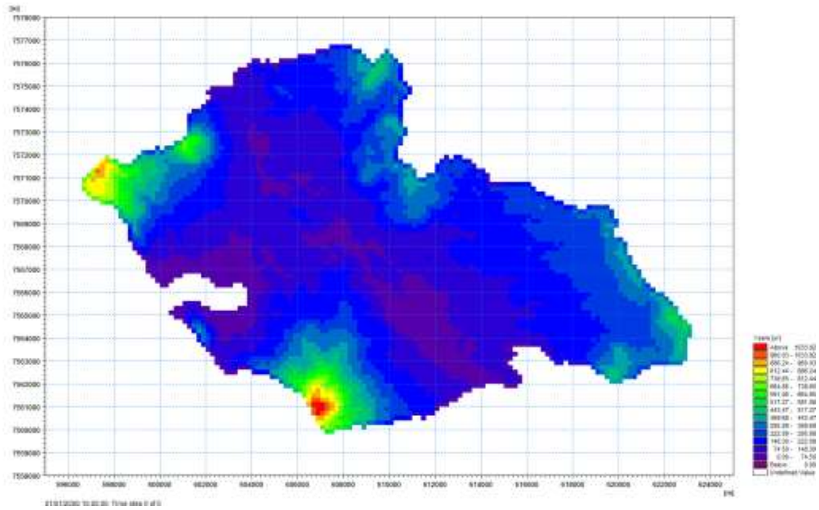


Figure B-10 Unsaturated travel time in years for the catchment based on simple transport model runs

Overall the total travel time from the analysis confirms fairly old water, over 1,000 years old on average. The thickness of the ignimbrite aquifer is unknown and could be more than the 250 m assumed in this assessment. A larger thickness of this main water-bearing layer would lead to a proportionally larger water age (assuming the unchanged groundwater gradients). However, even with a significant increase of the thickness of this layer, the model assessment would not be as large as 10,000 years, as indicated by the isotope analysis of the water from the wetland. Isotope dating is however uncertain and it is possible that some of the water feeding the wetlands is younger.

APPENDIX C

Measured surface water flows

C-2

C Measured flows

C.1 The surface water flow measurement program

Until the initiation of the surface water monitoring program under the present project, time series of flows in the Silala canals were only available at two locations, one at the old siltation chambers in Bolivia around 700m upstream of the border and another close to the border on the Chilean side.

These two continuous flow time series are of paramount importance for the assessment of the surface water discharge of the spring system at the border. However, the initial flow assessment (Reference 10) found that they contained significant uncertainty as to the magnitude of the flows in the Silala main canal.

Furthermore, the two series do not contain sufficient information to understand and quantify the processes in the various parts of the system. Such understanding is important to quantify how the canalisation and drainage of wetlands may have affected the natural flows at the border and to assess water requirements of a healthy natural wetland.

A consistent and mutually accepted flow assessment at the border will also be important if an agreement on fair sharing of the water resource between Bolivia and Chile.

To improve the accuracy of the existing series and to gain knowledge on the distributed flow contribution in the Silala Springs System, a surface flow measurement program[18] (Reference 5) has been planned by DIREMAR, SENAMHI and DHI. The surface flow measurement program is based on field inspections to pin down the best suitable gauging locations. SENAMHI was contracted by DIREMAR to carry out the program, which was initiated in May 2017. The measurements include simultaneous canal and spring flow measurements, continuous flow records collected at weirs installed at during 2017 at six new strategic locations (C1-C6) and at the existing permanent flume at the de-siltation chambers close to the Bolivian-Chilean border. At the latter location, the old automatic floater-based water level instrument has been supplemented with a new automatic pressure sensor similar to the ones used at the weirs (C1-C6).

This appendix describes the observations and findings derived from the data collected through this measurement program, as obtained up to October 15th, 2017. It is divided in three parts: “Simultaneous canal flow measurements”, “Continuous canal flow measurements” from the new weirs and “Long term flow series” from the two permanent flumes.

Figure C-1 shows the flow measurement locations including springs (Ojo de Agua), simultaneous flow measurement locations (S-1 – S-21) and continuous flume flow gauges (C-1 – C-7). Prior to establishment of the flumes, simultaneous flow measurements have been carried out at both S-1 – S-21 locations and at the locations C-1 – C7 where the flumes were later installed or already existed (C7).

A preliminary assessment of measured flows was carried out as part of the Surface water report[18]. In the following sections the flow data provided by the SENAMHI for the period May-September 2017 and the permanent flumes flow records at the Bolivian and the Chilean side of the border are updated, presented and analysed.

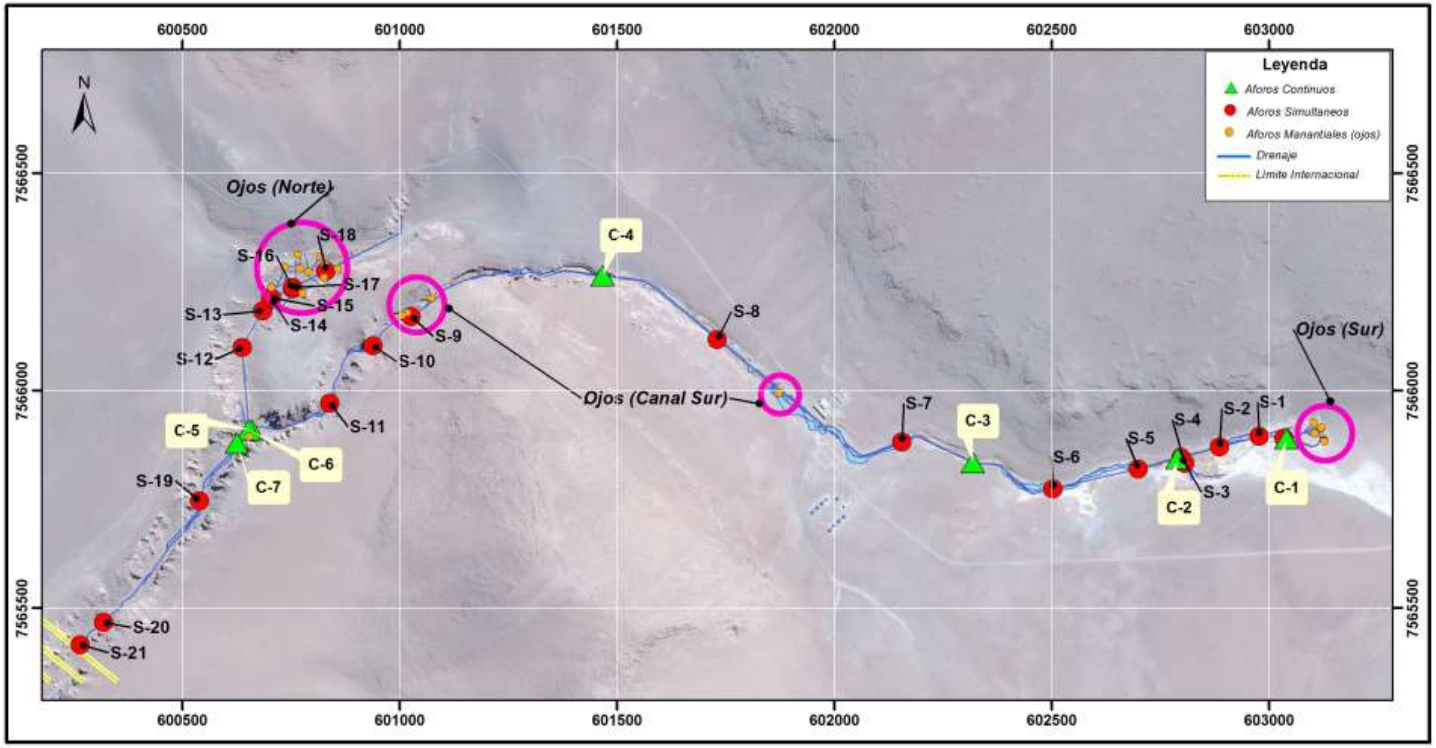


Figure C-1 Overview of flow measurement locations (SENAMHI)

C.2 Simultaneous canal flow data

The simultaneous flow measurement program is designed to provide a snapshot of flows in many points of the canal network. The measurements have been carried out, initially at a bi-weekly and later at a monthly frequency covering all locations within 2-3 days. Micro-propeller measurements in multiple points of the cross section provide a cross-sectional velocity profile, which is integrated to calculate the flow. The profile measurements have been carried out twice at each location to verify results and, if necessary, to take prompt on site action to prevent errors.

Figure C-1 shows the flow measured each location at ten different dates from May to September 2017. The average, minimum and maximum values have been calculated.

Figure C-2 shows minimum, maximum and mean simultaneous flow rates measured between May and September 2017.

Figure C-3 shows time series of simultaneous flows measured, i.e. ten values between May and September 2017. The C-7 flow ranging from 115 to 170 l/s is highlighted by a thicker line.

Figure C-4 to Figure C-6 show longitudinal flow profiles along the Southern Canal, the Northern Canal and the reach from C-7 to the border, respectively, for the ten dates measured.

Puntos de Aforo		May 6-7	May 12-14	May 15-17	May 27-30	June 3-4	June 12-14	June 20-21	July 24-25	Aug 25-27	Sep 25-27	Average	Min	Max	Std.dev
S-1, canal sur	S-1	25.80	33.00	32.50	29.05	31.55	29.10	29.15	31.75	27.45	26.45	29.58	25.80	33.00	2.41
C-1, canal sur	C-1	28.35	33.60		31.65	26.90	27.55	28.6	26.9	22.5	24.45	27.83	22.50	33.60	3.17
S-2, canal sur	S-2	24.45	24.50	28.10	23.75	31.80	25.75	27.8	30.9	30.45	26.95	27.45	23.75	31.80	2.74
C-2, canal sur	C-2	47.05	46.90		36.90	28.85	33.20	33.65	35.3	37	31.5	36.71	28.85	47.05	6.00
S-3, canal sur	S-3	34.95	28.10	31.05	34.30	30.05		32.25	32.85	28.5	25.35	30.82	25.35	34.95	2.96
S-5, canal sur	S-5	36.10	38.30	30.30	30.45	31.00	32.90	30.9	29.9	26.4	34.45	32.07	26.40	38.30	3.26
S-6, canal sur	S-6	34.75	40.60	40.25	34.35	36.85	35.20	37.85	37.75	32.55	33.45	36.36	32.55	40.60	2.62
S-7, canal sur	S-7	42.95	35.70	39.70	28.90	33.50	31.00	34.1	35.5	33.9	36.15	35.14	28.90	42.95	3.80
S-8, canal sur	S-8	56.40	53.10	53.10	49.95	51.05	49.05	47.8	50.15	49.85	45.05	50.55	45.05	56.40	2.98
C-4, canal sur	C-4	70.35	58.80		61.90	62.50	57.35	58.3	66.6	48.65	50.7	59.46	48.65	70.35	6.54
S-9, canal sur	S-9	88.45	107.05		89.35	78.65	83.65	83.75	92.3	83.7	81.65	87.62	78.65	107.05	7.93
S-10, canal sur	S-10	115.40	111.65	114.95	113.80	106.30	106.85	107.4	104	110.6	112.15	110.31	104.00	115.40	3.76
S-11, canal sur	S-11	96.95	101.05		102.15	95.45	94.55	98.75	102.1	111.25	109.8	101.34	94.55	111.25	5.56
C-5, canal sur	C-5	103.65	105.75		83.45	110.50	93.60	84.8	97.65	103.45	90.3	97.02	83.45	110.50	9.03
C-7, canal principal	C-7	169.70	126.90	126.10	126.45	130.40	112.90	128.6	128.45	130.55	138.25	131.83	112.90	169.70	13.95
S-19, canal principal	S-19	214.85	209.15		163.85	143.90	149.95	156.1	148.35	152.05	155.05	165.92	143.90	214.85	25.22
S-20, canal principal	S-20	167.80	194.15		149.70	157.55	141.55	157.1	175.4	152.95	157.1	161.48	141.55	194.15	14.77
S-21, canal principal	S-21	179.45	169.30	147.15	156.60	148.45	155.55		173.25	141.55	141.3	156.96	141.30	179.45	13.24
S-18, canal norte	S-18	6.15	6.20		7.05	4.85	5.60	3.95	4.55	3.8	4.9	5.23	3.80	7.05	1.03
S-17, canal norte	S-17	23.40	28.40		27.10	25.65	24.10	25.75	22.4	23.8	25.2	25.09	22.40	28.40	1.78
S-16, canal norte	S-16	15.75	14.85		10.30	11.40	13.25	12.2	12.05	9.85	10.6	12.25	9.85	15.75	1.92
S-15, canal norte	S-15	49.15	54.80		39.70	34.25	30.35	30.5	41.5	33.3	33.65	38.58	30.35	54.80	8.09
S-14, canal norte	S-14	11.00	11.10			8.90	10.90	10.7	9.9	11.15	12.85	10.81	8.90	12.85	1.05
S-13, canal norte	S-13	38.95	46.75		41.35	37.90	51.90	46.9	57.85	34.55	45.4	44.62	34.55	57.85	6.89
S-12, canal norte	S-12	53.40	58.15		51.35	46.60	52.30	52.45	53.35	51.05	50.45	52.12	46.60	58.15	2.88
C-6, canal norte	C-6	62.65	63.85		60.40	55.15	53.85	56.65	65.35	42.5	52	56.93	42.50	65.35	6.74

Table C-1 Table of simultaneous mean canal flow measurements (in l/s)

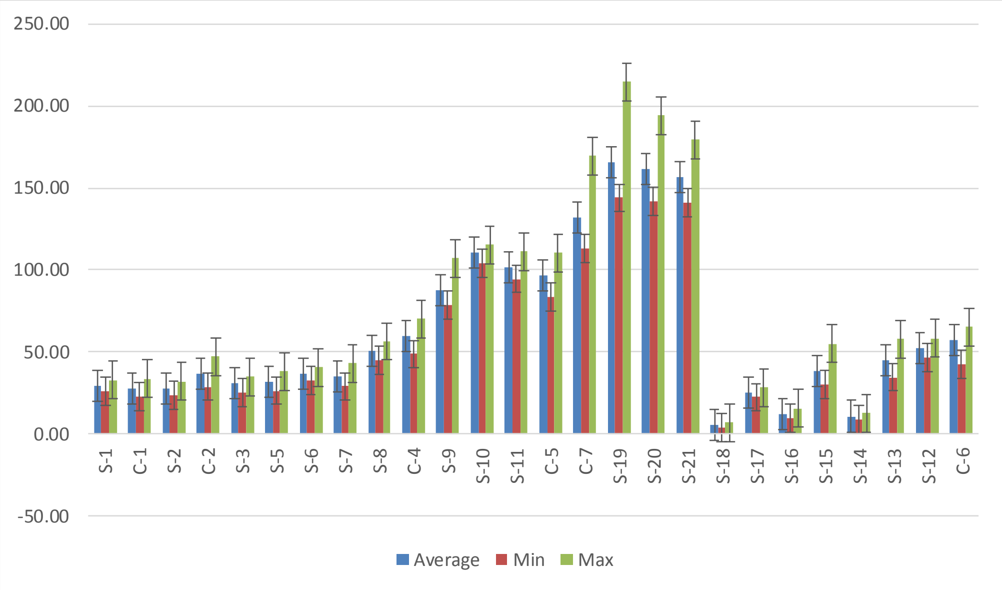


Figure C-2 Simultaneous flow measurements (Qmean,, Qmin and Qmax in l/s)

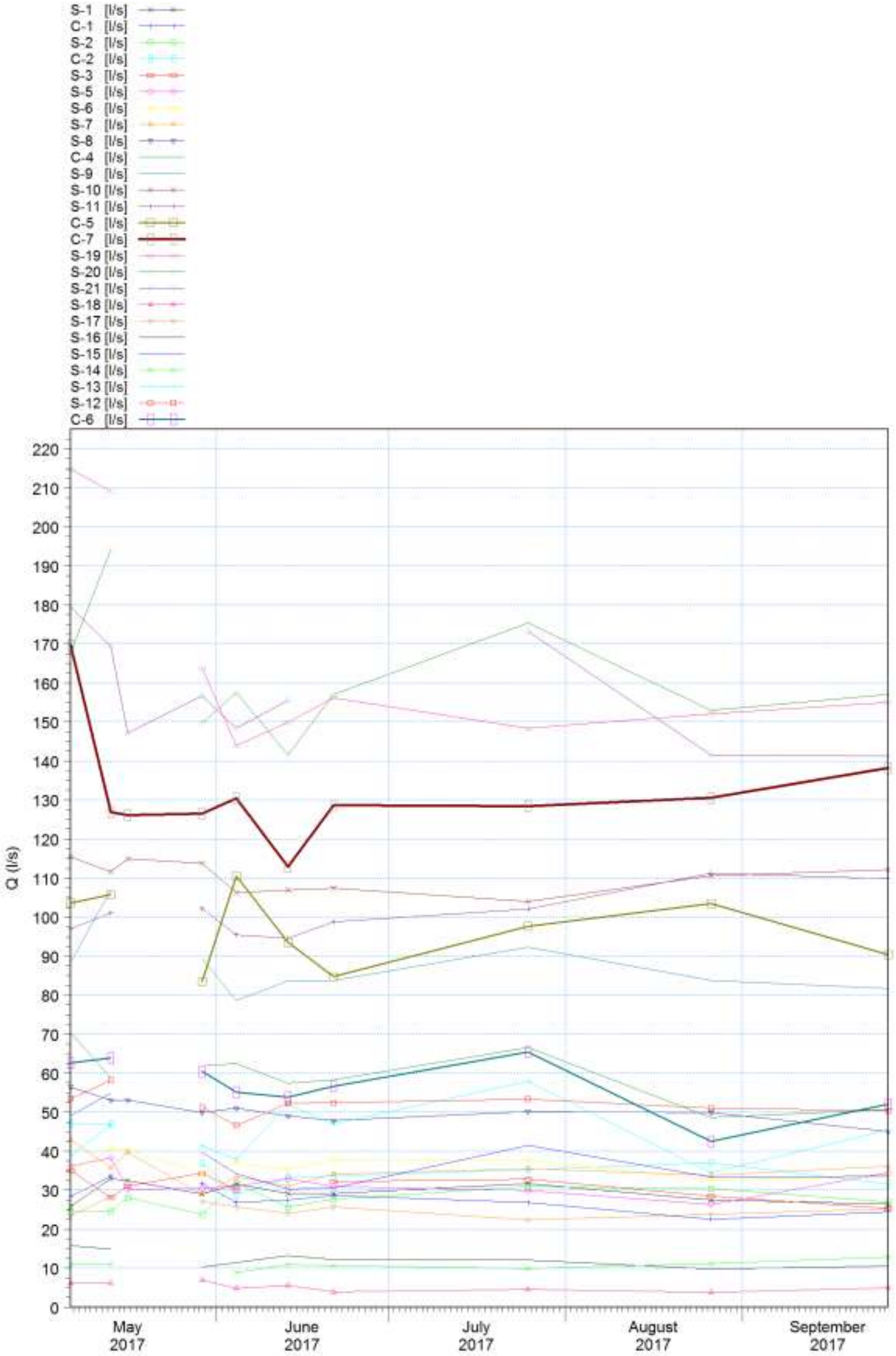
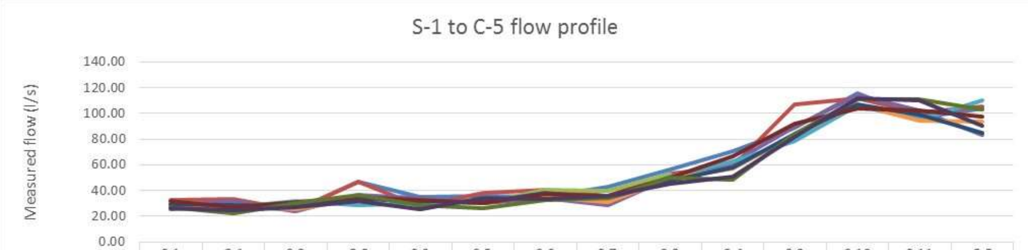
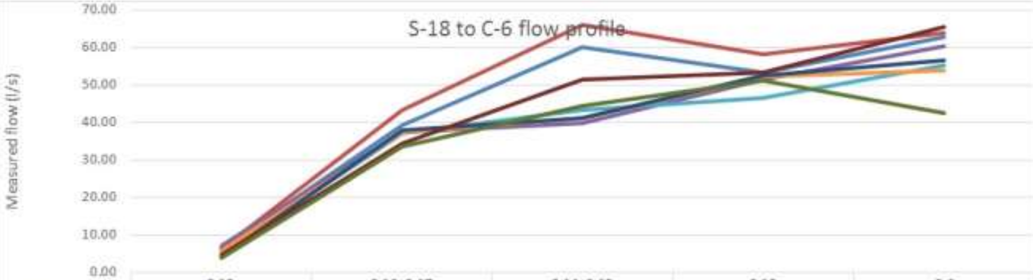


Figure C-3 Time series of flows (l/s)



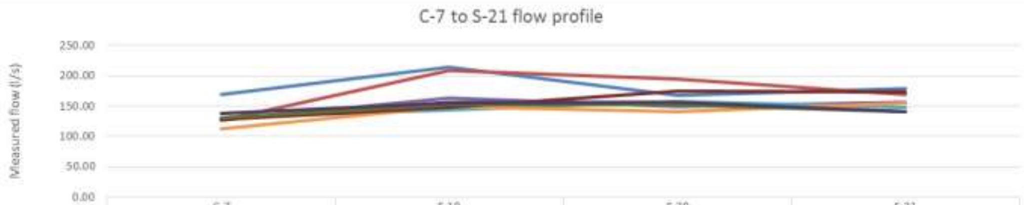
	S-1	C-1	S-2	C-2	S-3	S-5	S-6	S-7	S-8	C-4	S-9	S-10	S-11	C-5
May 6-7	25.80	28.35	24.45	47.05	34.95	36.10	34.75	42.95	56.40	70.35	88.45	115.40	96.95	103.65
May 12-14	33.00	33.60	24.50	46.90	28.10	38.30	40.60	35.70	53.10	58.80	107.05	111.65	101.05	105.75
May 15-17	32.50		28.10		31.05	30.30	40.25	39.70	53.10			114.95		
May 27-30	29.05	31.65	23.75	36.90	34.30	30.45	34.35	28.90	49.95	61.90	89.35	113.80	102.15	83.45
June 3-4	31.55	26.90	31.80	28.85	30.05	31.00	36.85	33.50	51.05	62.50	78.65	106.30	95.45	110.50
June 12-14	29.10	27.55	25.75	33.20		32.90	35.20	31.00	49.05	57.35	83.65	106.85	94.55	93.60
June 20-21	29.15	28.6	27.8	33.65	32.25	30.9	37.85	34.1	47.8	58.3	83.75	107.4	98.75	84.8
July 24-25	31.75	26.9	30.9	35.3	32.85	29.9	37.75	35.5	50.15	66.6	92.3	104	102.1	97.65
Aug 25-27	27.45	22.5	30.45	37	28.5	26.4	32.55	33.9	49.85	48.65	83.7	110.6	111.25	103.45
Sep 25-27	26.45	24.45	26.95	31.5	25.35	34.45	33.45	36.15	45.05	50.7	81.65	112.15	109.8	90.3

Figure C-4 Simultaneous flow profiles, Southern Canal (S-1 to C-5)



	S-18	S-16+S-17	S-14+S-15	S-12	C-6
May 6-7	6.15	39.15	60.15	53.40	62.65
May 12-14	6.20	43.25	65.90	58.15	63.85
May 15-17					
May 27-30	7.05	37.40	39.70	51.35	60.40
June 3-4	4.85	37.05	43.15	46.60	55.15
June 12-14	5.60	37.35	41.25	52.30	53.85
June 20-21	3.95	37.95	41.20	52.45	56.65
July 24-25	4.55	34.45	51.40	53.35	65.35
Aug 25-27	3.80	33.65	44.45	51.05	42.50
Sep 25-27					

Figure C-5 Simultaneous flow profiles, Northern Canal (S-18 to C-6)



	C-7	S-19	S-20	S-21
May 6-7	169.70	214.85	167.80	179.45
May 12-14	126.90	209.15	194.15	169.30
May 15-17	126.10			147.15
May 27-30	126.45	163.85	149.70	156.60
June 3-4	130.40	143.90	157.55	148.45
June 12-14	112.90	149.95	141.55	155.55
June 20-21	128.6000013	156.1000049	157.0999995	
July 24-25	128.4499988	148.3500004	175.4000038	173.2500046
Aug 25-27	130.55	152.05	152.95	141.55
Sep 25-27	138.25	155.05	157.1	141.3

Figure C-6 Simultaneous flow profiles, permanent flume to border (C-7 to S-21)

Puntos de Aforo	May 9	May 14	May 27	May 31	June 5	June 16	June 22	June 27	aug-28	sep-28	Average	Min	Max	Std.dev.
OJO 1 SUR	3.9	4.2		4.0	3.9	3.7	4.1	5.6	4.1	4.5	4.2	3.7	5.6	0.5
OJO 2 SUR	3.0	2.4			2.8	3.2	2.0	2.7	2.0	1.2	2.4	1.2	3.2	0.6
OJO 3 SUR	3.5	3.5		3.1	3.0	2.8	2.8	3.8	2.9	3.3	3.2	2.8	3.8	0.3
OJO 4 SUR	2.5	2.1			2.2	2.5	2.4	2.4	2.2	2.2	2.3	2.1	2.5	0.1
OJO 5 SUR	1.3	1.7			0.9	0.6	0.6	0.8	0.6	0.4	0.9	0.4	1.7	0.4
OJO 6 SUR	8.0	5.0				4.6		4.4	5.3	4.8	5.4	4.4	8.0	1.2
OJO 22 SUR	4.6							2.8	2.0	2.3	2.9	2.0	4.6	1.0
OJO 22 SUR	4.5										4.5	4.5	4.5	0.0
OJO UNION 9-10-11 SUR	1.9	2.0		1.5	1.2	1.5	1.1	1.2	1.1	0.8	1.4	0.8	2.0	0.4
OJO UNION 9-10-11 SUR	1.6	1.6									1.6	1.6	1.6	0.0
OJO - 30 - 84 SUR	6.3	3.9						4.0	3.2	3.2	4.1	3.2	6.3	1.1
OJO - 30 -84 SUR	6.4	3.9									5.1	3.9	6.4	1.2
OJO 31 SUR	3.5	3.8			3.5	3.8	3.2	1.8	4.4	2.7	3.3	1.8	4.4	0.7
OJO - 32-A SUR	2.5	1.0									1.7	1.0	2.5	0.7
OJO - 32-A SUR	2.4	1.0									1.7	1.0	2.4	0.7
OJO 32 SUR	6.2	3.6			3.0	3.9	3.7	2.0	3.8	1.9	3.5	1.9	6.2	1.3
OJO - 35 NORTE	1.6	2.6			1.4	1.5	1.4	1.4	1.9	1.5	1.7	1.4	2.6	0.4
OJO - 35 NORTE	2.3	2.7									2.5	2.3	2.7	0.2
OJO 37-38 NORTE	3.2	3.1			2.9	2.3	3.0	3.2	3.0	3.6	3.0	2.3	3.6	0.3
OJO - 41 NORTE	3.6	4.1		3.4		4.1					3.8	3.4	4.1	0.3
OJO 41 NORTE	3.6	4.1				4.1					3.9	3.6	4.1	0.2
OJO 46 NORTE	3.0	2.3		4.1	1.8	2.4	2.4	2.3	2.6	2.3	2.6	1.8	4.1	0.6
OJO 48 NORTE	1.3	1.2			0.9	1.2	1.2	0.7		1.0	1.1	0.7	1.3	0.2
OJO - 44 NORTE	8.1	8.6		9.0	9.2	9.6	9.8	9.7	9.9	9.3	9.2	8.1	9.9	0.6
OJO - 44 NORTE	9.1	8.7									8.9	8.7	9.1	0.2
OJO 49 SUR	2.0	1.8			2.1	1.8	1.8				1.9	1.8	2.1	0.1
OJO - 50	2.1	2.7									2.4	2.1	2.7	0.3
OJO 50	1.9	2.7			1.4						2.0	1.4	2.7	0.5
OJO 54, NORTE	4.5	5.2									4.8	4.5	5.2	0.4
OJO 59 NORTE	2.5	1.8		2.3	2.0	2.6	1.3	2.1	2.5	2.9	2.2	1.3	2.9	0.5
OJO - S7	1.4	1.8									1.6	1.4	1.8	0.2
OJO-S7	1.4	1.8									1.6	1.4	1.8	0.2
OJO 64 - SUR	3.7	4.3		5.3	5.0	3.4	3.5	6.1			4.5	3.4	6.1	1.0
Sum (l/s)	80.4	69.7	0.0	30.4	42.9	51.7	41.8	54.2	49.0	44.0	70.9			

Table C-2 Table of simultaneous spring flow measurements (in l/s)

C.3 Continuous canal flow data

C.3.1 The data collection campaign

Six new V-notch weirs were installed at strategic locations in the system and equipped with water level sensors (pressure transducers). Subsequently, discharge – water level relations were established during June- August 2017 by comparing different water levels with corresponding flows measured by propeller measurement in reliable cross sections downstream of each weirs.

Calibration was performed by controlling upstream flows and a number of corresponding values of flow and water level were measured covering the low to normal flow range at each site. For the low flow ranges, the flow was calculated by collecting the volume in a container for a period of time. For the higher flow ranges, micro propeller measurements were used. The rating curves were approximated by curve fitting to the set of water level and flow data.

The same type of water level sensor as used in the new weirs was installed at the existing flume at the old desiltation chamber (station C7). Measurement of water levels at 15 minutes intervals were taken during the period late June to end of September 2017 and corresponding discharges calculated by SENAMHI who has been in charge of the measurement campaign.

C.3.2 The rationale of the campaign

The rationale of the collection of continuous flows at strategic locations are:

4. To determine the flow rate as exact as possible at strategic locations in the canals of the Silala Springs System.
5. To reveal the temporal variation of the flow rate
6. To evaluate the daily flow variations and to detect possible short-term impact of precipitation event. The daily variations are important to evaluate the simultaneous observation taken at more locations and may also open for an independent, although not isolated, evaluation of the evaporation rates
7. To ease the observation of possible surface water impacts from the planned borehole pump tests.

C.3.3 Observations on the received data

A time series of the received data are shown in Figure C-8 for the stations C1 to C4 representing the conditions in the southern wetland in Figure C-10 for the stations C4-C7 illustrating the flow contributions in the ravine and from the Northern wetland

The water levels have been registered every 15 minutes and the raw discharges calculated with the same frequency.

A rather constant pattern of daily flow variations, with the highest flows after midday and lowest flows during nights, are visible in all the flow series. Although the amplitudes of the flow variations vary from series to series and sometimes also significantly with time, all series shows a general pattern of rather small and periodic daily variations, superimposing a much larger and relatively constant base flow component.

Abrupt changes in the base flow values as well as the daily variations are also noted. To further illustrate these base flow changes, the series have been averaged on a daily basis and the most obvious measurement errors substituted with missing values as shown in Figure C-9.

Abrupt changes in the base flow levels occurs at several weirs at the end of June, around July 29th and August 24th. While the base flows during the period (from the start of records to the first abrupt change) seem to be relatively stable, it is decreasing and sometimes reaching a new constant level in most of the stations, before exerting a new upwards abrupt jump. No explanation or comments on this behavior have been given by SENAMHI.

The abrupt changes in base flow only allow to analyse the series in the two periods: 1 July – 28 July and 29 July – 23 Aug. In these two periods, the individual series are rather constant and the sum of the flows from the two main branches are within 4% of the observed confluence flow at the de-siltation chambers (C7). After August 23rd, the flows both in C6 (Northern Branch) expels spurious variations which are not observed in the neighboring weirs. The confluence flows are on average 18% higher than the observations at the de-siltation chambers.

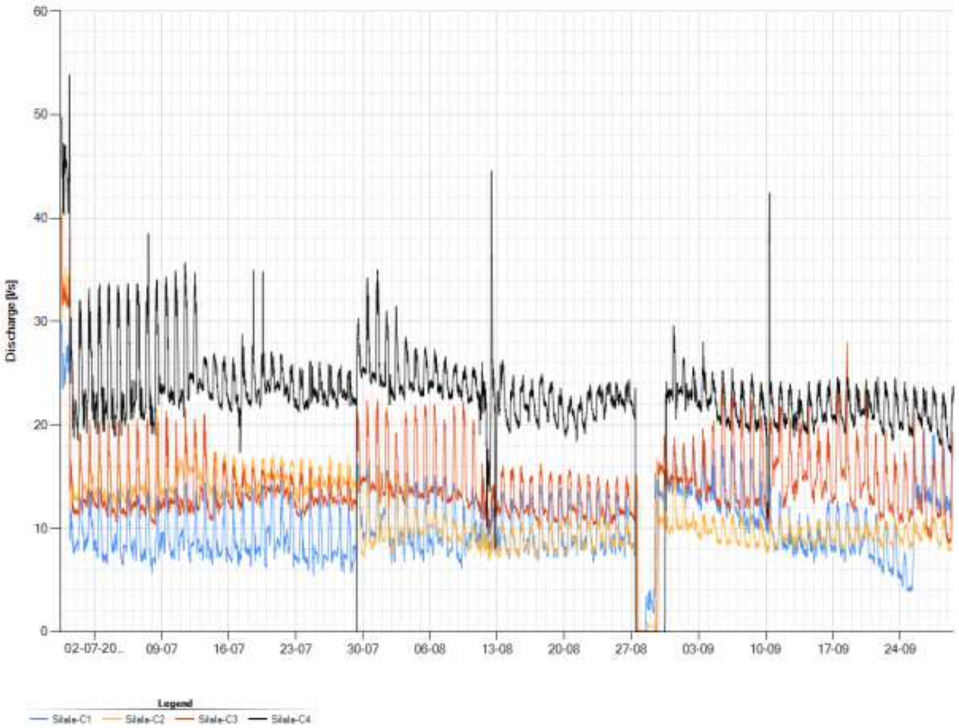


Figure C-7 Measured continuous flows in weirs C1-C4 located in the Southern wetland

Figure C-8 Measured flows in weirs C1-C4 located in the Southern wetland averaged to daily values and with obviously spurious data replaced by missing values (red crosses)

Measured flows

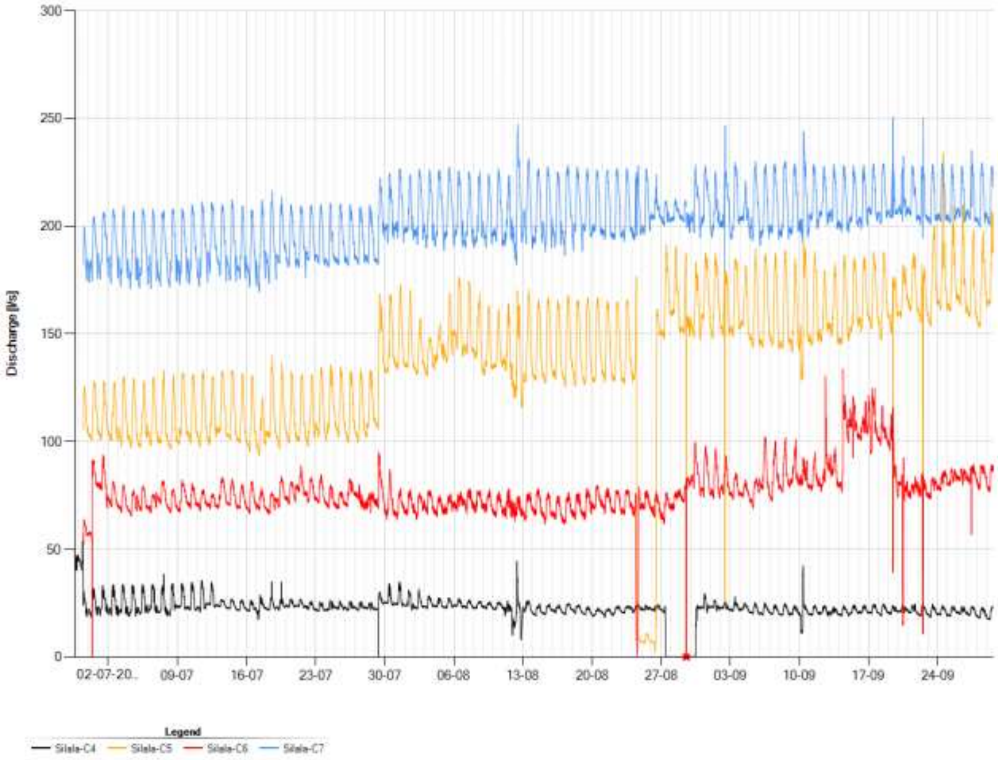


Figure C-9 Measured continuous flows in the weirs C4-C7 illustrating the flow contributions in through the ravine and from the Northern wetland.

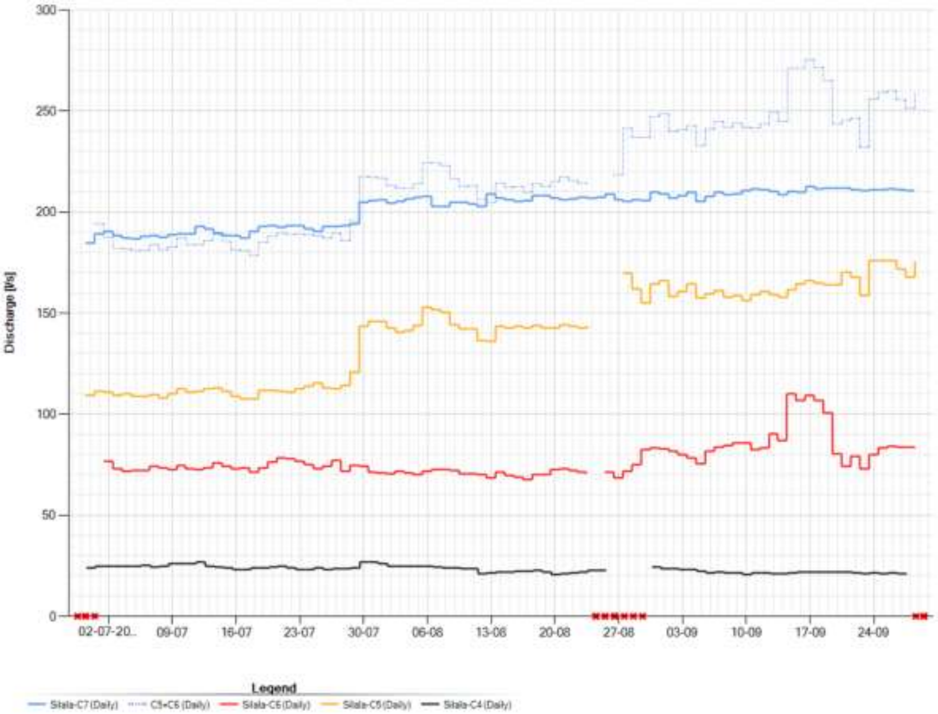


Figure C-10 Measured continuous flows in the weirs C4-C7 illustrating the flow contributions in through the ravine and from the Northern wetland averaged to daily values and with obviously spurious data replaced by missing values (red crosses)

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C.3.4 Conclusions on the continuous flow data

All series shows a high base flow level, superimposed with a smaller periodic daily variation peaking around midday. In all the series, the base flow exhibits abrupt jumps at certain dates and sometimes trends in the intermediate periods. None of which can be assigned to climatic events and must therefore be due to the equipment.

The daily variations vary slightly in amplitude for C7, the permanent weir, where the variation over the day is 25-35l/s. The daily variations cannot explain the spread in flows at the simultaneous measurements, which at C7 approximate 65 l/s. The flows peaks at midday at all stations and can therefore not be due to evaporation losses which peak at the same time. Hence, the daily variation must be assigned to freezing and thawing of the water in the wetlands.

For C5-C7, base flows seems rather consistent from 1-28 July and 29 July-23 Aug. The last period (24 Aug – 29 Sept) seems inconsistent with combined flows from C5 and C6, being 18% higher than the flows in C7. In the first two periods, this combined flow is within 4% of C7.

The data from the two periods confirms contributions from the Southern and Northern wetlands to be respectively ca. 60% and 40% of the confluence flow and that the flow contribution in the ravine between C4 and C5 is significant.

The most trustworthy period is deemed to be the one from 1 to 28 July 2017 where the records have the smallest trends and variations.

Location		C4	c5-c4	c5	c6	c5+c6	c7
Simultaneous	Average Flow (l/s)	60.6	38.1	98.7	57.6	156.3	131.8
Simultaneous	*Fraction of (C5+C6)*	*0.39*	*0.24*	*0.63*	*0.37*	*1.00*	*0.84*
Continuous Weirs	Average Flow (l/s) 01 Jul -> 28 Jul	24.3	87.0	111.3	74.1	185.4	190.4
Continuous Weirs	*Fraction of (C5+C6) 01 Jul -> 28 Jul*	*0.13*	*0.47*	*0.60*	*0.40*	*1.00*	*1.03*
Continuous Weirs	Average Flow (l/s) 29 Jul -> 23 Aug	23.2	120.4	143.6	70.9	214.5	205.8
Continuous Weirs	*Fraction of (C5+C6) 29 Jul -> 23 Aug*	*0.11*	*0.56*	*0.67*	*0.33*	*1.00*	*0.96*

Figure C-11 Recorded water levels at the C-1 – C-7 flumes, July-September 2017 (SENAMHI)

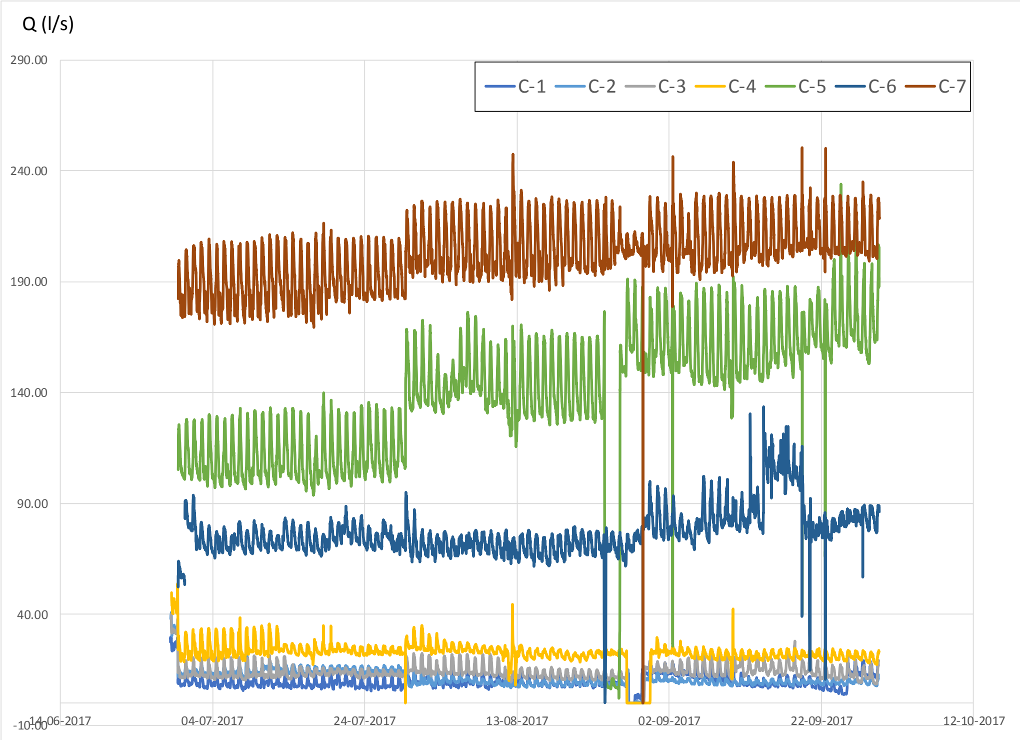

Figure C-12 Recorded flows at the C-1 – C-7 flumes, July-September 2017 (SENAMHI)

C.4 Permanent flume flow data

While qualitative descriptions of historical flows in the system are available from various sources (Reference 1, Reference 2, Reference 8, Reference 9 of the main report), long-term quantitative flow time series are only available at two locations, one at the old siltation chambers in Bolivia around 700m upstream of the border and another close to the border on the Chilean side.

While these continuous flow time series are of paramount importance for the study as information on the total outflow of the spring system as a whole, they do not contain sufficient information to understand and quantify the processes in the various parts of the system. Such understanding is important to quantify how the canalisation and drainage of wetlands may have affected the natural flows at the border and to assess water requirements of a healthy natural wetland.

The continuous flow series have therefore been supplemented by a number simultaneous propeller measurements of the canal flows at various locations and dates in the canal system upstream the border. This campaign has been intensified and streamlined during May and June 2017 to improve the basis for this flow assessment.

C.5 Long term flow series from Chile and Bolivia

Previous to the initiation of the intensive flow monitoring program, time series of the flows in the Silala primary canal were only available at two locations, one at the old siltation chambers in Bolivia around 700m upstream of the border and the other from Chile's Direción General Del Agua (DGA), close to the border on the Chilean side. An initial assessment of the flows from the two series was made in the surface water report (Reference 10) based on the data available by mid-June 2017. The present section gives an update of the analyses accounting for the additional data available by October 15th, 2017.

The two series would be expected to measure almost the same flow rates. Even though some flow losses between the two stations have been detected by the simultaneous flow observations, as described in the previous section, the two series would be expected – as a minimum – to show the same long-term variation and to react in the same way to hydrological events.

Flow records for the flume at the siltation chambers (Bolivian Territory)

The gauging site is a flume in a rectangular concrete trench constructed along the old siltation chambers and equipped with a V-notch and automatic (electronic) water level registration by floater with resolution around one millimetre.

Figure C-13 The existing flow-gauging flume at the old de-siltation chambers

The canal is not expected to carry substantial peak flows from sudden runoff events and the station should therefore be almost ideal for measuring the flows in the canal. Water levels are measured both manually (two times a day) by the military personnel and automatically (hourly).

Each of the two water level series has been converted to flows by a formula relating specific water level observations to flows and are shown with different temporal resolution in Figure C-14, Figure C-15 and Figure C-16. Particularly for V-notch weirs, such as the one installed here, standard formulae are regarded to be quite precise with uncertainties as low as 3-5 %.

It is noted that the two series (shown as blue and yellow lines in the figures) are characterised by a large constant base flow of 160-200 l/s, which clearly indicates that the canal is fed almost entirely by groundwater springs. However, many abrupt jumps in the calculated flows, sometimes from one time step to the next, are also observed. These jumps originate from similar jumps in the water level observations and it has, in general, not been possible to relate them to hydrological events or seasonality.

Consequently, the uncertainty they introduce must be assigned to uncertainty in the observations, maybe due to jamming of the float or sediment deposition in the stilling canal. The uncertainty in the two series is substantial, in the order of 25-30 % of the flow rate. This might also point out to possible faults in the electronic registration.

It was therefore decided to double the water level sensor in the weir with a pressure sensor of the same type as those installed in the new continuous weirs and that temporally overlapping data from both sensors should be collected during 2017. Unfortunately, the old sensor has not been reporting since start of June 2017 so no overlapping period can be analysed.

Data from the new sensor is shown on the figures in dark green on the above-mentioned figures. Although the observations from the new pressure sensor start at the same level as the old automatic floater-based device (of mark: Thalimedes), the pressure sensor increases with time and has an abrupt jump around June 29th (at the same time as the other pressure sensors). The increasing trend continues after the jump resulting in flow values around 210 l/s by the end of September. This is still less than the sum of the two upstream weirs (C5 and C6) that should represent the same flow as the permanent flume in question (C7) and in the end of the period higher that measured manually (200l/s rather constantly after May 2017)

It is noteworthy that the upward trend in the observations from the new sensor is in contradiction with the observations from the DGA gauge in Chile, which shows an abrupt fall from around 200 l/s to less than 106 l/s in the same period.

So even the new sensors still leaves the flow assessment at the border with a significant uncertainty.

Flow records from Dirección General de Agua (DGA), Chile

The DGA records cover the period from 2001 to 2017, a much longer period than the Bolivian series.

The data is illustrated as red lines in Figure C-14, Figure C-15 and Figure C-16. This series also includes abrupt jumps and does not resolve the problem of uncertainty. The DGA series indicate flow values around 15-25 l/s lower than the Bolivian series in large parts of the observation period but from January to end July 2017, it measures the same flow levels in the order of 200 l/s. During August, the flow level decreases rapidly to a level in the order of 160 l/s contradicting the observations in Bolivia.

As described in the foregoing section, sSince the simultaneous measurements indicate flow to be slightly increasing from around 150 l/s at the siltation chambers to around 160l/s at the border, it seems unlikely that the generally lower values of the DGA series are due to flow losses between the two gauging sites.

Although both series shows significant variations over time, 125-225 l/s for the Chilean series and 160-210 for the shorter Bolivian series, neither shows clear sign of seasonality or a direct correlation with local rainfall.

Measured flows

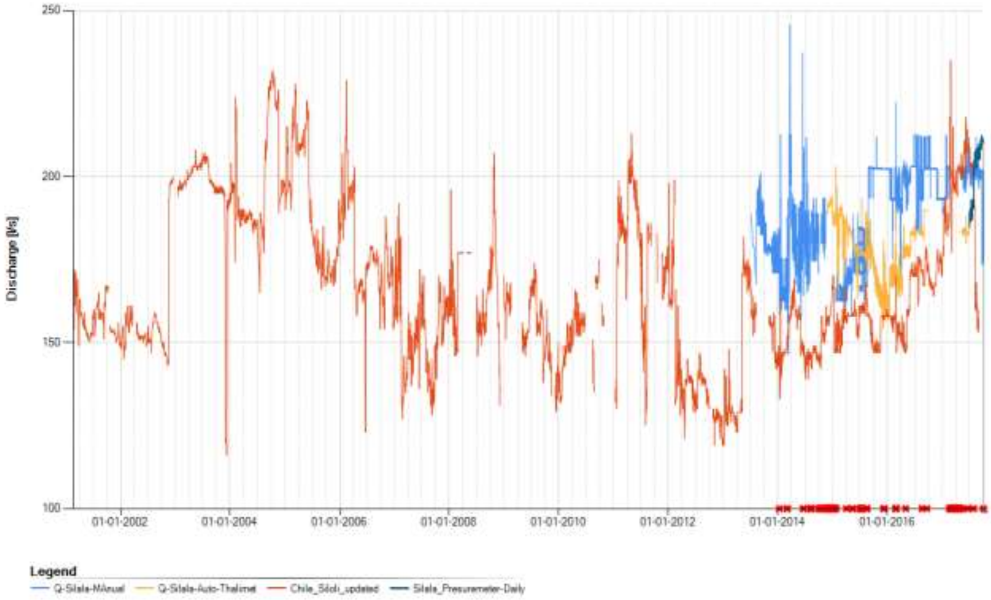

Figure C-14 Long-term series of Silala flows close to border In Chile and at the desiltation chambers and at DGA's Siloli Station in Chile close to the border upstream of the Fcab offtake

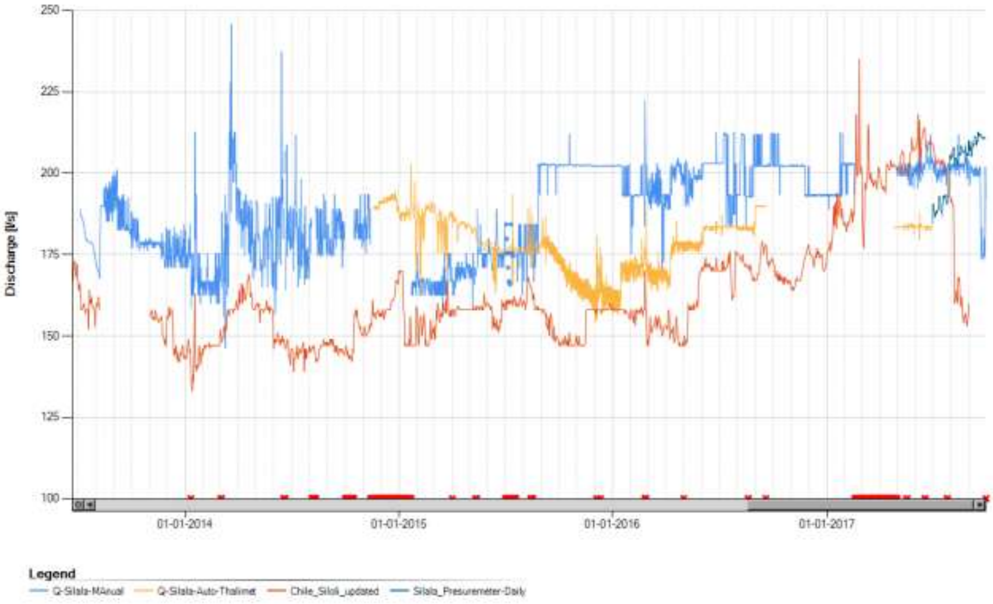

Figure C-15 Long-term series of Silala flows close to border In Chile and at the desiltation chambers and DGA's Siloli Station in Chile close to the border upstream of the Fcab offtake. Data after 2013

Figure C-16 Long-term series of Silala flows close to border In Chile and at the desiltation chambers and at DGA's Siloli Station in Chile Close to the border upstream of the Fcab offtake. Data from 2017.

Annex XVI

SERNAGEOMIN (National Geology and Mining Service), 2019.
A Brief Review of the Geology presented in Annexes of the Rejoinder of the Plurinational State of Bolivia

A BRIEF REVIEW OF THE GEOLOGY PRESENTED IN ANNEXES OF THE REJOINDER OF THE PLURINATIONAL STATE OF BOLIVIA

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GLOSSARY

This glossary of geologic terms is based on the glossary in Earth: An Introduction to Geologic Change, by S. Judson and S.M. Richardson (Englewood Cliffs, NJ, Prentice Hall, 1995). Where possible, definitions conform generally, and in some cases specifically, to definitions given in Robert L. Bates and Julia A. Jackson (editors), Glossary of Geology, 3rd ed., American Geological Institute, Alexandria, Virginia, 1987. Additionally, used the bibliography of Le Maitre (2002) and Bull and McPhie (2007) for the specific terms.

^{39}Ar/^{40}Ar method: A different method that was invented to supersede K/Ar method, to be more accurate.

Amphibole: Any of a group of dark green to black mineral of the often found in igneous rocks that contain calcium, sodium, magnesium, aluminum, or iron ions or a combination of them.

Andesite: A fine-grained volcanic rock of intermediate composition, consisting largely of plagioclase and one or more mafic minerals.

Assemblage: The collection of minerals that characterize a rock or a facies.

Basalt: A dark colored extrusive igneous rock composed chiefly of calcium plagioclase and pyroxene. Extrusive equivalent of gabbro, underlies the ocean basins and comprises oceanic crust.

Biotite: A generally black or dark green form of mica that is a constituent of crystalline rocks and consists of a silicate of iron, magnesium, potassium, and aluminium with excellent cleavage.

Caldera: A large, basin-shaped volcanic depression, more or less circular in form. Typically steep-sided, found at the summit of a shield volcano.

Cenozoic: Geological Era that meaning "new life", is the current and most recent of the three Phanerozoic geological eras, following the Mesozoic Era and extending from 66 million years ago to the present day.

Conformable: Lying parallel to, rather than cutting across surrounding strata.

Crystal: The multi-sided form of a mineral, bounded by planar growth surfaces, that is the outward expression of the ordered arrangement of atoms within it.

Debris flow: Fast-moving, turbulent mass movement with a high content of both water and rock debris. The more rapid debris flows rival the speed of rock slides.

Devonian: A geologic period and system of the Paleozoic, spanning 60 million years from the end of the Silurian, 419.2 million years ago (Mya), to the beginning of the Carboniferous, 358.9 Ma.

Dextral fault (right lateral-fault): The sense of displacement in strike-slip fault zones where one block is displaced to the right of the block from which the observation is made.

Diaclase: Planar discontinuities involving no relative displacement of the adjacent blocks.

Dome: An uplift or anticlinal structure, roughly circular in its outcrop exposure, in which beds dip gently away from the center in all directions.

Eutaxitic texture: Bedding-parallel alignment of fiamme in welded ignimbrite (see Bull and McPhie, 2007).

Extrusive: Pertaining to igneous rocks or features formed from lava released on the Earth’s surface.

Fault: The fracture or surface along which rock units break apart or rupture, and along which there has clearly been movement of the rock on either side. A fault plane can be paper-thin or it can be a zone, metres wide.

Fiamme: Aligned, “flame-like” lenses found in welded ignimbrite (see Bull and McPhie, 2007).

Hanging wall block: The body of rock that lies above an inclined fault plane.

Hercynian: A geologic mountain-building event caused by Late Paleozoic continental collision between Euramerica (Laurussia) and Gondwana to form the supercontinent of Pangaea.

Igneous rock: A rock that has crystallized from a molten state.

Joint: A surface of fracture in a rock, without displacement parallel to the fracture.

Lava: Molten rock that flows at the Earth's surface.

Magma: Molten rock, containing dissolved gases and suspended solid particles. At the Earth's surface, magma is known as lava.

Mesozoic: An interval of geological time from about 252 to 66 million years ago. It is also called the Age of Reptiles and the Age of Conifers.

Mineral: A naturally occurring inorganic solid that has a well-defined chemical composition and in which atoms are arranged in an ordered fashion.

***nanoTesla* (*nT*):** Unit of measurement of magnetic field strength; T = Tesla (Maxwell / cm^2), and $nT = 10^{-9}T$).

Normal fault: A geological fault where the hanging wall block has moved downwards relative to the foot wall block.

Oligocene: A geologic epoch of the Paleogene Period and extends from about 33.9 million to 23 million years before the present (33.9±0.1 to 23.03±0.05 Ma).

Olivine: A group of high temperature, dark magnesium iron silicate mineral.

Onlap: The termination of shallowly dipping, younger strata against more steeply dipping, older strata.

Ordovician: A geologic period and system, the second of six periods of the Paleozoic Era. The Ordovician spans 41.2 million years from the end of the Cambrian Period 485.4 Ma to the start of the Silurian Period 443.8 Ma.

Petrography: A branch of petrology that focuses on detailed descriptions of rocks.

Pyroclastic: Pertaining to clastic material formed by volcanic explosion or aerial expulsion from a volcanic vent.

Pyroclastic flow: A dense, hot (sometimes incandescent) cloud of volcanic ash and gas produced in a Pelean eruption.

Pyroxene: Any of a group of igneous-rock-forming silicate minerals of black color, that contain calcium, sodium, magnesium, iron, or aluminum.

Reverse fault: A dip-slip fault on which the hanging wall block is offset upward relative to the foot wall block.

Rock: An aggregate of one or more minerals in varying proportions.

Salt diaper: Type of geologic intrusion in which a more mobile and ductily deformable material (salt) is forced into brittle overlying rocks.

Silica: Silicon dioxide (SiO2) as a pure crystalline substance makes up quartz and related forms such as flint and chalcedony. More generally, silica is the basic chemical constituent common to all silicate minerals and magmas.

Silurian: A spanning 24.6 million years from the end of the Period, at 443.8 Ma, to the beginning of the Period, 419.2 Ma.

Structural domain: A portion of land, a geographically delimited volume with a longitude, latitude and height, a set of lithologies, kinematically related and delimited by a set of major structures (faults) with similar structural characteristics.

Sinistral fault (left lateral-fault): The sense of displacement in strike-slip fault zones where one block is displaced to the left of the block from which the observation is made.

Structural Geology: Structural Geology aims to characterise deformation structures (geometry), to characterize flow paths followed by particles during deformation (kinematics), and to infer the direction and magnitude of the forces involved in driving deformation (dynamics).

Structural model: A self-consistent framework providing a coherent explanation for the observed facts and allows to make verifiable predictions. A model is proven wrong if key predictions are not verified.

Synsedimentary: That forms or grows within a sediment during sedimentation.

TAS: A binary diagram ("Total Alkali versus Silica") of the content of silica (axis X) and content of total alkali (oxides of sodium and potassium) (axis Y) recommended for the classification of the volcanic rocks.

Tectonics: A general term that refers to the large-scale movements and deformation of the Earth's crust.

Tertiary: Geological Period widely used, but obsolete term for the geologic period from 66 to 2.6 Ma.

Texture: The general appearance of a rock as shown by the size, shape, and arrangement of the materials composing it.

Tuff: A general term for all consolidated pyroclastic rock. Not to be confused with tufa.

Unconformity: Cutting across surrounding strata.

Vitrophyre: A term for variety of porphyry in which the groundmass is glassy. Also applied to the basal portions of many welded ignimbrites (see Le Maitre, 2002).

Vesicular: A textural term applied to an igneous rock containing abundant vesicles, formed by the expansion of gases initially dissolved in the lava.

Volcanic ash: The dust-sized, sharp-edged, glassy particles resulting from an explosive volcanic eruption.

Volcano: A vent in the surface of the Earth, from which lava, ash, and gases erupt, forming a structure that is roughly conical.

Welded tuff: A pyroclastic rock in which glassy clasts have been fused by the combination of the heat retained by the clasts, the weight of overlying material, and hot gases.

σ_1: The state of major or main tension acting on a material point.

TABLE OF CONTENTS

1. INTRODUCTION

On 15 May 2019 Bolivia submitted to the International Court of Justice (ICJ) the Rejoinder of the Plurinational State of Bolivia (BR) in the Dispute over the Status and Use of the Waters of the Silala (Chile v. Bolivia). In this context, the National Director of the Dirección Nacional de Fronteras y Límites del Estado (DIFROL) of the Ministry of Foreign Affairs of Chile, Mrs. Ximena Fuentes, asked SERNAGEOMIN for its technical opinion of the geological content of the Rejoinder of Bolivia.

A major problem for the analysis of the several documents annexed to the BR that concern the geology of the Silala River area is that the quality of the Bolivian geological information is in many cases poor, inconsistent and confusing and is not adequate, in our opinion, to support the geological conclusions determined by Bolivian geologists.

This report discusses the validity of some of the geological statements, radiometric dates and assumptions made by Bolivian geologists in their reports, which caused them to arrive at their interpretations of the stratigraphy, rock petrography and structural geology. The geological understanding of the Silala Basin is fundamental to understanding the hydrogeology of the region and developing a conceptual model of groundwater flow to the Bolivian wetland springs and unseen groundwater flow across the international border into Chile.

This report is based on study and review of the following documents that were presented with the BR:

1. Annex 23.5: F. Urquidi, "Technical analysis of geological, hydrological, hydrogeological and hydrochemical surveys completed for the Silala water system", June 2018. (BR, Vol. 3, pp. 233-332).
2. Annex 23.5, Appendix a: SERGEOMIN (National Service of Geology and Mining), Study of the Geology, Hydrology, Hydrogeology and Environment of the Area of the Silala Springs, June 2000-2001, Final Edition 2003. (BR, Vol. 3, pp. 333-401).

3. Annex 23.5, Appendix b: SERGEOMIN, "Structural Geological Mapping of the Area Surrounding the Silala Springs", September 2017. (BR, Vol. 4, pp. 5-136). [1]
4. Annex 23.5, Appendix c: Tomás Frías Autonomous University, (TFAU), "Hydrogeological Characterization of the Silala Springs", 2018. (BR, Vol. 4, pp. 137-462).
5. Annex 24: DHI, "Analysis and assessment of Chile's reply to Bolivia's counter-claims on the Silala Case", March 2019. (BR, Vol. 5, pp. 5-46).

The main aims of the review were to establish the underpinning geological science behind the Bolivian experts' interpretation of the stratigraphy of the geological succession and the ages of the deposits in the area of the Silala River and ravine in Bolivia as well as the geological structure, including the evidence for the geological faults that have been interpreted as existing in the area. The stratigraphy and geological structure have been used to underpin an interpretation of the hydrogeology of the area, develop a conceptual understanding of groundwater flow and hence construct a numerical model of the hydrology and hydrogeology of the Silala wetlands and springs, referred to later as Bofedales Norte (Cajones) and Bofedales Sur (Orientales).

2. STRATIGRAPHY AND GEOLOGICAL MAPPING OF BOLIVIA

The stratigraphy presented by Bolivia in the technical geological annexes, either in maps or in stratigraphic columns, is inconsistent with the geological units defined in Chile by Chilean geologists and contains internal inconsistencies with Bolivia's own data and maps presented in the annexes of the Bolivian Rejoinder.

[1] The SERGEOMIN, 2017 report, including annexes C and D, was submitted by Bolivia on 22 November 2018, in response to Chile's data request dated 5 November 2018. Bolivia resubmitted the SERGEOMIN, 2017 report with its Rejoinder, but this time only the first two (out of 95) pages of Annex C were included and Annex D was excluded entirely. Hence, the references contained in the present report to Annex C and Annex D to SERGEOMIN, 2017, refer to annexes C and D as filed on 22 November 2018. For the convenience of the Court, Annex C to SERGEOMIN, 2017 is resubmitted as Appendix A and Annex D to SERGEOMIN, 2017 is resubmitted as Appendix B of the present report.

The following provides a series of observations on the Bolivian stratigraphy, followed by a series of observations on Bolivian petrography:

2.1 Bolivian stratigraphy

The unit "Silala Ignimbrite" (Bolivian name, hereinafter "Bol"), of dacitic-andesitic composition, is assigned to the Upper Miocene (7.8-6.6 Ma) (BR, Vol. 3, p. 248; BR, Vol. 4, pp. 39, 43 and 46) and Bolivian geologists affirm that it constitutes the regional basement (BR, Vol. 4, pp. 39, 125 and 148). According to the geological maps presented by Bolivia (BR, Vol. 3, p. 245; BR, Vol. 4, pp. 113-115) for the Silala Ignimbrites (Bol) there is an age of 7.8±0.3 Ma obtained from a sample located south of Bofedales Norte (Cajones) (BR, Vol. 4, pp. 113-115).

Table 1 summarizes the stratigraphy of the Silala Ignimbrites (Bol) unit, with the ages indicated for each subunit and the differences between the descriptions among the different studies conducted by Bolivia.

References	**SERGEOMIN (2017)**	**TFAU (2018)**	**Observations**
Annex	**23.5b**	**23.5c**	
Silala Ignimbrites (Bol)	Silala Ignimbrite 3 (Nis-3)	Dacitic Ignimbrites with Na-Plagioclase	6.6±0.5 Ma
	Debris flow (Nfd2)		
	Silala Ignimbrite 2 (Nis-2)	Dacitic Ignimbrite with Andesitic Clast	
	Crystal vitreous tuff (Ntcv)		
	Silala Ignimbrites 1	Hypocrystaline Dacitic Ignimbrites	correlation with 7.8±0.3 Ma
	Debris flow 1 (Nfd1)		

Table 1. Summary of the stratigraphy of the Silala Ignimbrites (Bol) of Annex 23.5b (BR, Vol. 4, pp. 44-51) and Annex 23.5c (BR, Vol. 4, pp. 157-159) documents.

2.1.1 Observations

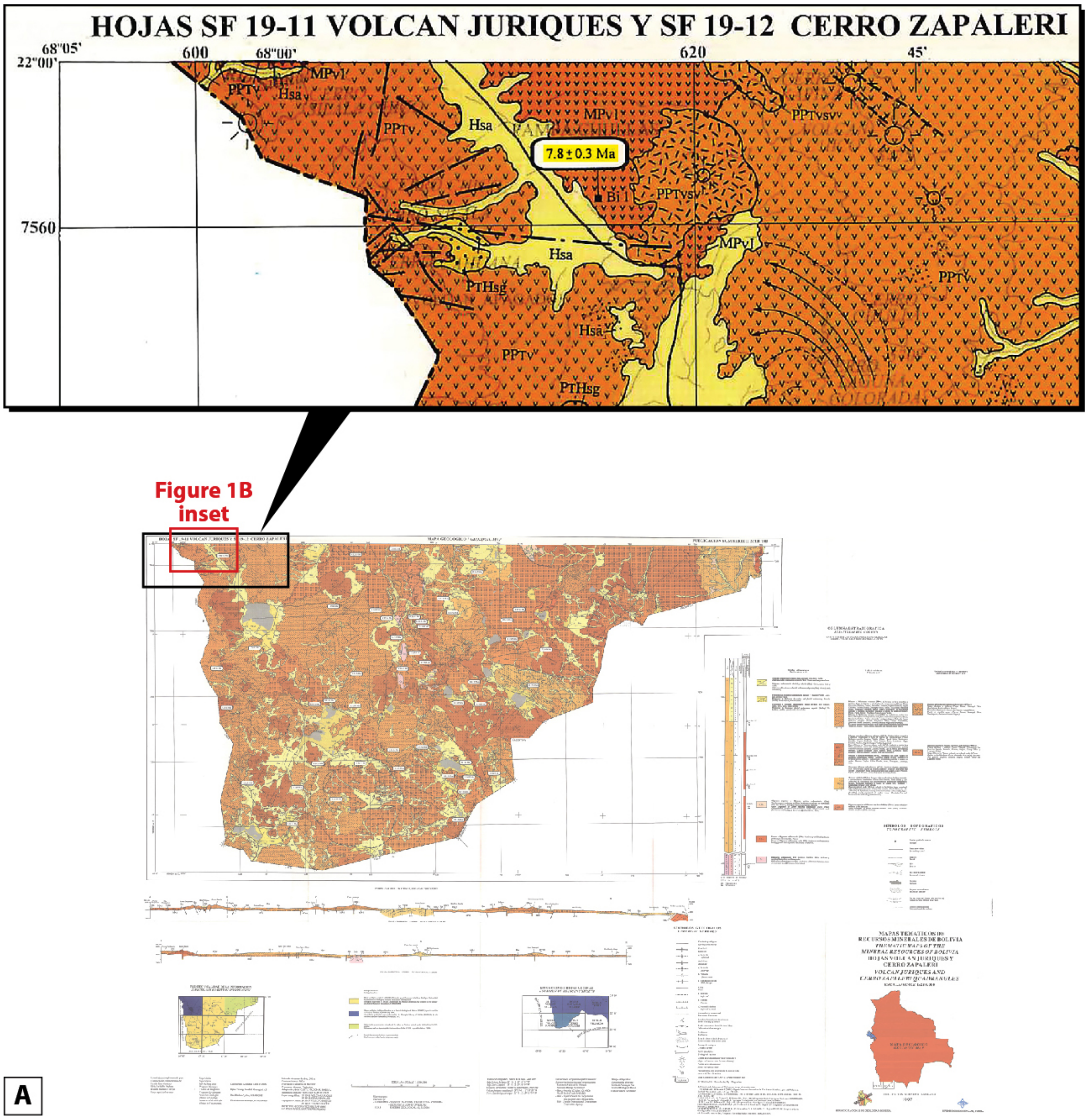
The so-called Silala Ignimbrites (Bol) correspond to several pyroclastic flows of contrasting chemical composition, radiometric age and stratigraphic position. In Annex 23.5c (BR, Vol. 4, pp. 157-160) the Silala Ignimbrites (Bol) succession is reported to have three units (Table 1), from the oldest to youngest: Dacitic-Hypocrystalline Ignimbrite, Dacitic ignimbrite with andesitic clasts and Dacitic Ignimbrites (with Na plagioclase). The Dacitic ignimbrite with andesitic clasts is important because they "[…] pertain to the first Inacaliri volcanic event" (BR, Vol. 4, p. 158) and are the source of the andesitic composition. However, since the age of the Inacaliri volcano lavas is 5.84±0.09 Ma (Almendras et al., 2002) the Dacitic Ignimbrite with andesitic clasts must be younger, indicating that Bolivia's age of the overlying Dacitic Ignimbrite with Na Plagioclase (6.6±0.5 Ma) must be incorrect.

On the basis of our field observations in Chile, photointerpretation of satellite images and observation of photographs in annexes of Bolivian Rejoinder, it is clearly observed that the unit of the pyroclastic flow that crops out along the course of the Silala River in Chile, corresponding to the Silala Ignimbrite (Chilean name, herein after Chi) can be traced with complete confidence in the continuity of outcrop beyond the international border and to the Bofedales Sur (Orientales) in Bolivia. This deposit corresponds to several flow units, of andesitic composition, which as a whole constitutes a single cooling unit. In addition, it includes several slag fluxes, with centimetre to decimetre sized fragments of vesicular andesitic slag, which according to the Bolivian geology corresponds to the Debris Flows 1 and 2 units (BR, Vol. 3, pp. 250-251; BR, Vol. 4, pp. 44 and 49). The Silala Ignimbrite (Chi) is from the Lower Pleistocene and was dated at 1.61±0.068 Ma ($^{40}Ar/^{39}Ar$ in plagioclase; Blanco and Polanco, 2018). This is significantly younger than the ages of 7.8±0.3 Ma and 6.6±0.5 Ma assigned by Bolivia to the so-called Silala Ignimbrites (Bol).

The age of 7.8 Ma for the Silala Ignimbrites (Bol) comes from a regional context and has been extrapolated to this location (BR, Vol. 4, p. 149), near the "confluencia" (confluence in English) area of the Cajones and Orientales ravines.

In fact, in the regional geological map of the Volcán Juriques and Cerro Zapaleri area, scale 1:250,000 (Ríos et al., 1997) an age of 7.8±0.3 Ma (K-Ar in biotite) is attributed to Baker and Francis (1978), and located on that map 16.5 km SE of Bofedales Norte (Cajones), in an ignimbrite field (Figure1A). However, according to the original work of Baker and Francis (1978), this age corresponds to andesitic lavas located 8 km E of the hill Silala Grande (sample B51). On the 2017 map found in BR, Vol. 4. p. 115, this age is correctly located in the lava of the La Apacheta-Cerro Chico hills (Figure 1B, Age 1). According to this last map, a large part of this field of ignimbrites corresponds to the unit "Tobas Pastos Grandes" (Ntpg), dated at 3.2±0.4 Ma (biotite) (Figure 1B Age 2). From this discussion it is clear that there is considerable inconsistency between the maps presented in the Bolivian Rejoinder and an erroneous interpretation of the date for the Silala Ignimbrites (Bol) has been made.

On the other hand, 6.5 km E of Bofedales Sur (Orientales), an age of 6.6±0.5 Ma is presented for the unit "Silala Ignimbrite 3" (Nis-3) (biotite, BR, Vol. 4, p. 115) (Figure 1B Age 3). However, to the ENE of Bofedales Sur (Orientales), it can be seen in Figure 2 (prepared by the authors of this report using satellite imagery) that the Silala Ignimbrite (Chi) lies under the 1.48 Ma andesitic lava (Figure 1B, Age 4) flow and this deposit is in unconformable contact (*onlap*) with the Silala Ignimbrite 3 (Nis-3) (Bol), which is the uppermost ignimbrite unit described by the Bolivian geologists. This is quite clearly not the youngest ignimbrite in the sequence because the Silala Ignimbrite (Chi) overlies this sub-unit, and as already shown (see above) the age of 6.6 Ma must be incorrect. The Silala Ignimbrite (Chi) is not recognised in any Bolivian maps or SERGEOMIN reports.



HOJAS SF 19-11 VOLCAN JURIQUES Y SF 19-12 CERRO ZAPALERI
68°05'
22°00'
600
68°00'
620
45'
7560
MPvl
PPTv
Hsa
7.8 ± 0.3 Ma
Bi 1
PPTvs
PPTvsv
PTHsg
Figure 1B inset
A

6

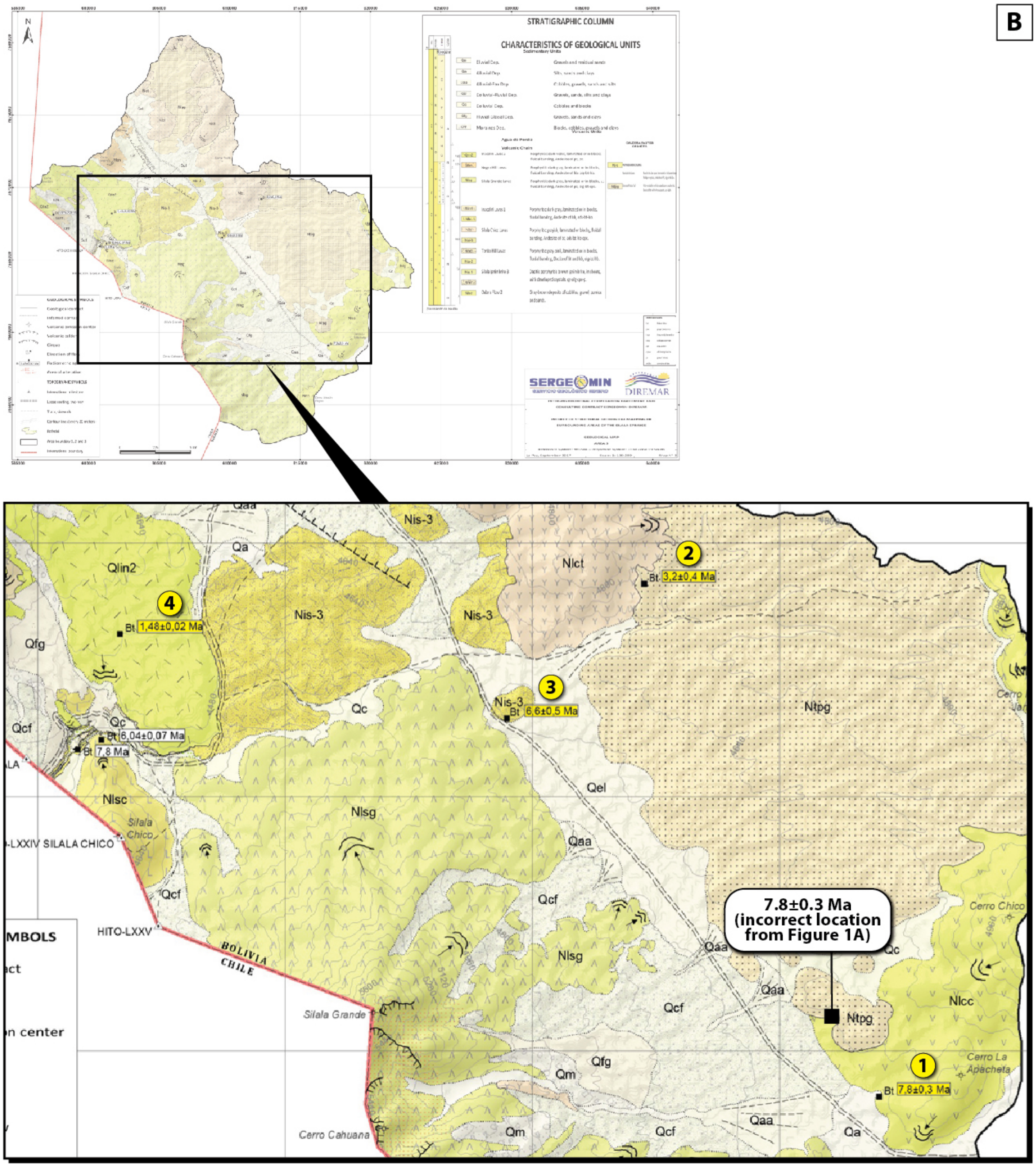


Figure 1. Source of ages for the Silala Ignimbrites (Bol). The origin of the age of 7.8 Ma of Baker and Francis (1978) extrapolated to this unit in the area of the Silala River, has been erroneously mapped in Volcán. Juriques Cerro Zapaleri map (A), but rectified on the 2017 map of Annex 23.5b (BR, Vol. 4, p. 115) (Figure 1B, Age 1). Part of what was mapped as Silala Ignimbrites corresponds to the 'Toba Pasos Grande', age 3.2 Ma (Figure 1B, Age 2). The age of 6.6 Ma (Figure 1B, Age 3) corresponds to the Silala Ignimbrite 3 (Bol) unit (Nis-3).

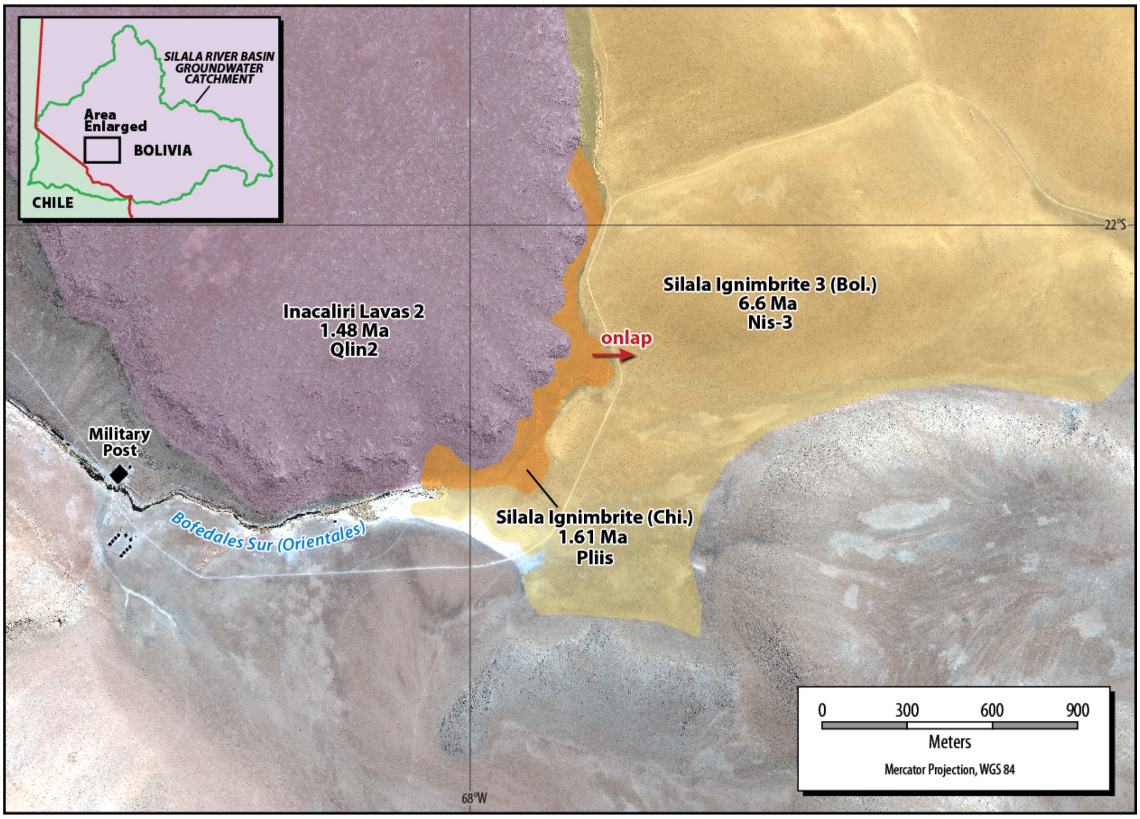


Figure 2. Unconformity or onlap relationship between the Silala Ignimbrite (Chi) and the Silala Ignimbrite 3 (Bol), located east of Bofedales Sur (Orientales).

It is also mentioned that the Silala Chico (Bolivian name, Cerrito de Silala in Chile) volcanic dome intrudes the Silala Ignimbrites (Bol) (BR, Vol. 4, pp. 125 and 149). That statement is based on an age of 6.6 Ma obtained for the Silala Ignimbrites (Bol) (BR, Vol. 4, p. 115), subunit Silala Ignimbrite 3 (Nis-3), which is the youngest or uppermost ignimbrite subunit recognised by Bolivia, located 8.5 km to the ENE of the summit of the Silala Chico hill. As shown above this age is incorrect. According to the geological cartography carried out by Chile (CM, Vol. 5, Annex VIII) the geological units that are in contact with the Silala Chico dome are the Silala Ignimbrite (Chi), dated at 1.6 Ma and the lavas that descend from the Silala Grande (Bol) (Volcán Apagado in Chile) dated at 1.74 Ma (BR, Complete Copies of Certain Annexes, Vol. 2, Annex 23.5 Appendix a, p. 69); both units cover in *onlap* (unconformably overlying) the deposits of this volcanic dome at its base. So, the Bolivian statement above is wrong, because a volcanic dome dated in 6.04±0.07 Ma (biotite) (BR, Vol. 4, pp. 113-115) cannot intrude and settle on younger rocks that are dated 1.74 to 1.6 Ma.

Further confusion arises from Bolivia's depiction of the relationship between the Silala Chico Dome unit (Nevsch on Bolivia's geological map at Figure 3), with the age 6.04±0.07 Ma, and the Silala Grande volcano deposits (Nevs on Bolivia's geological map at Figure 3), with the younger age of 1.74±0.02 Ma. Bolivia's Generalized Geologic Section (BR, Vol. 4, p. 125), is inconsistent with these dates (see Figure 4). It shows the older Silala Chico Dome unit overlying the younger Silala Grande volcano deposits. The correct stratigraphic relationship is therefore the opposite, namely, the lava flows of Silala Grande volcano overlie the older volcanic rocks of the Silala Chico Dome unit.

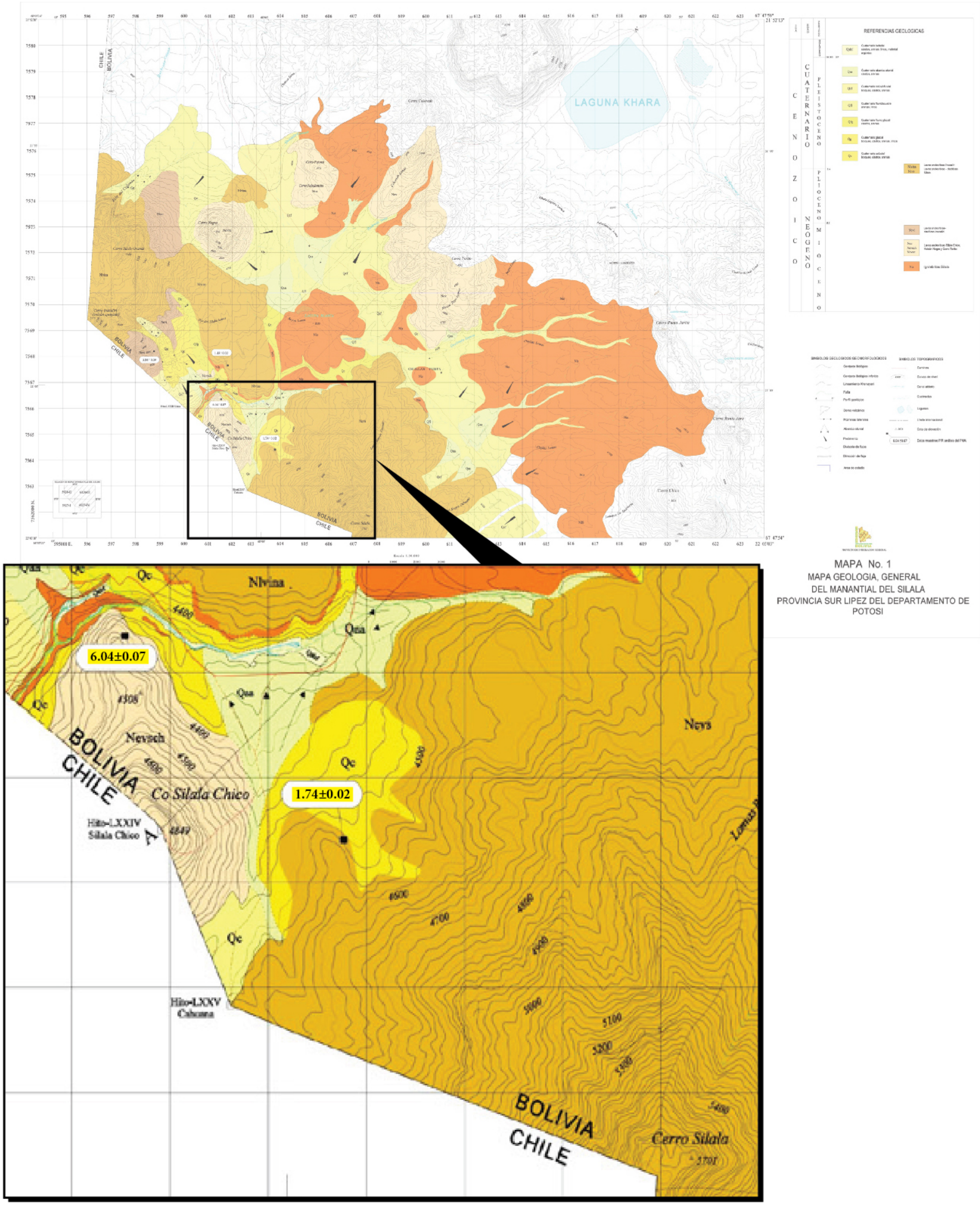


Figure 3. Zoom of the part of Geological Map (BR, Complete Copies of Certain Annexes, Vol. 2, Annex 23.5 Appendix a, p. 69), showing the location of an age of 1.74±0.02 Ma in a lava flow of the Silala Grande (Bol) volcano and the location age of 6.04±0.07 Ma of the volcanics of the Silala Chico (Bol) dome.

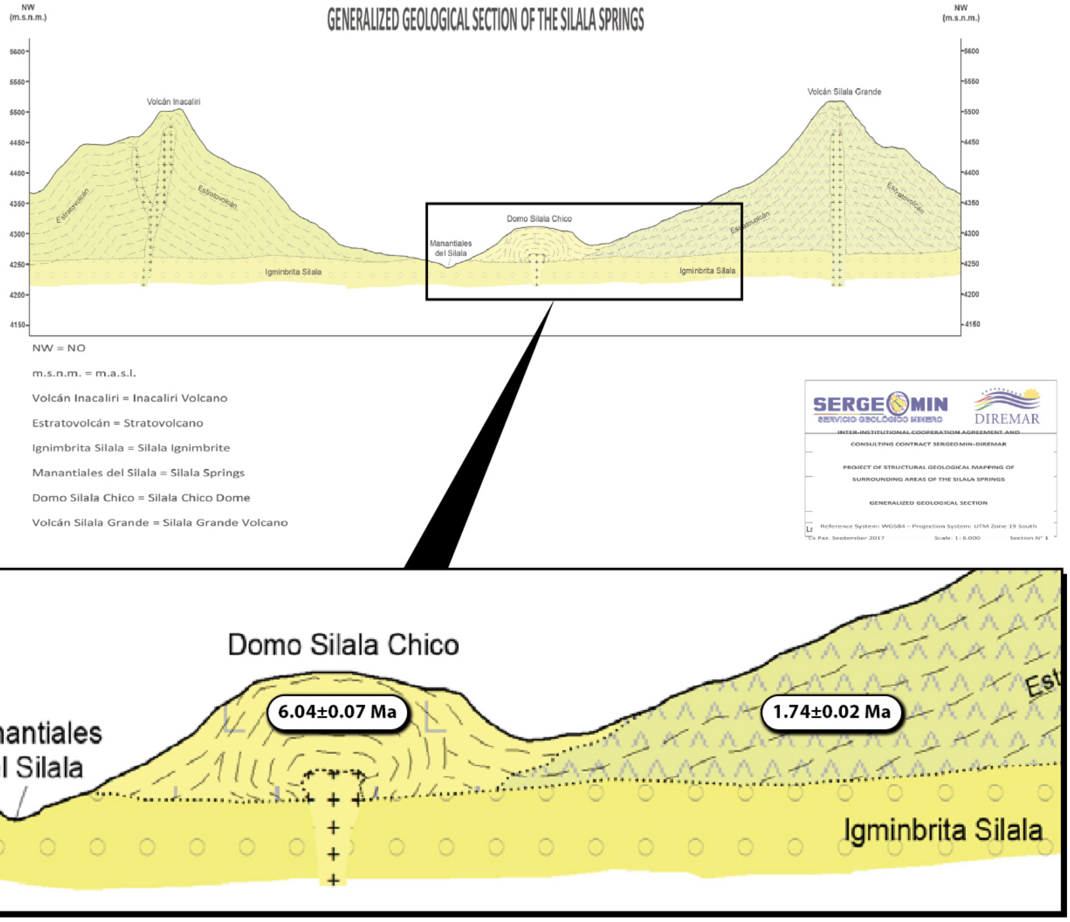


Figure 4. Generalized Geologic Section that shows that the ages (added for clarity) cited in Figure 3 do not support the stratigraphic relationship determined by Bolivian geologists. The section also shows the ignimbrites underlying the lavas of the Silala Chico dome, which is also incorrect, since they are younger than the lavas of the dome (BR, Vol. 4, p. 125).

2.2 Bolivian Petrography

Table 2 summarizes the petrographic characteristics of the Silala Ignimbrites (Bol) unit, and the differences between the descriptions among the different studies conducted by Bolivia. There are several difficulties with the information contained therein.

SERGEOMIN (2017)				TFAU (2018)		
Unit	**Description**	**Assemblage**	**Petrography**	**TAS**	**% SiO_2**	**Petrography**
Silala Ignimbrite 3 (Nis-3)	Moderate welded tuff of 12 m of thickness with lithics (dacite and andesite) and pumice (BR, Vol. 4, pp. 50-51)	Pl- K feld-qz-bt (BR, Vol. 4, p. 51)	Pl-qz-bt±amph±K feld-Fe oxides (pp.7-8,23-24, 27-28; SERGEOMIN, 2017)	Andesite	55-60	Pl Na-qz-K feld (BR, Vol. 4, p. 50 and pp. 158-159
Debris flow 2 (Nfd2)	Massive and chaotic unit with igneous clast subangular to subrounded (< 40 cm) in sandy-claytly and 50-180 cm of thickness with vesicular texture in some sectors (BR, Vol. 4, pp. 49-50)					
Silala Ignimbrite 2 (Nis-2)	Ignimbrites (or flow tuffs) welded, banded to massive texture of 10 m of thickness with lithics (andesites) and pumice (<10 cm) (BR, Vol. 4, pp. 48-49)	Pl-qz-px-amph (BR, Vol. 4, p. 49)	Pl-amph±px-Fe oxides (pp.55-56; SERGEOMIN, 2017)	Dacite	> 66	Pl-qz-K feld (BR, Vol. 4, p. 158)
Crystal-vitreous tuff (Ntcv)	Fine ash fall tuff (andesitic ignimbrite) of 15 cm of thickness average, vesicular texture in some sectors and an alternation of lenses of bands of different colors (banded and fluidal texture) (BR, Vol. 4, pp. 47-48)	K feld-bt-pl±px (BR, Vol. 4, p. 47)	Pl-px±qz±Fe oxides (pp.1-4; SERGEOMIN, 2017)			
Silala Ignimbrite 1 (Nis-1)	3-8 m of thickness with vertical fractures parallel and subparallel to lithics (igneous) and pumice. Fluidal or banded microtexture (BR, Vol. 4, pp. 46-47)	K feld-qz-bt±px (BR, Vol. 4, p. 46)	Pl-qz-bt-Fe oxides	Dacite	63-66	Pl-qz-bt (BR, Vol. 4, p. 157)
Debris flow 1 (Nfd1)	Massive and chaotic unit with igneous clast subangular to subrounded (< 40 cm) of in sandy-claytly matrix and 60-140 cm of thickness (BR, Vol. 4, p. 44)					

Table 2. Descriptions of the Silala Ignimbrites of TFAU and SERGEOMIN documents. TAS is a diagram of classification of the volcanic rock (Total Alcalis versus Silica, Le Maitre, 2002). Petrography corresponds to petrographic descriptions of the samples in both documents.

2.2.1 Observations

The Debris flow 1 (Nfd1) (Tables 1 and 2) is in reality a "scoria blocks tuff" (or tuff with scoria blocks) with rounded and subrounded fragments of vesicular scoria with plagioclase and pyroxene and is a flow unit or cooling unit of the ignimbrite of age 1.61 Ma, the Silala Ignimbrite (Chi). This kind of ignimbrite is well studied in other places (for example, Lohmar et al., 2007).

The Bolivian samples 7702, 7706, 7807 and 7808 are from Ntcv unit, Crystal-vitreous tuff ("Toba Cristalo Vítrea" in Spanish) (Tables 1 and 2), (BR, Vol. 4, p. 47). This is named "Andesitic ignimbrite" too (BR, Vol. 4, pp. 134-135) but the name of the sample 7807 has been changed to Andesite of pyroxene lava (Annex C to SERGEOMIN, 2017, p. 13[2]). In reality this level of "Silala Ignimbrites" is a vitrophyre, a highly welded tuff with fiammes and eutaxitic texture and normally is located at the base of ignimbrite (for example, Gimeno et al., 2003).

The Silala Ignimbrite 2 unit (Nis-2) (Bol) (BR, Vol. 4 p. 116) is the same deposit as the Chilean Silala Ignimbrite (RSP-52t), which can be traced crossing the border into Bolivia. A pumice sample collected in the Silala ravine in Chile, within approximately 5 metres of the border, of Chilean Silala Ignimbrite (RSP-52t), corresponds to a fragment that under the petrographic microscope appears as a vesicular pyroxene andesite (see Figure 5). It is possible to recognize an accumulation of pyroxene crystals, which is a very common texture. This rock, as found in Chile, at the border, is an andesitic ignimbrite, not a dacitic ignimbrite. Nevertheless, in all descriptions in the Bolivian documents, they refer to Nis-2 as a dacitic ignimbrite (see Table 2), which is incorrect.

[2] Resubmitted as Appendix A to this report.

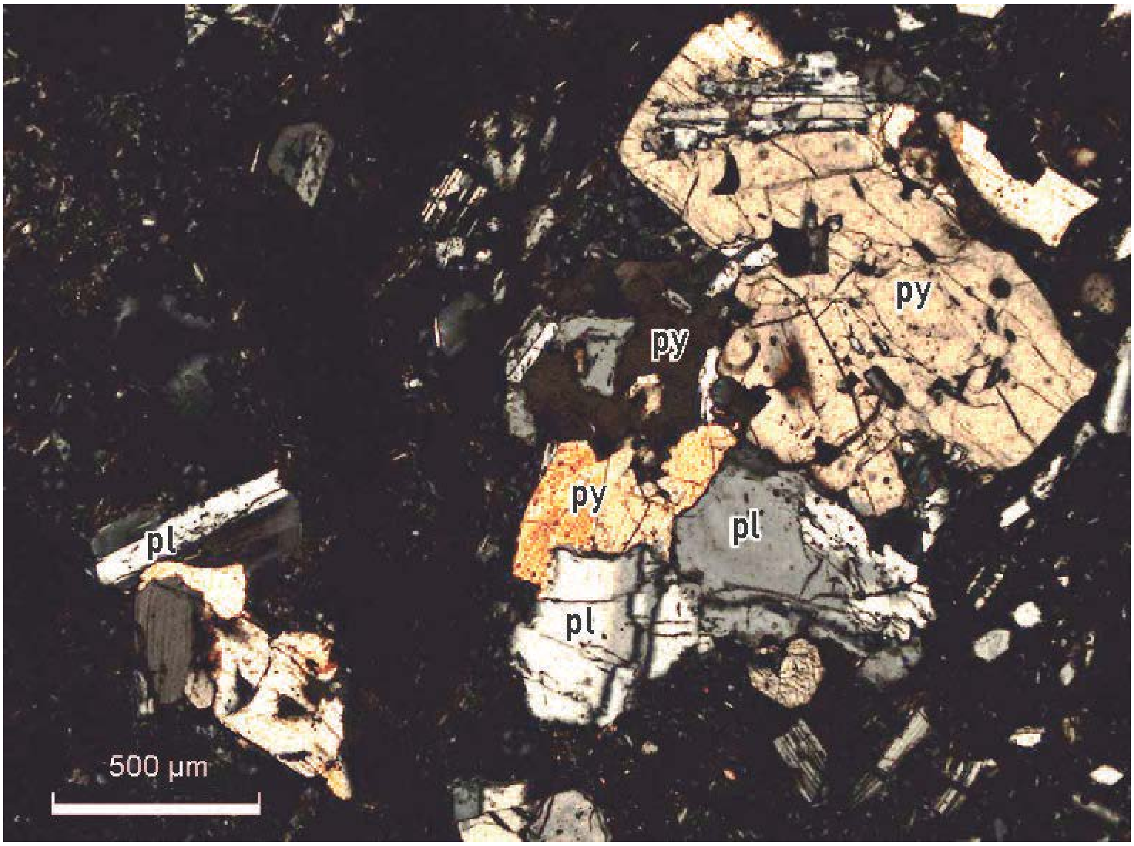


Figure 5. Photograph of the thin section of RSP-52t sample (Silala Ignimbrite (Chi)) showing pyroxene and plagioclase crystals. This sample was collected on 7 November, 2018, within approximately 5 metres of the international border in the south wall of the Silala River ravine.

Another issue with the descriptions of the different units of Silala Ignimbrites (Bol) is that the mineral assemblage in the main text and the petrographic descriptions are different and inconsistent. Also these descriptions differ from those of TFAU. For example, the Silala Ignimbrite 2 (Bol) (Nis-2), is described as having a quartz-like mineral assemblage in the main text (BR, Vol. 4, p. 158) but quartz does not appear in the petrographic descriptions of the thin sections (Table 2). The same inconsistency occurs between the mineral assemblage and petrographic description of Silala Ignimbrite 3 Nis-3 (Bol) (Table 2). No amphibole appears in the mineral assemblage but is found in the petrographic description (Table 2).

In addition, our examination provides evidence of a lack of systematic nomenclature by Bolivian geologists for the naming of the rocks in the various units. Normally, the nomenclature of a volcanic rock is a function of the relative abundance of the mafic minerals present (olivine, pyroxene, amphibole and biotite) as determined by its petrography. Table 3, prepared with data from Annex C to SERGEOMIN (2017) (Annex C to SERGEOMIN, 2017, pp. 49-50 and 53-54), shows two samples with the minerals and relative content (% in volume). These very similar rocks have been given different rock names, for example, if samples 7810 and 7811 are compared, it can be seen they have very similar mineral contents but different petrographic names (basalt and andesite; Table 3 below).

Sample	**7810**	**7811**
Quartz		
Plagioclase	31-33%	25-27%
Biotite		
K-Feldespate		
Hornblende		
Clinopyroxene	2-3%	3-5%
Groundmass	58-60%	56-58%
Fe-oxides	1-2%	
Calcite		
Pumice		
Other	1-2% (very high mafic oxide)	8-10% (lithoclast)
Name	Pyroxenic basalt	Pyroxenic andesite
Systematic rock	Pyroxene andesite	Pyroxene andesite

Table 3. Percentage of minerals (crystals content) of two "andesite" samples in Annex C to SERGEOMIN (2017). Systematic rock names should correspond to the rock name based on the mineralogy recognized in the rock sample.

Rock samples of the Silala Chico Lava (Cerrito de Silala) unit correspond to a dacitic dome, but in Table 4, prepared with data from Annex C to SERGEOMIN (2017) (Annex C to SERGEOMIN, 2017, pp. 5-6, 15-16 and 47-48), three different names are recognized by Bolivia for the same geological unit, however the systematic name that can be deduced is simply: biotite and amphibole dacite. There seems no reason for the three rock names for this same unit. This confusion and inconsistency does not give any confidence in the Bolivian geological expertise.

Sample	7809	7712	7713
Quartz	1-2%	6-8%	1-2%
Plagioclase	25-27%	23-25%	25-28%
Biotite	4-6%	3-5%	3-5%
K-Feldespate			
Hornblende	2-3%	2-3%	2-3%
Clinopyroxene	1-2%	1-2%	1-2%
Groundmass	53-55%	50-52%	55-57%
Fe-oxides	2-3%	2-3%	2-3%
Calcite	1-2%	1-2%	
Pumice			
Rock name	Biotitic andesite	Biotitic dacite	Biotitic andesite (quartzily)
Systematic rock	Biotite and amphibole dacite	Biotite and amphibole dacite	Biotite and amphibole dacite

Table 4. Relative percentage of minerals (crystals content) of selected samples of Silala Chico Lava unit in the Annex C to SERGEOMIN (2017). Systematic rock correspond to the rock name based in the mineralogy recognized in the rock sample.

3. STRUCTURAL GEOLOGY

3.1 Bolivian Structural Interpretation

Two main structural systems have been defined by Bolivia in the area of the wetland springs of the Silala River in Bolivia, which are assigned great importance by Bolivia as providing high permeability pathways for groundwater and controlling the locations of the springs in Bolivia (BR, Vol. 3, p. 249), in particular the Bofedales Norte (Cajones) and Bofedales Sur (Orientales). For the Bofedales Norte (Cajones), a fault called the "Silala Fault" (BR, Vol. 3, pp. 254 and 283), of NE-SW orientation, has been interpreted by Bolivia, as part of the Uyuni-Khenayani Fault System (UKFS) (Sempere et al., 1990; Martínez et al., 1994; Elger et al., 2005). For the Bofedales Sur (Orientales), a structure linked to the Silala-Llancor lineament (BR, Vol. 4, p. 73), of ENE-WSW (70°) orientation has been invoked. According to its authors, both structural systems are due to regional compressive stress ($\sigma1$), in general, of East-West orientation (BR, Vol. 4, p. 66). The structures were determined on the basis of numerous measurements of fractures and, subordinately, faults. Also, a regional aeromagnetic map was used to define the main magnetic lineaments, some of which, in our opinion, were forced to coincide with these structures (see discussion in relation to the structures below).

3.2 Analysis of Bolivian structural data

In geological science a fault is a planar or gently curved fracture in the rocks of the Earth's crust, where compressional or tensional forces cause relative displacement of the rocks on the opposite sides of the fracture. There are three types of fault, normal, reverse (or inverse) and transcurrent (or strike-slip). The relative displacement of transcurrent faults can be sinistral or dextral (left or right to the observer). SERGEOMIN (2017) reports 2754 geographically located structural data items (Annex D to SERGEOMIN, 2017[3]) (Table 5). Of these, only 487 (dextral, inverse, normal, sinistral faults) can be used in structural analysis and an attempt to formulate a structural model of the structural stresses that produced the faults. However, it is clear that some of the items included are fractures caused by primary cooling of lava flows or ignimbrite primary cooling (prismatic) joints. These are not indicative of faults. Indeed in the description of Silala Ignimbrite 1 (Bol) (Table 2) the presence of parallel and subparallel vertical fractures (columnar jointed) are noted but again, these do not indicate faults.

Additionally, the data in Table 5 are not ascribed to rock units of particular ages, i.e., there is mixing of faults of different ages which make their interpretation uncertain, unreliable or meaningless.

[3] Resubmitted as Appendix B to this report.

STRUCTURES	QUANTITY
Diaclase	1955
Fault	179
Dextral fault	23
Inverse fault	87
Normal fault	331
Sinistral fault	12
Strike lip fault	6
inverse fault	34
Pseudostratification	127
Structures total	2754

Table 5. Quantitative statistics of the structural data (Annex C to SERGEOMIN, 2017).

179 of these structural data are listed as faults, but none of these in Table 5 above, show relative movement (by defining the movement, i.e. sinistral, dextral, inverse, normal), so that one can reasonably think that they correspond to diaclases (fractures or joints). Also, 127 of the data points correspond to pseudo-stratification, i.e., indicating the flow direction or spatial disposition of the lava flow or ignimbrite, so the incorporation of this type of data in a structural model is also incorrect. In other words, many of these data are not structural and so are not useful to understand local or regional stress regimes.

3.2.1 The "Silala Fault"

From their structural analysis the Bolivian geologists from TFAU concluded "that the maximum stress axis has a preferred E-W direction, which gave rise to four structural domains, each with particular characteristics" (BR, Vol. 3, pp. 257-258).

The Bolivian-described "Falla Silala" is a NE-SW oriented structure, which runs along the Silala River ravine, from Bofedales Norte (Cajones) following the course of the river to the SW, crossing the border into Chile (BR, Vol. 3, pp. 254 and 283). The measurement of fractures by Bolivia in this sector (Domain 4) they indicate is dominated by a NW-SE pattern (125-305°), corresponding to normal faults, and coinciding with the orientation of Inacaliri Graben (BR, Vol. 3, p. 267). However, according to the deformation model proposed by Bolivia (BR, Vol. 3, p. 263), with a main stress vector σ1 WNW-ESE (~ N85°W) such normal faults should have a WNW-ESE orientation (~ 275-95), which does not coincide with the preferential or most frequent fractures measurements (NW-SE) (BR, Vol. 3, p. 267, Figure 13a) or with orientation of the Graben Inacaliri.

Also, a fault oriented N45°E and inclined 48° towards the SE, with fault stria or slickenlines forming an angle of 11° to the SW (BR, Vol. 4, p. 322) with respect to the strike of the fault was measured. The Bolivian authors indicate that this fault plane coincides with the current direction of the Silala ravine in that area and that the vertical and almost vertical walls of the ravine are "strong evidence of the formation of the ravines by tectonism and movement of glacial ice and fluvioglacial waters" (BR, Vol 3, p. 323). This assertion is inconsistent, because they define a fault with an inclined plane at 48° to the SE, so that the vertical walls of the ravine must have another origin, not from one influenced by a structure, or by the action of glacial ice. This has previously been demonstrated by Chile as has the fluvial origins of the ravine (SERNAGEOMIN, 2017; Latorre and Frugone, 2017).

In relation to the structure that supposedly controls the Silala River ravine (N45°E/48°SE), it has stria or slickenlines that form an angle of 11° with respect to the strike of the fault (*rake* = 11°SW) (Figure 6), which indicates that it would be a fault of lateral displacement or heading, with very little vertical displacement. In the deformation model for Domain 4, the NE-SW orientation faults correspond to right lateral faults, with which the south-eastern block of the fault drops slightly with respect to the north-western block (Figure 6). This situation contrasts with the assertion that the units that are located on the eastern side of the river, south of Bofedales Norte (Cajones), are raised 5 metres from the western side (BR, Vol. 5, p. 24), implying that the Silala Fault is responsible for that upward displacement (BR, Vol. 5, p. 24; BR, Vol. 4, p. 48). In fact such a fault would result in the opposite displacement, as shown in Figure 6; the south eastern block would be displaced downwards.

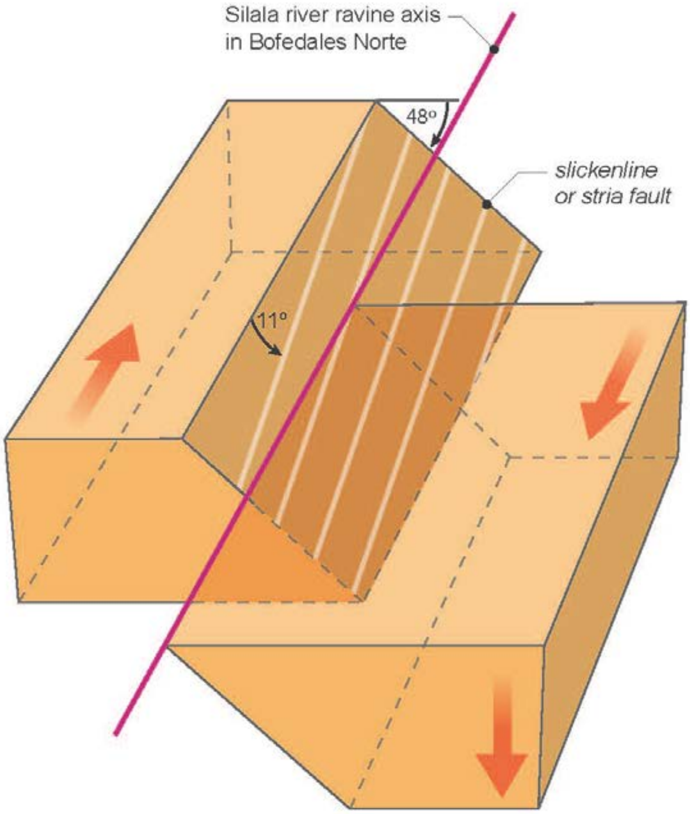


Figure 6. Block diagram for the structural model of the Silala Fault, of orientation N45°E/48°SE, with dextral displacement and southeast block slightly displaced downwards with respect to the northwestern block according to rake= 11°SW.

In their analysis of fractures in the structural domains (BR, Vol. 3, pp. 260-263; BR, Vol. 4, pp. 306-325) it is mentioned that in Domains 2 and 3 the orientation of the predominant fractures coincide with compressive and shear fractures, which are closed fractures, and that therefore, in those sectors, there are no springs, because there are no open fractures to facilitate the emergence of groundwater (BR, Vol. 3, pp. 258-259). This assertion and structural interpretation is clearly in contradiction with what they interpreted for the Bofedales Norte (Cajones), in which it is asserted that the upwelling of water is controlled by NE-SW shear structure that coincides with the orientation of the Silala ravine (BR, Vol. 3, p. 258), also aligned NE-SW. There, a dextral shear structure is mapped by Bolivia and matches their proposed structural model. But according to this the Bolivian geologists would postulate that shear fractures or shear faults are closed and unlikely to support the emergence of springs and, therefore, at Bofedales Norte (Cajones) spring arisings would not be expected to be favorably influenced by a NE-SW structure shear structure because it would be closed. There is clearly another control for water upwelling in that sector but it would not be by a NE-SW shear fault.

A possible control for the emergence of groundwater in Bofedales Norte (Cajones) could be related to its location being on the trace of a regional structure, of N-S orientation, determined by the alignment of dacitic volcanic domes, which we will call the Silala Chico-Cerro Negro Lineament. For this reason and, possibly like the Quebrada Negra spring located in Chilean territory, the emergence of underground water in Bofedales Norte (Cajones) could be determined by the existence of this regional structure (Figure 7).

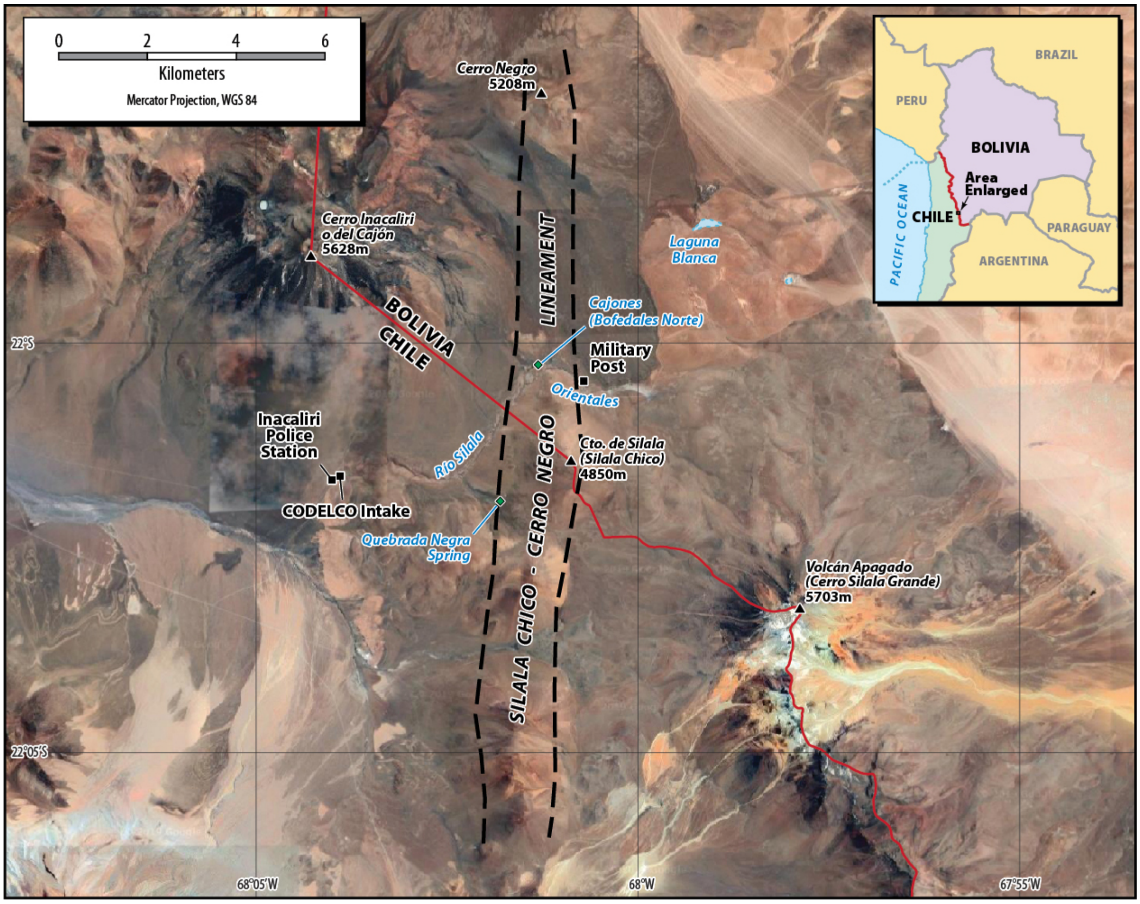


Figure 7. Spatial relationship of the emergence of underground water springs possibly associated with the Silala Chico-Cerro Negro structural lineament, in particular for the Quebrada Negra springs in Chile and Bofedales Norte (Cajones) in Bolivia.

For the Bolivian cross section of the Silala River ravine located SW of Bofedales Norte (Cajones), with a NW-SE orientation, it is indicated that there is a displacement of approximately 5 metres of the rock units located on the southeast side of the river (Figure 8) (BR, Vol. 5, p. 24). Moreover, this is explicitly said with the phrase "subdividing the Silala Ignimbrite in two members (Nis1 and Nis2) and it is also an indicator of possible vertical displacements produced by the faulting" (BR, Vol. 4, p. 48). This indicator appears to be intended, in our opinion, to reinforce the idea of the existence of a fault in that sector that is the cause of this displacement. However, if the hypothesis of the existence of this fault is accepted, as indicated for the Silala Fault (Figure 6), the movement of the south-eastern block of the fault should be displaced downwards according to the dextral shear movement and the orientation of the stria or slickenlines associated with the fault, that is, the opposite of what is indicated by Bolivian geologists. On the other hand, a slightly higher position of the SE block can also be explained because the Silala Ignimbrites (Bol) unit is tilted to the west as indicated by the Bolivian geologists (BR, Vol. 4, p.149).

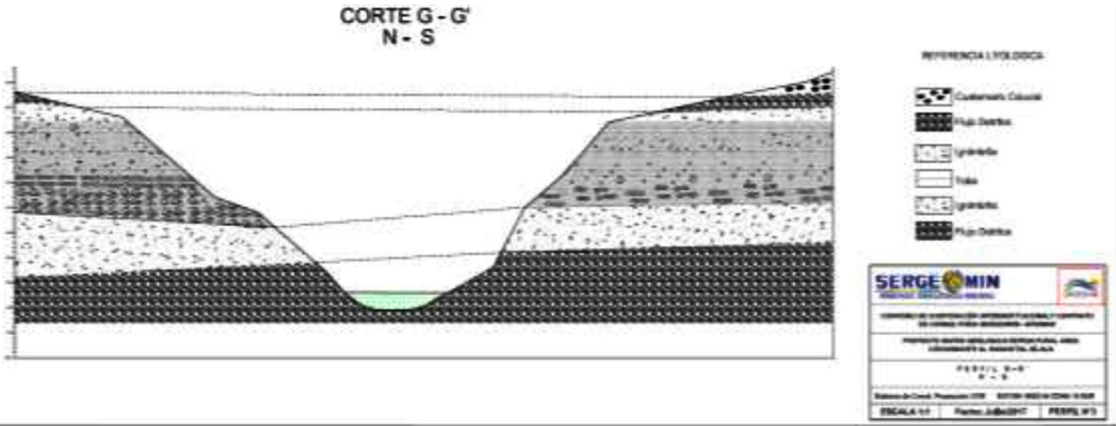


Figure 8. Profiles GG' located SW of Bofedales Norte (Cajones), that indicate there is displacement of ~ 5 m of the rock units located on righthand side of the river in this figure. (BR, Vol. 5, p. 24).

In the Bofedales Norte (Cajones) area it is not possible to see or photo-interpret any NE-SW lineament or structure. The dominant structural fabric has a NW-SE trend (Figure 9), as indicated by the fracture rose diagram (BR, Vol. 3, p. 263). The association of vertical walls with the supposed structure NE-SW is erroneous, and it is possible to see that the verticality of the slopes of the ravine corresponds to an erosional form that follows the course of the river (Figure 9).

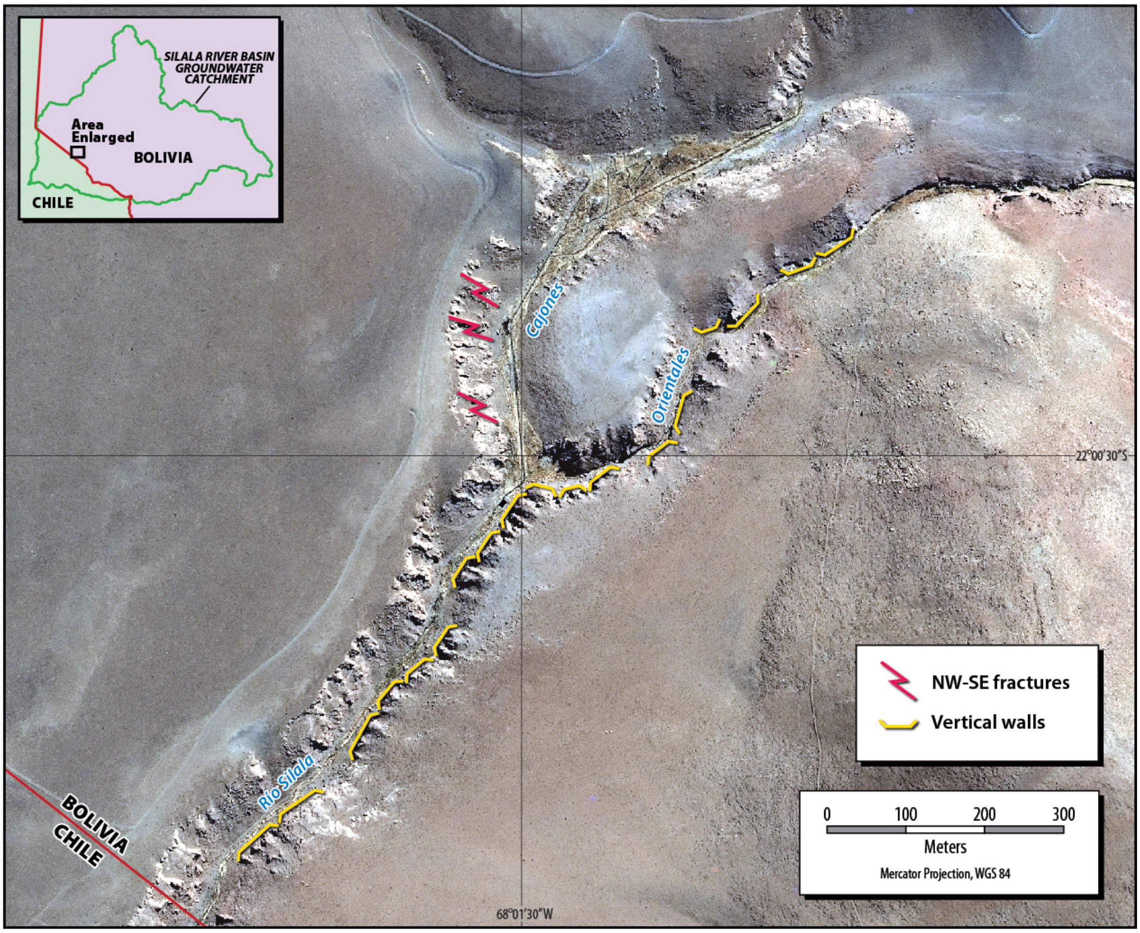


Figure 9. This shows the main orientation of NW-SE fractures, transverse to the course of the Silala ravine. The orientation of vertical walls in the ravine follows the course of the river, indicating that they are formed by erosion.

In our opinion, the change of direction of the course of the Silala River, starting from Bofedales Sur (Orientales), is due to a lithological control, that is to say, to the resistance that the rocks present to the fluvial erosion. Indeed, where the course of the river intersects the dacitic lavas, both at the northern end of Cerrito de Silala (Chi) hill and NE of the Inacaliri police station, the course is modified significantly and then it is restored its general direction to the SW from Bofedales Norte (Cajones) (Figure 10).

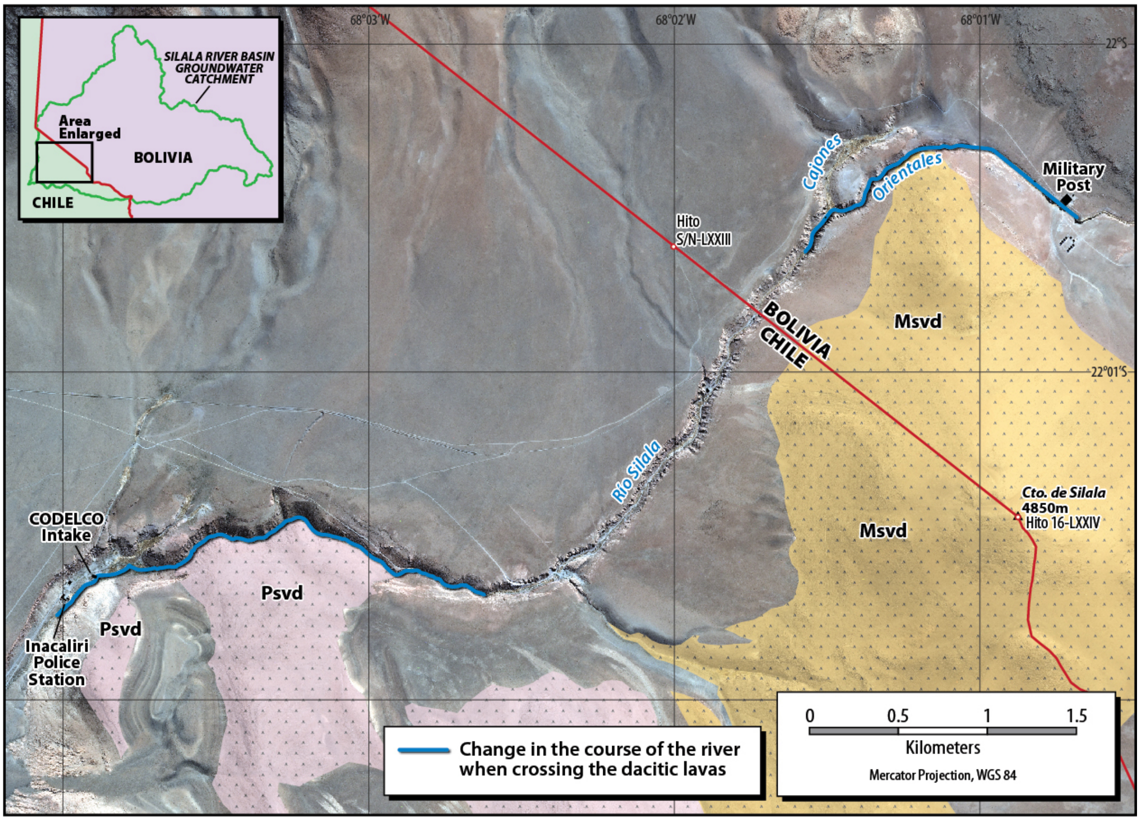


Figure. 10. Effects of competent lithology (dacitic lavas) on the Silala River course. Light brown (Msvd code) and light pink (Psvd code) colors represents the envelope of dacitic lavas.

3.2.2 The "Silala-Llancor Lineament"

Bolivia asserts: "The Silala-Llancor lineament – which has an ENE-WSW (75°) orientation, that coincides pro-parte with the South Canal of the Silala springs – is modeled in the middle of the Silala Ignimbrite [Bol] and the Silala Grande (Bol) hill lava" (BR, Vol. 4, p. 106). Its trace towards the East is dextrally displaced by another system or transversal lineament of NW (300°) direction at the level of the lavas of Cerro Torito, (Figure 11A). For the Silala-Llancor lineament, a sinistral displacement was determined (BR, Vol. 4, p. 106), in part, using satellite images and aeromagnetic geophysics. They indicate this lineament may have some influence on the upwelling of water in Bofedales Sur (Orientales) (BR, Vol. 4, p. 106).

We have the following comments:

1.- In our opinion, this lineament does not correspond to the rectilinear alignment of any geological element (eg. volcanic emission centers, water drainage systems, escarpments, etc.) (Figure 11 A). Its layout appears to have been chosen to coincide with and hence justify the groundwater springs of Bofedales Sur (Orientales). Its "trace", which would pass between the lavas of the Silala Grande (Volcán Apagado) and Silala Ignimbrites (Bol), is not a tectonic feature, and there is not a structural escarpment inclined 45° to the North (BR, Vol. 4, p. 102). In this area, there is a contact between the ignimbrites and the front of an andesitic lava with a lobed face (Figure 11 B). The escarpment corresponds to the end of the andesitic lava flow, whose morphology is sinuous or lobed, far from being rectilinear as would be expected by the presence of a fault (Figure 11 B). In addition, it is mentioned that this lineament is displaced, in the dextral sense, by a NW fault. That is based on the supposed displacement between the Cerro Torito lavas and the lavas of the Silala Grande (Volcán Apagado). However such a displacement is not real, because the lavas of these hills have very different ages: 5.8 Ma in Cerro Torito lavas (Almendras et al., 2002) and 1.7 Ma for Silala Grande (Volcán Apagado) lava flows. Thus, this displacement caused by this supposed structure, is incorrect. The structure does not exist so there can be no displacement.

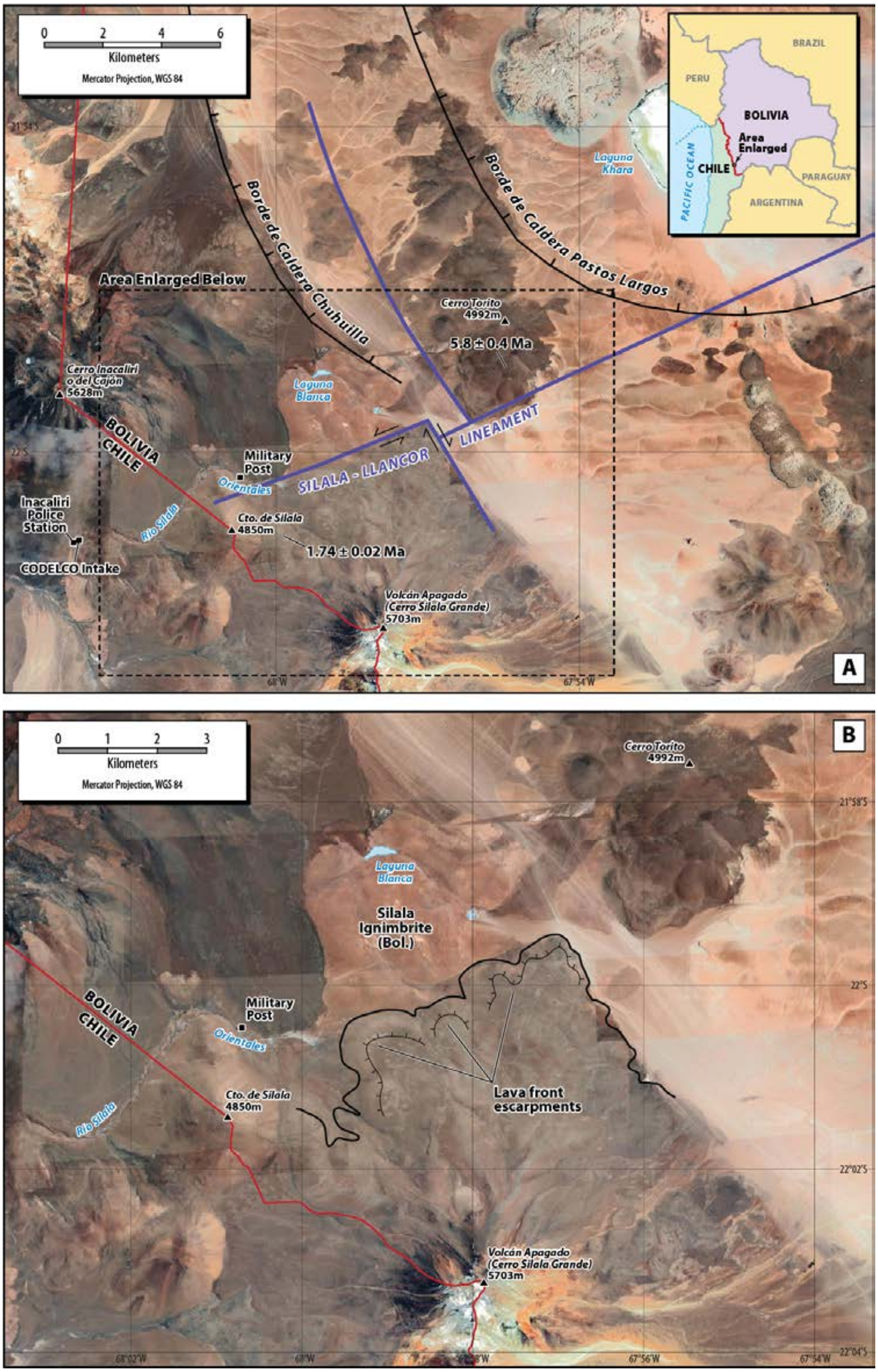


Figure 11. Layout of the Silala-Llancor lineament (A) and its supposed control over Bofedales Sur (Orientales), displaced dextrally by the NW-SE structure, which uses very different ages of rocks as displacement reference. The lobed end of Pleistocene lava flows (B) that is interpreted as an escarpment fault by Bolivian geologists.

2. - On a local scale, the Bolivian geologists suggest that the sinistral movement of the "Silala-Llancor fault" is supported by fractures in the Cerro Torito and Silala Grande (Volcán Apagado) lava flows. The Bolivian geologists established that in the Cerro Torito lavas there are tension fractures of NE-SW trend (15 to 35 degrees) arranged obliquely to the Silala-Llancor lineament forming an angle inferior to 35 degrees (BR, Vol. 4, p. 103). In the Silala Grande (Volcán Apagado) lava flows, tension fractures have a similar orientation (BR, Vol. 4, p. 103). The orientation of these tension fractures involves a tectonic maximum principal stress σ_1- oriented NE-SW. However, it is described that in Silala Grande (Volcán Apagado) lavas there are reverse faults (only 6 inverse faults and 23 unidentified faults) of general orientation ~ N36-38°E / ~75-80°SE (BR, Vol. 4, p. 95). For this average plane of reverse faulting a maximum principal stress σ_1 oriented NW-SE is required, which would generate tensional fractures or tensional fault(s) in the NW-SE direction, almost 90° from the tension fractures observed in Silala Grande (Volcán Apagado) and Cerro Torito lava flows, which supposedly justify a sinistral movement along Silala-Llancor lineament.

Furthermore, for structural Domain 1 (BR, Vol. 3, p. 260) the maximum principal stress σ_1 determined for the Bofedales Sur (Orientales) area is oriented ENE-WSW, generating a dextral fault in a NE-SW direction. As determined by the Bolivian geologists this would be a non-extensional fault. The information provided for the interpretation of the kinematics of the Silala-Llancor lineament is contradictory and is not compatible with a sinistral movement for this proposed structure.

3.- To define the trace of the Silala-Llancor lineament at regional scale, a map of total magnetic intensity reduced to the local pole, first derivative, is used (BR, Vol. 4, p. 118) (Figure 12). This magnetic map is questionable for the following reasons:

(i) It is indicated that it is a magnetic map processed with the first derivative, but in the scale of intensities it has magnetic field units in (nT). If it were the correct scale the units should be nT /m or nT /km.

(ii) The Bolivian report (BR, Vol. 4, p. 118) does not present information about the spacing, height and orientation of main flight lines. This information is fundamental, since the patterns of anomalies can be caused by the effect of the direction of flight and not necessarily indicate a real geophysical anomaly. The flight height is also important to know in order to establish the depth range of the anomalies (> flight height> depth of the anomaly, and vice-versa). Due to the attenuation of magnetic field anomalies with altitude, it may not be possible to provide information to the required scale for recognition of important structures.

(iii)The map presents a marked trend E-W to ENE-WSW, which could reflect a flight direction and not a real anomaly. (Note that the magnetic anomalies cross the international boundary in an approximate EW to WNW direction, which suggests that the direction of the flight line could have the same path and not a path, for example, in a N-S direction.)

The magnetic anomaly used to define the trace of the Silala-Llancor lineament is more consistent with the clearer definition of the southern segment of the Pastos Largos caldera boundary, because this lineament is not clearly traceable beyond the limits of this caldera (Figure 12). The magnetic anomalies in the area of the springs of the Silala River could be explained, alternatively, by the presence of lavas and andesitic volcanic edifices of the Pleistocene age and not a structure. For this it is essential to know the flight height of the data collection, in order to know if these anomalies are deep or shallow, however this information was not presented.

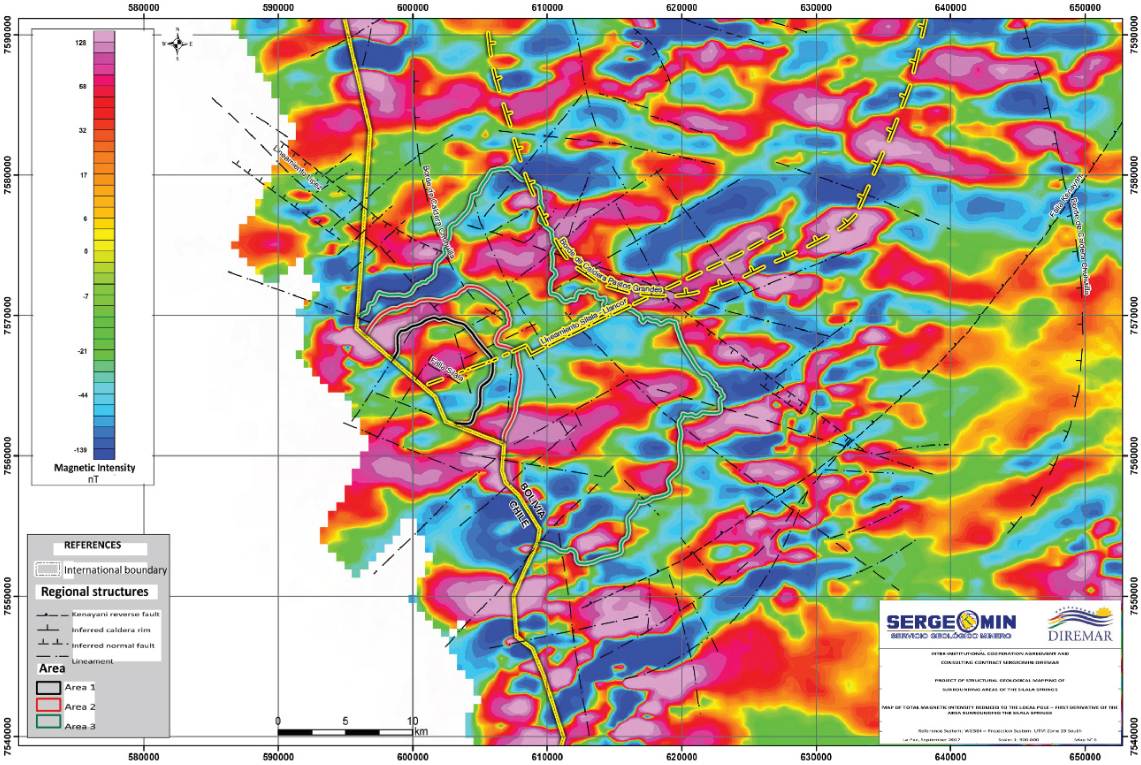


Figure 12. Total magnetic intensity map local pole reduced, first derivative (BR, Vol. 4, p. 118). Note that the magnetic information traverses the international border (solid yellow line), which infers a possible E-W to ENE-WSW flight direction (uninformed data), thus favorably conditioning the anomaly trend of this map. For clarity, yellow highlighting has been applied to the international border, Silala-Llancor Lineament, and edge of the Pastos Largos Caldera. Grey highlighting has been applied to the borders of Area 1, Area 2, and Area 3, where Area 3 is equivalent to the hydrological catchment area and Area 1 encompasses the Orientales and Cajones wetlands.

3.2.3 Conclusions

The main lineaments in the near Silala River area are markedly oriented to the NW-SE, followed by a secondary NE-SW trend and, subordinately a N-S trend (Figure 13). The main and objective geological elements to define these lineaments are the dispositions of eruptive centers (Sellés and Gardeweg, 2017; Tibaldi et al., 2017), and none of these agree with the orientation of the regional structures proposed in the Bolivian technical reports (Figures 13 and 14).

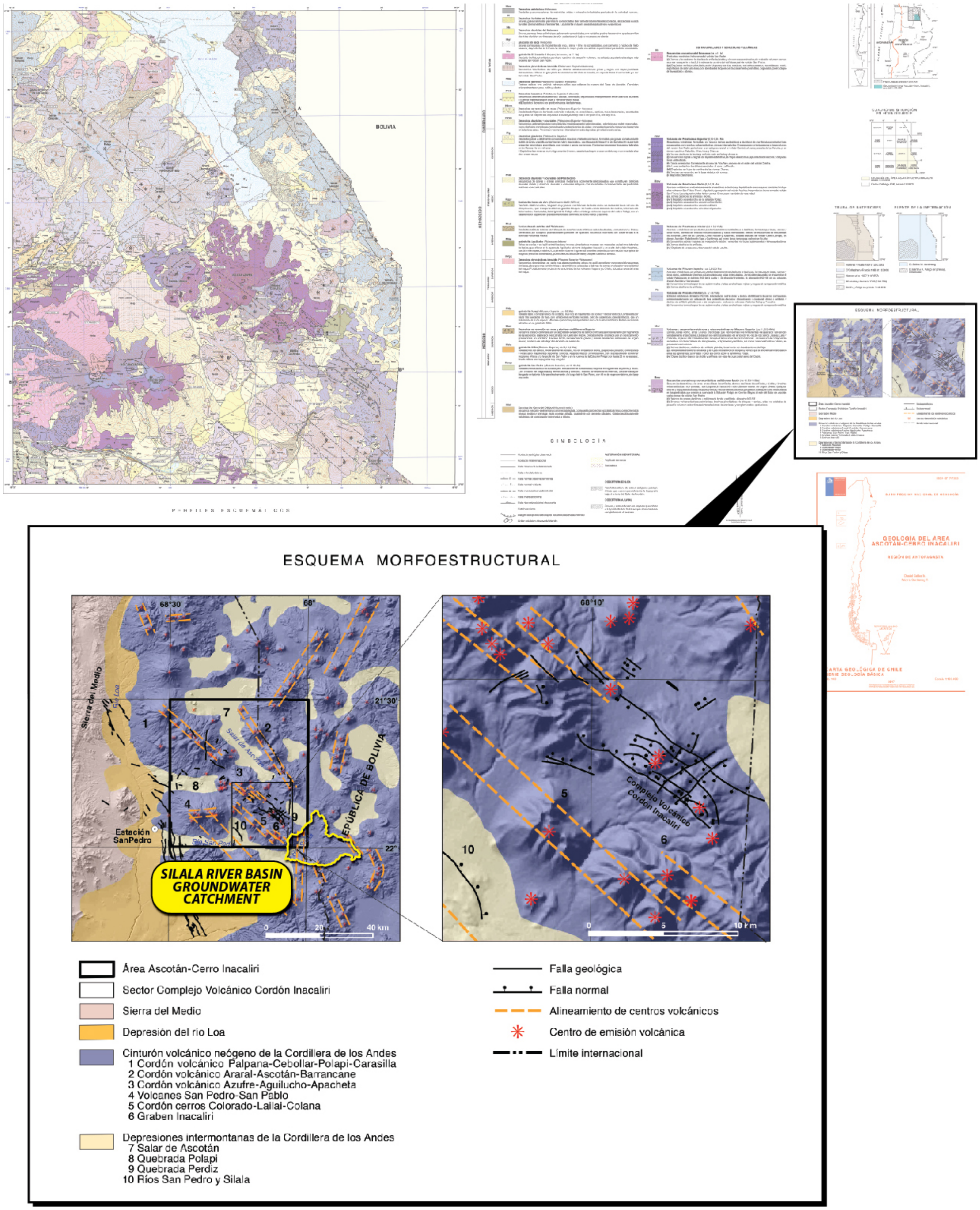


Figure 13. Regional lineaments located in the vicinity of the Silala River. Yellow label added. Those are objectively supported, by lineament of eruptive centers (Sellés and Gardeweg, 2017).

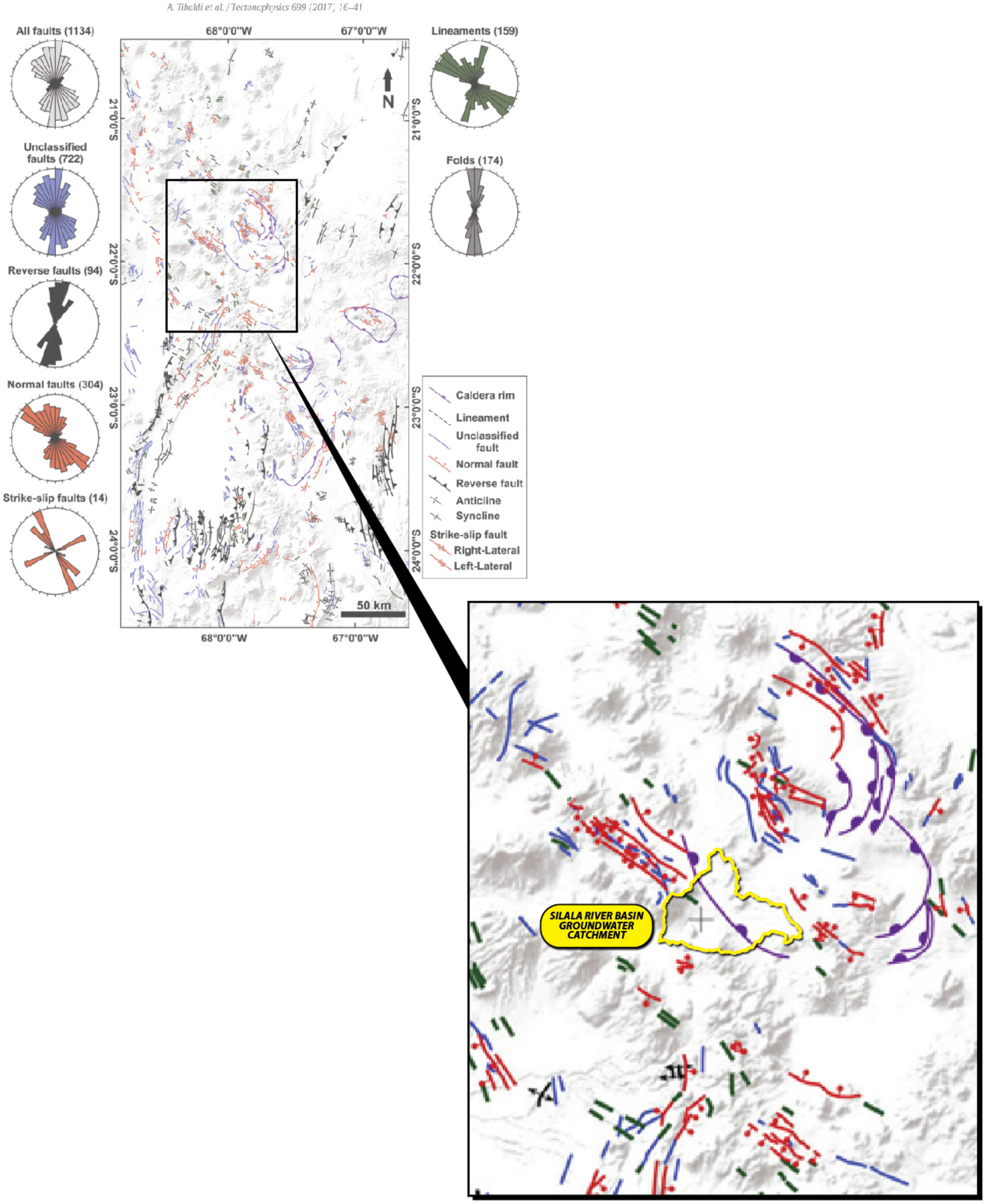


Figure 14. Structural map around Silala River area with main Neogene-Quaternary faults and folds (Tibaldi et al., 2017). Yellow label added.

3.3 Chile's interpretation of the geological deformation in the Silala River area

In order to better understand the errors in Bolivian Structural geological interpretations it is necessary to understand Chile's knowledge and interpretations from recent geological mapping in the Silala River area in Chile.

The most specific deformation history recorded in the Silala River area corresponds to the activity of the Cabana reverse fault, located in Chilean territory. This structure, from N-S to NNW-SSE orientation, is not exposed, but is inferred by the alignment of water drainages and by the deformation of adjacent units, tilting to the East (11°) in both the Cabana Ignimbrite (Chi) (4.1 Ma) as well as the dacitic lavas of 2.6 Ma (SERNAGEOMIN, 2017) that overlie it. This deformation does not affect the Silala Ignimbrite (Chi), which seals or covers its trace and fills depressions formed by subsidiary normal faults that accommodate the rise and rotation in the deformation front (Figure 15). This deformation is located in the time period between 2.6 and 1.6 Ma (Lower Pleistocene).

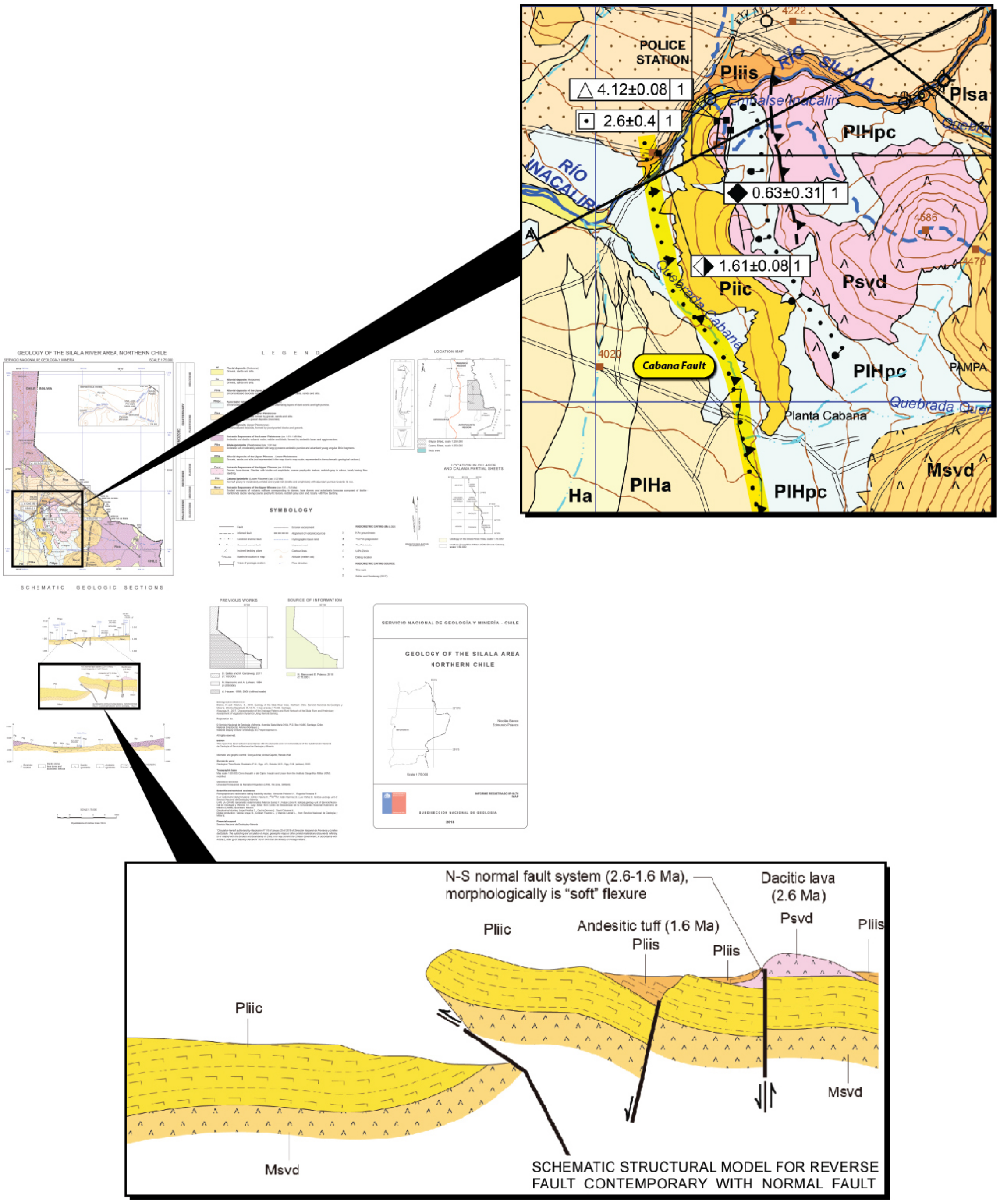


Figure 15. Pleistocene deformation in the Silala River area, represented by Cabana reverse fault activity (Blanco and Polanco, 2018).

3.3.1 The Uyuni-Khenayani Fault System

This system “corresponds to an east vergent thrust zone, which separates the western sector of the southern Altiplano from the Lipez Basin, a Cenozoic intramontane basin located between that area of thrusts and the converging eastern system, Falla San Vicente [SVFZ on Figure 16]. The upper block of the Uyuni-Khenayani thrust system involves an Ordovician and Silurian-Devonian basement; which folded, fractured and elevated, supports some Mesozoic remnants and an incomplete coverage of Cenozoic” (Martínez et al., 1994).

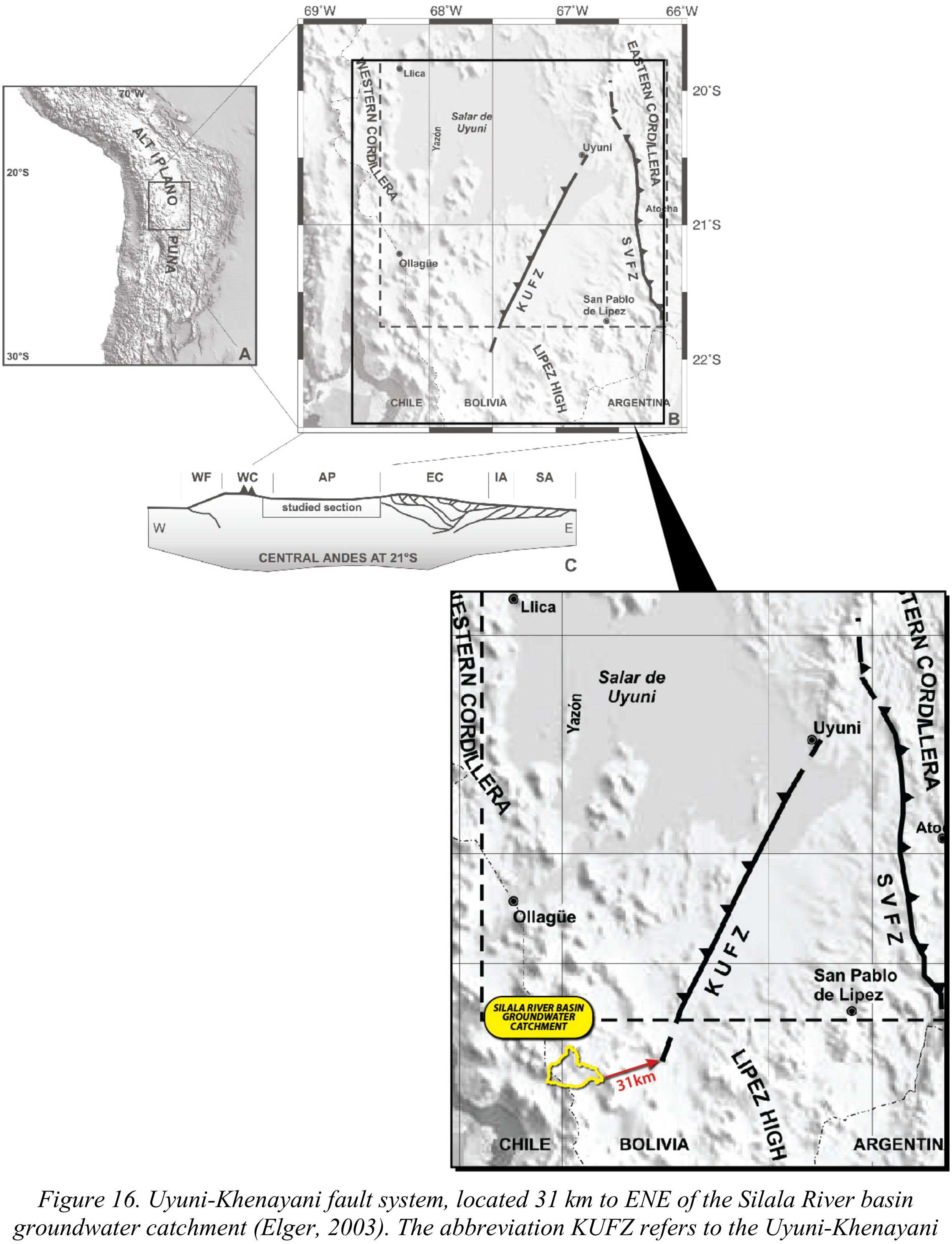


Figure 16. Uyuni-Khenayani fault system, located 31 km to ENE of the Silala River basin groundwater catchment (Elger, 2003). The abbreviation KUFZ refers to the Uyuni-Khenayani Fault System used in this report.

"The structural complexity of the upper hanging wall of the Uyuni-Khenayani crustal thrust system (UKFS) results from the arrangement of Andean deformation to a substratum previously deformed by Hercynian tectonics and then subdivided into smaller, scaled and eroded blocks during the Upper Cretaceous. The successive deformations, synsedimentary in the Tertiary, reactivated the paleo-structures and caused the propagation, to the east, of a system of thrusts and associated folds, accompanied by superficial landslides" (Martínez et al., 1994).

In several studies it has been documented that the UKFS was active between the Oligocene and Middle Miocene (27-10 Ma) (Sempere et al., 1990; Martínez et al., 1994; Elger, 2003; Elger et al., 2005). This deformation would have finished between 11 and 10 Ma when its trace was sealed by subhorizontal tuffs and dacitic lavas dated at 10±0.3 Ma and 11±0.5 Ma, respectively. (Silva-González, 2004 in Elger et al., 2005). The Upper Miocene, sinistral faults, of NW-SE orientation, tear the UKFS (Martínez et al., 1994).

On the other hand, some authors indicate that the UKFS extends beyond Bolivia and into Chile and is related to the system of thrusts of the Cordillera de Domeyko - Salar de Atacama in Chile, with similar structural characteristics (Buddin et al., 1993; Martínez et al., 1994). In the Cordillera de Domeyko - Salar de Atacama area, tectonic activity has been documented in the Upper Oligocene with normal faults and a system of reverse faults in the Upper Miocene, including salt diapirism during Quaternary (Mpodozis et al., 2000; Henríquez et al., 2014). Such an extension of the fault system would not pass through the Silala River groundwater catchment (Figure 16).

At item 9.1 "Regional Geology of Bolivia, chapter 9, Conclusions and recommendations" (BR, Vol. 3, p. 397), the Bolivian authors write the following:

"The area of the Silala Springs was geologically formed during the Upper Miocene (7.5 to 8 Myr), when the Silala Ignimbrites were deposited. The latter were strongly fractured and jointed by tectonic movements caused by the Khenayani Faulting system."

There is clearly a mistake in this official translation because there are two very important omissions that change the sense of exposed ideas. The omissions are: the age “of 27-17 Ma” of the Khenayani Fault System and the phrase “"that is, before the ignimbrite deposition”.

A literal translation of the original Spanish document (SERGEOMIN, 2003) is:

“The Silala Ignimbrites are deposited during the Upper Miocene (between 8 to 7.5 Ma) (A).

These rocks are strongly fractured and diaclased by the tectonic movements caused by the Khenayani Fault System *of 27-17 Ma, that is, before the ignimbrite deposition* (B).”

We have the following comments:

(1) The oldest age obtained in the Silala Ignimbrites (Bol), by Bolivia is 6.6±0.5 Ma (K-Ar in biotite; BR, Vol. 4, p. 115), so the Bolivian statement (A), above, is incorrect.

(2) The assertion (B) is a contradiction. It is not possible that an older tectonic process (27-17 Ma) can affect younger rocks. The fracturing in the Silala Ignimbrites (Bol) must have been caused by an event after the deposition of these ignimbrites, i.e., younger than 6.6 Ma.

(3) It would appear that the incorrect age of 7.8±0.3 Ma attributed to the Silala Ignimbrites (Bol) has been used to justify the proposed faults as active structures of the Uyuni-Khenayani Fault System, even though this fault system had ceased to be active more recently than 10-8 Ma.

3.3.2 Ratio of deformation and crustal depth

In relation to fracturing found in the Silala Ignimbrite (Chi), it is most probable that these structures have been formed by cooling or gravitational adjustments rather than by tectonic effects. Indeed, much experimental data in rocks show that in the upper crust the differential stress due to the tectonic forces increases linearly from the surface, where it has a zero value, with depth (Brace and Kohlstedt, 1980; Kohlstedt et al., 1995; Townend, 2006; Scholz, 2019) (Figure 17).

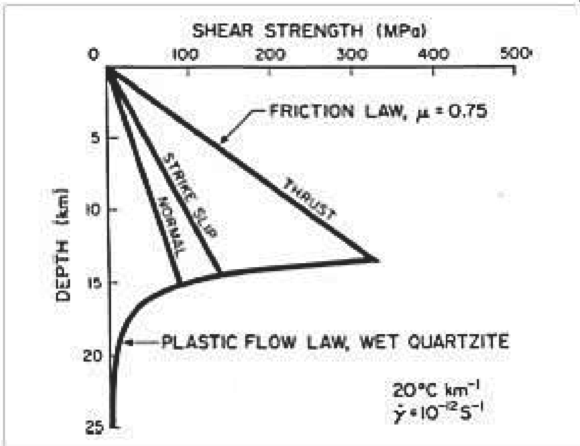


Figure. 17. Graph showing the linear increase of the deformation stress with the depth in the crust, with a value of zero at the earth's surface (Scholz, 2019).

Since the Silala Ignimbrite (Chi) constitutes a thin sheet on the surface of the land, with a free face (the alluvial cover is not considered because it is very thin), it is very unlikely that it is affected by tectonic stresses and, therefore, the family of fractures that affect it are most likely to be cooling and/or gravitational fractures, and cannot be attributed to a regional structural system such as the UKFS, which also was most active over the Oligo-Miocene period, well before the dated Silala Ignimbrite (Chi) or the Cabana Ignimbrite (Chi) was deposited, or the Silala Ignimbrites (Bol).

4. CONCLUSIONS

1. The so-called Silala Ignimbrites (Bol), correspond to several pyroclastic flows of contrasting chemical composition, radiometric age and stratigraphic position. This Bolivian unit is composed of three pyroclastic flows, two of them of dacitic-rhyolitic composition, of 6.6 Ma, although we suspect that this date is incorrect (see section 2.1.1) and 3.2 Ma, and a third of andesitic composition, of 1.6 Ma (Chilean date). The latter corresponds to the Silala Ignimbrite (Chi) that overlaps unconformably onto the ignimbrite of 6.6 Ma. found in Bofedales Sur (Orientales) and that in Chilean territory is deposited on top of the Cabana Ignimbrite of 4.12 Ma. (SERNAGEOMIN, 2017). Bolivian ignimbrites of 6.6 and 3.2 Ma have not been recognized in the area of the Silala River basin in Chilean territory.

2. The Bolivian affirmation that Silala Chico (Cerrito de Silala) volcanic dome intrudes the Silala Ignimbrites (Bol), which was dated at 6.04±0.07 Ma (biotite), is not correct. The Silala Ignimbrite (Chi), dated 1.6 Ma covers in onlap the deposits of this volcanic dome at its base.

3. As a general conclusion, the unit Silala Ignimbrites (Bol) is assigned, erroneously, to the Upper Miocene (7.8 Ma). The supposed structures that affect it and that control the upwelling of groundwater in the springs of Silala River (e.g. the proposed Silala Fault) are attributed to the activity of the Uyuni-Khenayani Fault System, a structural system which was active until ca. 10 Ma and, furthermore, is 31 kilometres to ENE away from the Silala River area. We know that the ignimbrite units that are exposed in the Silala River ravine correspond to Silala Ignimbrite (Chi) unit, dated at 1.6 Ma. It would appear that the incorrect age attributed to these rocks has been used to justify the proposed faults as active structures of the Uyuni-Khenayani Fault System, even though this fault system had ceased to be active more recently than 10-8 Ma.

4. The incorrectly interpreted regional faults in the area of the Bofedales Sur (Orientales) and Bofedales Norte (Cajones) springs that feed the Silala River, are

conveniently located where the groundwater sources are located. The interpreted data for these proposed faults are found in four structural domains. Structural domains 2 and 3 are of a different nature to domains 1 and 4. That is, domains 2 and 3 are shear or compression fractures, which do not conduct water because these types of fractures are closed. However, this criterion has not been considered for the Bofedales Norte (Cajones) springs, where Bolivian geologists interpret the existence of a NE-SW dextral fault through which groundwater is conducted and emerges. This structure corresponds to a shear fracture or closed fracture, therefore there should be no groundwater springs there. This is a clear contradiction.

5. The family of fractures that affect the Silala Ignimbrite (Chi), 1.6 Ma, which is considered as a thin exposed sheet on the surface of the land, correspond to cooling fractures and/or gravitational adjustments during and soon after deposition, and they cannot be attributed to the effects of crustal tectonics, nor to the regional structural system such as the Uyuni-Khenayani Fault System, which was active between the Oligocene and the Upper Miocene, ending its activity ca. 10-8 Ma.

6. The normal faults of the principal structural trend in the Silala River area are of NW-SE orientation (125 to 305 degrees) and these have been related by Bolivia to the Inacaliri Graben. However, according to the determined stress model, particularly for Domain 4, normal faults should have a WNW-ESE orientation (275 to 95 degrees). This suggests that the Graben Inacaliri is a structure linked to the magmatic chambers of the effusive centres and not to a result of deep and ancient regional faults.

7. The Silala-Llancor lineament has been used by Bolivia as a geological artefact related to the upwelling of water in the Bofedales Sur (Orientales) area. The presented data contradict the kinematics deduced for this structure and the Bolivian model of the orientation of the regional stress field. The fault escarpments supposedly associated with it correspond to fronts of lobate lava flows.

8. The magnetic data presented by Bolivia to justify the regional lineaments are not valid, since the basic information is not presented (height of flight, direction of flight

lines, spacing of flight lines), which would allow correction for geophysical artefacts conditioned by the direction of the flight lines and depth of investigation.

9. The only evidence of compressive deformation registered in the area is documented between 2.6-1.6 Ma (Lower Pleistocene), and is linked to the activity of the Cabana Fault, in Chilean territory, and is not linked to an Oligo-Miocene deformation as proposed by the Bolivian geologists.

10. It is stated that the Silala River ravine was carved by erosive activity of the glacial ice through a Silala fault trace, which is attributed to the Uyuni-Khenayani Fault System activity. It has been clearly established that the origin of the Silala River ravine has been excavated by river action during the Upper Pleistocene and 8,400 cal. year BP, and that the ice action had no part in the formation of the ravine (SERNAGEOMIN, 2017; Latorre and Frugone, 2017). It should be noted that glacial activity never generates valleys as narrow as 80 meters (the ravine of the Silala River to SW of Bofedales Norte (Cajones)). In the Silala River area, where vestiges of glacial activity are found, the valleys formed by the action of the ice and that descend from the volcanic edifices have dimensions of 480 to 740 metres wide, far greater than the channel of fluvial origin of the Silala River.

11. This review of several Bolivian technical documents has identified many errors in the mapping of the ignimbrite units in Bolivia. It demonstrates that the contact relationships and stratigraphic position proposed by Bolivia have been mistaken, data have been ignored, and the Bolivian mineralogical description of the ignimbrites is confused and contradictory. They have been grouped into a single age-bounded unit, yet there are published age dates that indicate they can be separated into at least two separate units of distinctly different ages.

5. ACKNOWLEDGEMENTS

The authors thanks to colleague Andrew J. Tomlinson, PhD in structural geology, SERNAGEOMIN geologist, for his contributions to the discussion of faults and structures in general as well as providing specialized literature in the area of crustal deformation. We also thank the librarian of SERNAGEOMIN, Mrs. María Teresa Cortés, who provided us with access to the technical bibliography.

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APPENDIX A

CONVENIO DE COOPERACIÓN INTERINSTITUCIONAL Y
CONTRATO DE CONSULTORIA DIREMAR - SERGEOMIN

SERGEOMIN
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ANEXO C

RESULTADOS DE ANÁLISIS DE LABORATORIO

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SERVICIO GEOLOGICO MINERO

DIRECCION ESTRATEGICA DE REINVINDICACION MARITIMA, SILALA Y RECURSOS

HIDRICOS INTERNACIONALES MAPEO GEOLOGICO DEL AREA CIRCUNDANTE AL MANANTIAL DEL SILALA

TABLA RESUMINDA DE RESULTADOS DE LABORATORIO

N°	ESTE (UTM)	NORTE (UTM)	ELEVACION (m.s.n.m)	CODIGO MUESTRA	ENVIADOS LABORATORIO	NOMBRE DE LA ROCA	RESULTADO PETROGRÁFICO	RESULTADO MINERAGRAFICO (Asociaciones Minerales)
1	601181	7565996	4457	7801	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA	
2	604895	7567297	4541	7802	SERGEOMIN	TOBA VITRO CRISTALINA	DACITA BIOTITICA	
3	605449	7566078	4602	7803	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
4	608499	7567690	4595	7804	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA	
5	609737	7568016	4597	7805	SERGEOMIN	LAVA ACIDA	DACITA BIOTITICA	
6	606789	7561214	5649	7806	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
7	606758	7562878	5041	7807	SERGEOMIN	TOBA CRISTALO VITREA	IGNIMBRITA ANDESITICA	Magnetita-Hematita-Limonita
8	607192	7567230	4601	7808	SERGEOMIN	TOBA CRISTALO VITREA	IGNINBRITA ANDESITICA	Magnetita-Hematita-Limonita
9	600816	7566953	4485	7809	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA	
10	600661	7567938	4547	7810	SERGEOMIN	LAVA BASICA	BASALTO PIROXENICO	
11	600166	7569312	4671	7811	SERGEOMIN	TOBA LITICA INTERMEDIA	ANDESITA PIROXENICA	
12	599317	7568831	4759	7813	SERGEOMIN	TOBA SOLDADA INTERMEDIA	IGNIMBRITA ANDESITICA	
13	603126	7565890	4422	7814	SERGEOMIN	TOBA INTERMEDIA	ANDESITA HORNBLENDICA	
14	603483	7564079	4558	7816	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
15	606447	7562228	5165	7817	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
16	606447	7562228	5165	7818	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
17	607792	7564663	4802	7820	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
18	601256	7572117	5181	7821	SERGEOMIN	LAVA INTERMEDIA	ANDESITA HORNBLENDICA	
19	601256	7572117	5181	7822	SERGEOMIN	LAVA INTERMEDIA	ANDESITA HORNBLENDICA	
20	606578	7568225	4555	7824	SERGEOMIN	VOLCANO SEDIMENTARIA	ARCILLITA	
21	600813	7566226	4367	7702	SERGEOMIN	TOBA CRISTALO VITREA	IGNINBRITA ANDESITICA	Hematita-Magnetita-Calcopirita Limonita
22	600973	7566397	4395	7706	SERGEOMIN	TOBA CRISTALO VITREA	IGNINBRITA ANDESITICA	Hematita-Magnetita-Calcopirita Limonita
23	604396	7576010	4522	7708	SERGEOMIN	TOBA	IGNIMBRITA ANDESITICA	
24	601942	7564641	4606	7712	SERGEOMIN	LAVA ACIDA	DACITA BIOTITICA	
25	602052	7564099	4756	7713	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA CUARZOSA	
26	606242	7568071	4593	7716	SERGEOMIN	TOBA VITRO CRISTALINA	DACITA BIOTITICA	
27	600879	7566738	4437	7717	SERGEOMIN	TOBA VITRO CRISTALINA	DACITA BIOTITICA	
28	603557	7567635	4500	7720	SERGEOMIN	LAVA INTERMEDIA	ANDESITA CUARZOSA	
29	605051	7569399	4580	7721	SERGEOMIN	TOBA VITRO CRISTALINA	DACITA BIOTITICA	
N°	ESTE (UTM)	NORTE (UTM)	ELEVACION (m.s.n.m)	CODIGO MUESTRA	ENVIADOS LABORATORIO	NOMBRE DE LA ROCA	RESULTADO PETROGRÁFICO	RESULTADO MINERAGRAFICO (Asociaciones Minerales)
30	611232	7567663	4626	7722	SERGEOMIN	TOBA VITRO CRISTALINA	DACITA BIOTITICA	

31	611225	7567577	4640	7723	SERGEOMIN	TOBA VITRO CRISTALINA	DACITA BIOTITICA	
32	609442	7569033	4630	7726	SERGEOMIN	LAVA ACIDA	DACITA DE BIOTITA Y HORBLENDA	
33	601557	7573260	4834	7727	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA OXIDADA	
34	605330	7574972	4741	7729	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA OXIDADA	
35	602573	7575219	4607	7732	SERGEOMIN	LAVA INTERMEDIA	ANDESITA BIOTITICA OXIDADA	
36	610800	7562642	4647	7825	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
37	619857	7562113	5107	7827	SERGEOMIN	LAVA ACIDA	DACITA PIROXENICA	
38	608546	7556911	5420	7830	SERGEOMIN	LAVA INTERMEDIA	ANDESITA HORNBLENDICA	
39	598653	7567307	4609	7833	SERGEOMIN	LAVA INTERMEDIA	ANDESITA HORNBLENDICA	
40	620023	7566597	4864	7737	SERGEOMIN	LAVA INTERMEDIA	ANDESITA PIROXENICA	
41	595872	7569264	5631	7743	SERGEOMIN	LAVA INTERMEDIA	ANDESITA HORNBLENDICA	

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RESULTADOS
ANÁLISIS DE PETROGRAFÍA

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 22 de Junio de 2016
Nº LAB: SGM-087/17 Muestra 7702.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba ignimbrítica) de composición intermedia, muestra estructura bandeada o fluidal y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de color marrón y bandas de tono negruzco, ambas muestran cristales de feldespatos blanquecinos, escaso cuarzo, piroxenos, pómez alargadas y óxidos de hierro diseminados, rodeados por una pasta ferruginosa y vítrea, con mayor presencia de hierro en las bandas negruzcas. La toba cristalo-vítrea presenta alto grado de soldadura (ignimbrita), por lo que muestra elevada dureza y compactación, y también es llamada toba soldada.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente muy reducido de la toba, presente en forma de cristales anhedrales con bordes sub-angulosos, de hasta 0,5 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes angulosos (Fig. 1).

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2 mm de largo, muestran maclas polisintéticas tipo Albita, y combinada Albita-Carlsbad, con inclusiones de la pasta vítrea, corresponden a la variedad Oligoclasa (An: 25), se hallan fracturadas y ligeramente orientadas (Fig. 1).

Clinopiroxenos.- Se observan en moderado porcentaje, fenocristales subhedrales de hábito prismático y tabular de clinopiroxenos de tono pardo pálido, algunos con maclas polisintéticas, alcanzan hasta 0,7 mm de largo y probablemente se tratan del tipo augita (Fig. 1).

Pasta.- La pasta de la toba es abundante y está conformada principalmente por óxidos de hierro de tono marrón-rojizo del tipo limonita (ferruginosa), más abundante en las bandas oscuras, junto a vidrio volcánico de tonalidad parda oscura que muestra textura masiva, y en menor porcentaje por microlitos de plagioclasas, rodeando a los fenocristales (Fig. 1).

Pómez.- Se observan en reducido porcentaje, pómez blanquecinas de formas ovaladas y alargadas con bordes irregulares, formados por esquirlas de vidrio volcánico, que alcanzan hasta 3 mm de largo, contienen cristales de plagioclasas y minerales máficos muy oxidados.

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito subhedral, diseminados en la pasta también ferruginosa, que corresponderían a las variedades hematita y magnetita.

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Composición porcentual observada.-

Cuarzo (SiO_2)……………………………………………………	2-3 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………………………	28-30 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………	3-5 %
Pasta (Óxidos de hierro y Vidrio volcánico)………………………………	53-55 %
Pómez (Vidrio volcánico)…………………………………………………	3-4 %
Óxidos de Hierro (Hematita y magnetita)…………………………………	2-3 %
Total……………………………………………………………………	**100 %**

Textura y estructura.- La toba presenta una estructura bandeada o fluidal y textura porfídica de grano medio (>1 mm), con pasta ferruginosa y vítrea de textura masiva, pómez y diseminación de óxidos de hierro (Fig. 1).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una roca piroclástica (toba cristalo-vítrea soldada) de composición intermedia, que corresponde a una **Ignimbrita ANDESÍTICA**.

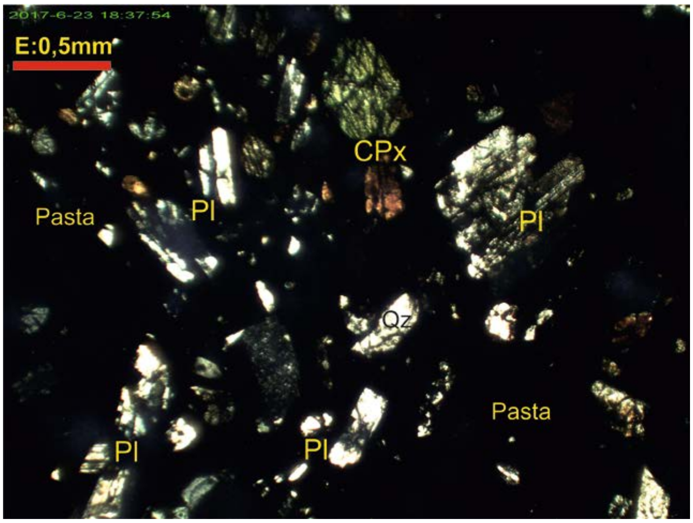

Fig. 1. Muestra 7702, aumento 4x, polarizadores X. Toba Ignimbrítica Andesítica, con fenocristales de plagioclasas (Pl), poco cuarzo (Qz), clinopiroxenos (CPx), pómez, y una pasta ferruginosa-vítrea.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 23 de Junio de 2016
Nº LAB: SGM-088/17 Muestra 7706.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba ignimbrítica) de composición intermedia, muestra estructura bandeada o fluidal y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de color marrón y otras bandas de tono negruzco, ambas muestran cristales de feldespatos blanquecinos, muy escaso cuarzo, piroxenos, pómez alargadas y abundantes óxidos de hierro diseminados, rodeados por una pasta ferruginosa y vítrea, con mayor contenido de hierro en las bandas negruzcas. La toba cristalo-vítrea presenta alto grado de soldadura (ignimbrita), por lo que muestra elevada dureza y compactación, y también es llamada toba soldada.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente escaso de la toba, presente en forma de cristales anhedrales con bordes sub-angulosos, de tamaño inferior a 0,5 mm de largo, muestran fracturas y engolfamientos, también se observan como fragmentos de bordes angulosos (Fig. 2).

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 1,5 mm de largo, muestran maclas polisintéticas tipo Albita, y combinada Albita-Carlsbad, con inclusiones de la pasta vítrea, corresponden al límite entre los tipos Oligoclasa-Andesina (An: 30), se hallan fracturadas y orientadas (Fig. 2).

Clinopiroxenos.- Se observan en reducido porcentaje, fenocristales subhedrales de hábito prismático y tabular de clinopiroxenos de tono pardo pálido, algunos con maclas polisintéticas, alcanzan hasta 0,6 mm de largo y probablemente se tratan del tipo augita (Fig. 2).

Pasta.- La pasta de la toba es abundante y está conformada principalmente por óxidos de hierro de tono marrón-rojizo del tipo limonita (ferruginosa), que es más abundante en las bandas oscuras, junto a vidrio volcánico de tono pardo oscuro que muestra textura masiva, y en menor porcentaje por microlitos de plagioclasas, rodeando a los fenocristales (Fig. 2).

Pómez.- Se observan en reducido porcentaje, pómez blanquecinas de formas ovaladas y alargadas con bordes irregulares, formados por esquirlas de vidrio volcánico, que alcanzan hasta 2,5 mm de largo, contienen micro-cristales de plagioclasas.

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito subhedral, diseminados en la pasta también ferruginosa, que corresponderían a las variedades hematita y magnetita.

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Composición porcentual observada.-

Cuarzo (SiO_2)……………………………………………………………………	1-2 %
Plagioclasas (Oligoclasa-Andesina) $NaCaAl(Si_3O_8)$……………………………	31-33 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	3-4 %
Pasta (Óxidos de hierro y Vidrio volcánico)……………………………………	53-55 %
Pómez (Vidrio volcánico)…………………………………………………………	2-3 %
Óxidos de Hierro (Hematita y magnetita)…………………………………………	2-3 %
Total……………………………………………………………………………	**100 %**

Textura y estructura.- La toba presenta estructura bandeada o fluidal y textura porfídica de grano medio (>1 mm), con pasta ferruginosa y vítrea de textura masiva, pómez y diseminación de óxidos de hierro (Fig. 2).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una roca piroclástica (toba cristalo-vítrea soldada) de composición intermedia, que corresponde a una **Ignimbrita ANDESÍTICA**.

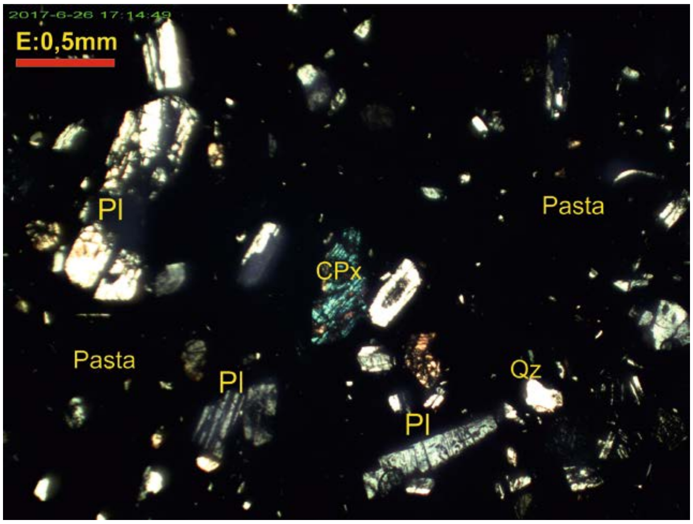

Fig. 2. Muestra 7706, aumento 4x, polarizadores X. Toba Ignimbrítica Andesítica, con fenocristales de plagioclasas (Pl), escaso cuarzo (Qz), clinopiroxenos (CPx), pómez, y una pasta ferruginosa-vítrea.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 04 de Julio de 2017
Nº LAB: SGM-115/17 Muestra 7712.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con superficies de meteorización, composición ácida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, contiene agregados de calcita rellenando pequeñas cavidades de la roca, la cual muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente moderado de la lava, presente en forma de fenocristales anhedrales con bordes sub-redondeados de hasta 2,5 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes sub-angulosos (Fig. 3).

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Andesina (An: 35), se hallan fracturadas y ligeramente orientadas (Fig. 3).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares y euhedrales poligonales que alcanzan hasta 4 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas.

Clinopiroxenos.- Se observan en reducido porcentaje, fenocristales subhedrales de hábito prismático y de tono verdoso pálido, de hasta 1 mm de largo, se trata del tipo augita (Fig. 3).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales poligonales de color marrón, se hallan reemplazados parcialmente por limonita, alcanzan hasta 3 mm de largo.

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas ligeramente orientados con textura afieltrada, y en menor porcentaje por óxidos de hierro diseminados de tono marrón oscuro del tipo limonita y hematita (Fig. 3); también se observan en escaso porcentaje micro-cristales de apatito de hábito prismático.

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, que corresponderían a las variedades hematita y limonita.

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Calcita.- Se observan agregados anhedrales de calcita secundaria de grano fino y de color blanquecino, rellenando pequeñas cavidades, mejor observables en la muestra de mano.

Composición porcentual observada.-

Cuarzo (SiO_2)……	6-8 %
Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$……	23-25 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……	3-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$……	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……	1-2 %
Pasta (microlitos de plagioclasas)……	50-52 %
Óxidos de Hierro (Hematita y limonita)……	2-3 %
Calcita ($CaCO_3$)……	1-2 %
Total……	**100 %**

Textura y estructura.- Presenta estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta microlítica de textura afieltrada y diseminación de óxidos de hierro (Fig. 3).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición ácida, que corresponde a una **DACITA Biotítica**, ligeramente oxidada, contiene cavidades con calcita.

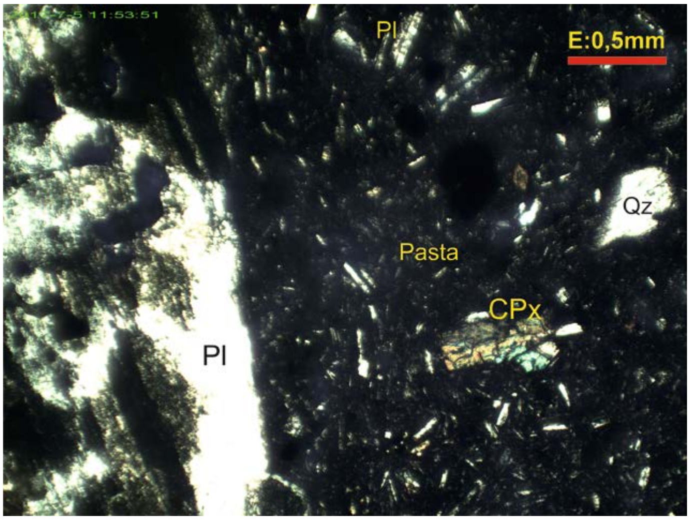

Fig. 3. Muestra 7712, aumento 4x, polarizadores X. Lava Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), clinopiroxenos (CPx) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 04 de Julio de 2017
Nº LAB: SGM-116/17 Muestra 7716.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos, cuarzo, biotita con orientación, pómez blanquecinas y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderado grado de soldadura y de dureza.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente moderado de la toba, presente en forma de fenocristales anhedrales con bordes sub-angulosos de hasta 2 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes angulosos (Fig. 4).

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Oligoclasa (An: 25), se hallan también como fragmentos angulosos (Fig. 4).

Feldespato potásico.- Se observan en reducido porcentaje, fenocristales anhedrales y subhedrales de feldespatos potásicos, sin maclas, de hasta 1,5 mm de largo (sanidina).

Biotita.- Se presenta en moderada proporción, como fenocristales subhedrales prismáticos y euhedrales poligonales que alcanzan hasta 2 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas (Fig. 4).

Pasta.- La pasta de la toba es abundante y está formada principalmente por esquirlas de vidrio volcánico de tono pardo oscuro con textura masiva, junto a óxidos de hierro del tipo limonita (Fig. 2); también se observan en muy escaso porcentaje micro-cristales prismáticos de circón.

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita, que corresponderían a las variedades hematita y limonita.

Pómez.- Se observan en moderado porcentaje, pómez blanquecinas de forma ovalada, constituidas por esquirlas de vidrio volcánico de tono pardo y textura masiva que contienen cristales de plagioclasas, cuarzo y biotita, que alcanzan hasta 1 mm de largo en la sección delgada y hasta 2,5 cm en la muestra de mano.

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Composición porcentual observada.-

Cuarzo (SiO_2)……	13-15 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$……	23-25 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……	4-5 %
Feldespato Potásico $(K)AlSi_3O_8$……	2-3 %
Pasta (Vidrio volcánico)……	45-47 %
Óxidos de Hierro (Hematita y limonita)……	2-3 %
Pómez (vidrio volcánico)……	1-2 %
Total……	**100 %**

Textura y estructura.- Presenta estructura hipocristalina y textura porfídica de grano medio (>1 mm), con pasta vítrea de textura masiva, pómez y diseminación de óxidos de hierro (Fig.4).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una toba vitro-cristalina de composición ácida, que corresponde a una **DACITA Biotítica**, con contenido de pómez.

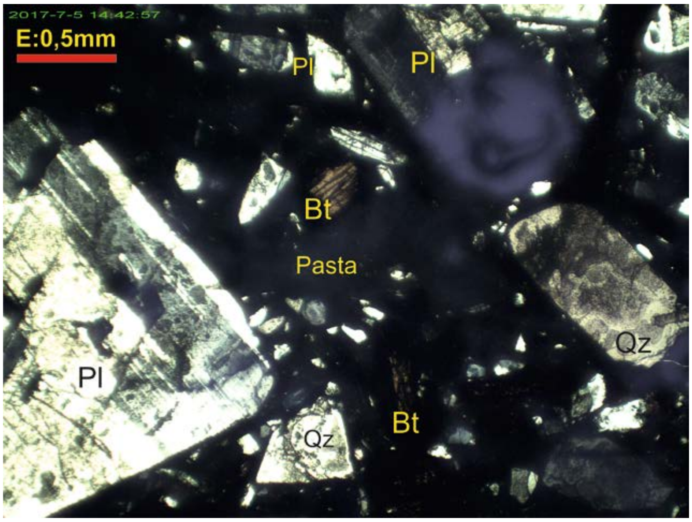

Fig. 4. Muestra 7716, aumento 4x, polarizadores X. Toba Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), biotita oxidada (Bt), pómez y pasta vítrea de textura masiva.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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LABORATORIO DE PETROGRAFÍA-MINERAGRAFÍA

SERGEOMIN
SERVICIO GEOLÓGICO MINERO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 05 de Julio de 2017
Nº LAB: SGM-117/17 Muestra 7804.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Andesina (An: 35), se hallan fracturadas y marcadamente orientadas (Fig. 5).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales y tabulares que alcanzan hasta 0,5 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación.

Clinopiroxenos.- Se observan en reducido porcentaje, en forma de fenocristales subhedrales de hábito prismático y de tono verdoso pálido, de hasta 0,5 mm de largo, se hallan fracturados y se trata del tipo augita (Fig. 5).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas marcadamente orientados de acuerdo al flujo de la lava, con textura afieltrada, rodeando a fenocristales, y en menor porcentaje por óxidos de hierro diseminados de tono marrón oscuro del tipo limonita, hematita y magnetita (Fig. 5).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y cúbico, diseminados en la pasta y alterando a fenocristales de biotita, que corresponderían a las variedades hematita, limonita y probablemente magnetita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………………………………………	28-30 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………	3-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	1-2 %

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Pasta (microlitos de plagioclasas)………………….........………….....……..	58-60 %
Óxidos de Hierro (Hematita, limonita, magnetita)…….………………..…...…….	2-3 %
Total………………………………………………...……………….….……	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>1 mm), con pasta microlítica de textura afieltrada y diseminación de óxidos de hierro (Fig. 5).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Biotítica**, ligeramente oxidada.

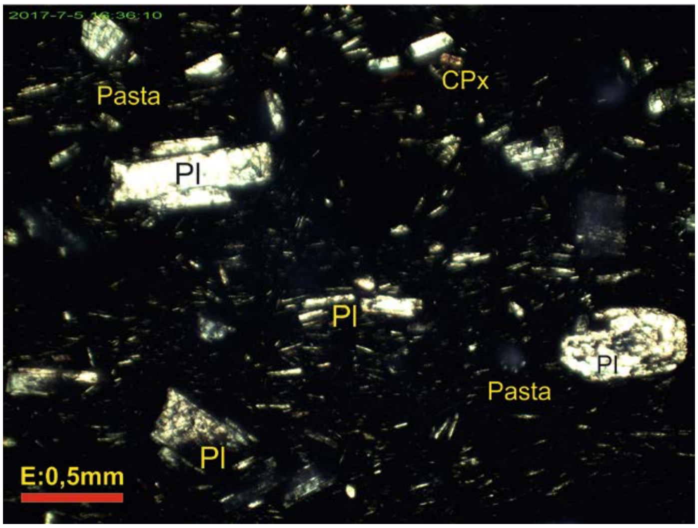

Fig. 5. Muestra 7804, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), escasos clinopiroxenos (CPx) y pasta con microlitos de plagioclasas orientadas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 05 de Julio de 2017
Nº LAB: SGM-118/17 Muestra 7805.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con superficies de meteorización, de composición ácida, muestra estructura holocristalina y textura porfídica de grano medio (>3 mm), donde se observan grandes cristales de feldespatos blanquecinos, cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente moderado de la lava, presente como fenocristales anhedrales y subhedrales con bordes sub-redondeados de hasta 2 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes sub-angulosos (Fig. 6).

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 7 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Oligoclasa (An: 25), se hallan fracturadas (Fig. 6).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 1,5 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas.

Clinopiroxenos.- Se observan en reducido porcentaje, fenocristales subhedrales de hábito prismático y euhedrales poligonales de tono verdoso pálido, de hasta 1 mm de largo, se trata de la variedad augita (Fig. 6).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales romboédricos de color marrón oscuro, que se hallan reemplazados parcialmente en sus bordes por limonita, alcanzan hasta 1 mm de largo (Fig. 6).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas ligeramente orientados con textura afieltrada, y en menor porcentaje por óxidos de hierro diseminados de tono marrón oscuro del tipo limonita y hematita (Fig. 6).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita, hematita y magnetita.

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Composición porcentual observada.-

Cuarzo (SiO_2)……………………………………………………………………	10-12 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$……………………………………….	23-25 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………………...	4-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$…………………………………………	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$………………………………………..	1-2 %
Pasta (microlitos de plagioclasas)………………………………………………..	48-50 %
Óxidos de Hierro (Hematita, limonita, magnetita). …………………………………	2-3 %
Total………………………………………………………………………………	**100 %**

Textura y estructura.- Presenta estructura holocristalina y textura porfídica de grano medio (>3 mm), con pasta microlítica de textura afieltrada y diseminación de óxidos de hierro (Fig. 6).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición ácida, que corresponde a una **DACITA Biotítica**, ligeramente oxidada.

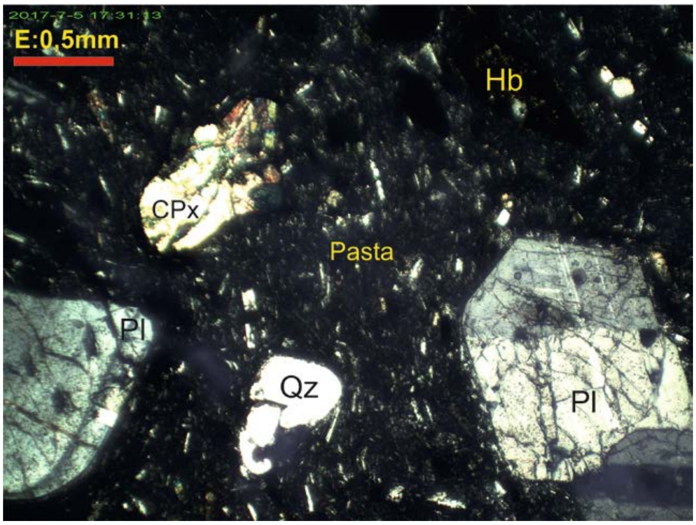

Fig. 6. Muestra 7805, aumento 4x, polarizadores X. Lava Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), clinopiroxenos (CPx), hornblenda oxidada, y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 05 de Julio de 2017
Nº LAB: SGM-119/17 Muestra 7807.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcanico (flujo de lava) de composición intermedia, muestra estructura ligeramente bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de color marrón-rojizo y bandas de tono gris oscuro, ambas muestran cristales de feldespatos blanquecinos, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta ferruginosa y vítrea, con más presencia de hierro en las bandas grises. La toba presenta coloracion gris-verdusca, por lo que muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Andesina (An: 35), se hallan como fragmentos (Fig. 7).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 1 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas (Fig. 7).

Clinopiroxenos.- Se observan en moderado porcentaje, fenocristales subhedrales de hábito prismático y euhedrales poligonales de tono verdoso pálido con maclas de dos individuos, alcanzan hasta 1 mm de largo, se trata de la variedad augita (Fig. 7).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales romboédricos de color marrón-rojizo, que se hallan reemplazados parcialmente en sus bordes por limonita, alcanzan hasta 0,5 mm de largo (Fig. 7).

Pasta.- La pasta de la toba es abundante y está formada principalmente por esquirlas de vidrio volcánico de tono pardo oscuro de textura masiva, junto a óxidos de hierro diseminados de tono marrón del tipo limonita y en menor porcentaje por microlitos de plagioclasas ligeramente orientados (Fig. 7).

Óxidos de Hierro.- Se presentan en moderado porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$……………………………………	30-32 %
Biotita $(K_2(Mg,Fe)_2(OH)_2(AlSiO_{10}))$……………………………………	3-4 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$……………………………………	3-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……………………………	2-3 %
Pasta (vidrio, limonita y microlitos)……………………………………	50-53 %
Óxidos de Hierro (Hematita, limonita, magnetita). ……………………	2-3 %
Total……………………………………………………………………	**100 %**

Textura y estructura.- Presenta estructura bandeada y lenticular, y textura porfídica de grano medio (>1 mm), con pasta vítrea masiva, ferruginosa y en menor grado microlítica. La roca se presenta compacta y dura (Fig. 7).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una roca volcanica (cristalo-vítrea) de composición intermedia, que corresponde a una **ANDESÍTICA piroxenica**.

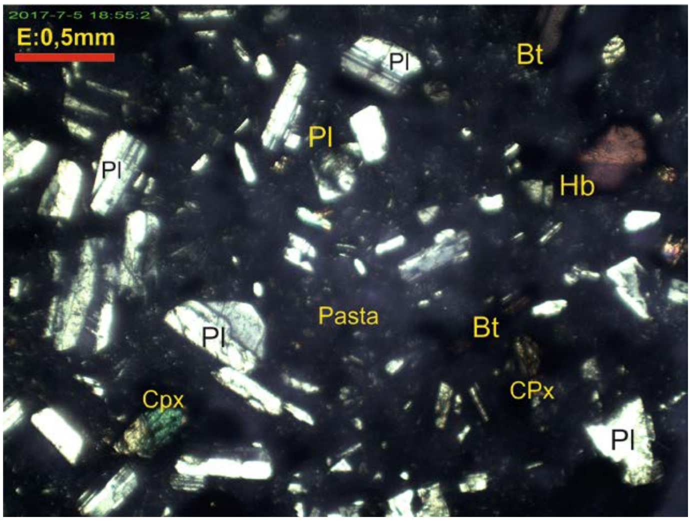

Fig. 7. Muestra 7807, aumento 4x, polarizadores X. Ignimbrita Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx), biotita (Bt), hornblenda (Hb) y pasta vítrea-ferruginosa con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORI

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 06 de Julio de 2017
Nº LAB: SGM-120/17 Muestra 7713.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, presenta superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan grandes cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente presente en escaso porcentaje, en forma de fenocristales anhedrales con bordes sub-redondeados, de hasta 0,5 mm de largo, muestran fracturas y engolfamientos (Fig. 8).

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden al límite entre las variedades Oligoclasa-Andesina (An: 30) (Fig. 8).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 2 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, contienen pequeñas inclusiones de plagioclasas.

Clinopiroxenos.- Se observan en reducido porcentaje, fenocristales subhedrales de hábito prismático y tabular, de tono verdoso pálido, de hasta 0,4 mm de largo, se trata de la variedad augita (Fig. 8).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales romboédricos de color marrón oscuro, que se hallan reemplazados parcialmente por limonita, alcanzan hasta 2,5 mm de largo (Fig. 8).

Pasta.- La pasta de la lava es abundante y está formada principalmente por vidrio volcánico de textura masiva, y en menor porcentaje por microlitos de plagioclasas sin orientación, y óxidos de hierro diseminados de tono marrón oscuro del tipo limonita y hematita (Fig. 8).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita y hematita.

Composición porcentual observada.-

Cuarzo (SiO_2)……	1-2 %
Plagioclasas (Oligoclasa-Andesina) $NaCaAl(Si_3O_8)$……	25-28 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……	3-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$……	1-2 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……	2-3 %
Pasta (Vidrio volcánico, microlitos de plagioclasas) ……	55-57 %
Óxidos de Hierro (Hematita, limonita). ……	2-3 %
Total……	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>1 mm), con pasta vítrea y microlítica, junto a óxidos de hierro (Fig. 8).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Biotítica (cuarzosa)**, ligeramente oxidada.

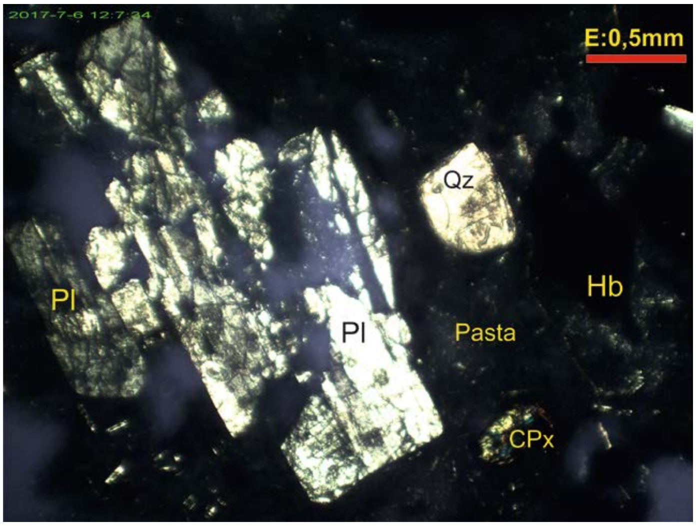

Fig. 8. Muestra 7713, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), escaso cuarzo (Qz), clinopiroxenos (CPx), hornblenda oxidada y pasta vítrea con microlitos de plagioclasas.

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ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 19 de Julio de 2017
Nº LAB: SGM-121/17 Muestra 7708.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcanico (lava) de composición acida, muestra estructura bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre delgadas bandas lenticulares de color marrón-negruzco y bandas de tono gris claro, ambas muestran cristales de feldespatos blanquecinos, biotita,piroxenos y óxidos de hierro diseminados, rodeados por una pasta vítrea, con más presencia de hierro en las bandas oscuras. La roca se presenta masiva, compacta, por lo que muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta y de piroxenos, corresponden a la variedad Andesina (An: 40) (Fig. 9).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 0,7 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas.

Clinopiroxenos.- Se observan en moderado porcentaje, fenocristales subhedrales de hábito prismático y euhedrales poligonales de tono verdoso pálido con maclas de dos individuos, alcanzan hasta 1 mm de largo, se trata de la variedad augita (Fig. 9).

Pasta.- La pasta de la toba es abundante y está formada principalmente por esquirlas de vidrio volcánico de tono pardo oscuro de textura masiva y localmente esferulítica, junto a óxidos de hierro diseminados de tono marrón del tipo limonita (Fig. 9).

Óxidos de Hierro.- Se presentan en moderado porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita, que corresponderían a las variedades limonita (Fig. 9), hematita y magnetita (magnética).

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$……………………...……...………..	30-32 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………...………………………………....	5-7 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$..……..……	<1 %

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Pasta (vidrio, limonita y microlitos)…………………..........…………....….….	51-55 %
Óxidos de Hierro (Hematita, limonita, magnetita)..…………………..…...….….	<1 %
Total……………………………………………………...……………….….……	**100 %**

Textura y estructura.- Presenta estructura bandeada y textura porfídica de grano medio (>1 mm), con pasta vítrea masiva y esferulítica. La roca es masiva, compacta y presenta elevada dureza (Fig. 9).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una roca volcanica (cristalo-vítrea) de composición intermedia, que corresponde a una **DACITICA biotitica.**

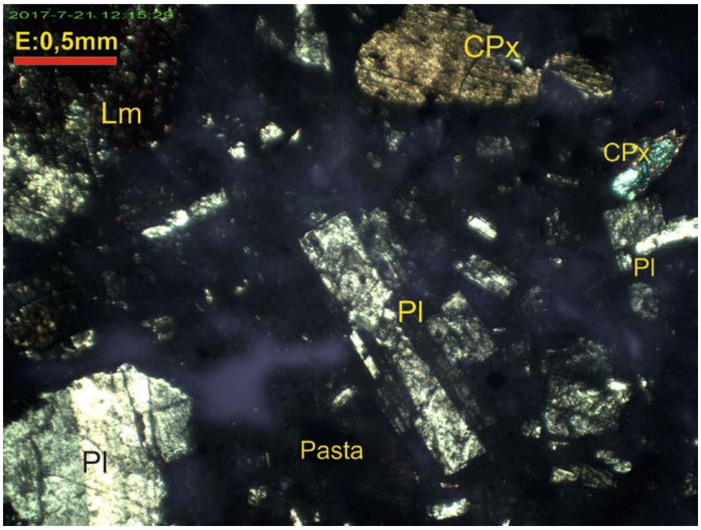

Fig. 9. Muestra 7708, aumento 4x, polarizadores X. Ignimbrita Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx), limonita diseminada (Lm) y pasta vítrea masiva.

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LABORATORIO DE PETROGRAFÍA-MINERAGRAFÍA

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SERVICIO GEOLÓGICO MINERO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 24 de Julio de 2017
Nº LAB: SGM-123/17 Muestra 7717.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico, de color gris oscuro con superficies de meteorización, de composición ácida, muestra estructura vitro-cristalina y textura porfídica de grano medio (>3 mm), donde se observan grandes cristales de feldespatos blanquecinos, cuarzo, biotita, anfíboles, escasos piroxenos, pómez alargadas de tono rosáceo y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente moderado de la lava, presente como fenocristales anhedrales y subhedrales con bordes sub-redondeados de hasta 2 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes sub-angulosos (Fig. 10).

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Oligoclasa (An: 25), se hallan fracturadas (Fig. 10).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 3,5 mm de largo, de color marrón oscuro por la intensa oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas y muestran orientación (Fig.10).

Clinopiroxenos.- Se observan en muy reducido porcentaje, como fenocristales subhedrales de hábito prismático y anhedral, de tono verdoso pálido, de hasta 0,5 mm de largo, corresponden a la variedad augita.

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales romboédricos de color marrón-rojizo, que se hallan reemplazados parcialmente en sus bordes por limonita, alcanzan hasta 1 mm de largo (Fig. 10).

Pasta.- La pasta de la toba es abundante y está formada principalmente por vidrio volcánico de textura masiva y en menor porcentaje por microlitos de plagioclasas y óxidos de hierro diseminados de tono marrón oscuro del tipo limonita (Fig. 10).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita, hematita y magnetita.

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Pómez.- Se observan ocacionalmente, clastos de pómez de forma sub-redondeada y otra alargada formadas por esquirlas de vidrio volcánico y micro-cristales de plagioclasas, biotita y hornblenda (Fig. 10).

Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………	8-10 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………………………	20-22 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……………………………	4-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$…………………………	< 1 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………	2-3 %
Pasta (vidrio volcánico y microlitos)……………………………	48-50 %
Óxidos de Hierro (Hematita, limonita, magnetita). …………………	2-3 %
Pómez (vidrio y micro-cristales)………………………………	< 1%
Total………………………………………………………	**100 %**

Textura y estructura.- Presenta estructura vitro-cristalina y textura porfídica de grano medio (>3 mm), con pasta vítrea y microlítica, y pómez alargadas (Fig. 10).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una roca vitro-cristalina de composición ácida, que corresponde a una **DACITA Biotítica**, débilmente oxidada.

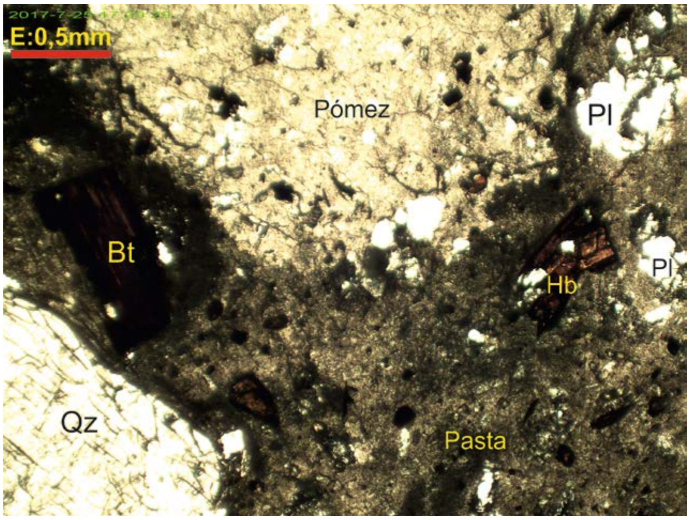

Fig. 10. Muestra 7717, aumento 4x, polarizadores ll. Toba Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), biotita (Bt), hornblenda (Hb), pómez y pasta vítrea masiva.

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UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 24 de Julio de 2017
Nº LAB: SGM-124/17 Muestra 7720.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de meteorización, de composición intermedia, muestra estructura cavernosa o vesicular y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, escaso cuarzo, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra moderada dureza y compactación, y cavidades rellenas por cuarzo.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente presente en escaso porcentaje, en forma de fenocristales anhedrales y subhedrales con bordes sub-redondeados, de hasta 0,5 mm de largo, muestran fracturas y engolfamientos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 4 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Andesina (An: 45) (Fig. 11).

Clinopiroxenos.- Se observan en reducido porcentaje, fenocristales subhedrales de hábito prismático, de tono verdoso pálido, de hasta 0,5 mm de largo, se trata de la variedad augita.

Pasta.- La pasta es abundante y está formada principalmente por microlitos de plagioclasas con textura afieltrada (sin orientación), y en menor porcentaje por vidrio volcánico de textura masiva y óxidos de hierro de tono marrón oscuro del tipo limonita y hematita (Fig. 11).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita y hematita.

Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………………………	1-2 %
Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$…………………………………………	30-32 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	1-2 %
Pasta (Microlitos de plagioclasas)……………………………………………	58-60 %
Óxidos de Hierro (Hematita, limonita). …………………………………………	3-4 %
Total………………………………………………………………………………	**100 %**

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Textura y estructura.- Presenta una estructura cavernosa o vesicular y textura porfídica de grano medio (>2 mm), con pasta microlítica, junto a óxidos de hierro (Fig. 11).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA (cuarzosa)**, ligeramente oxidada.

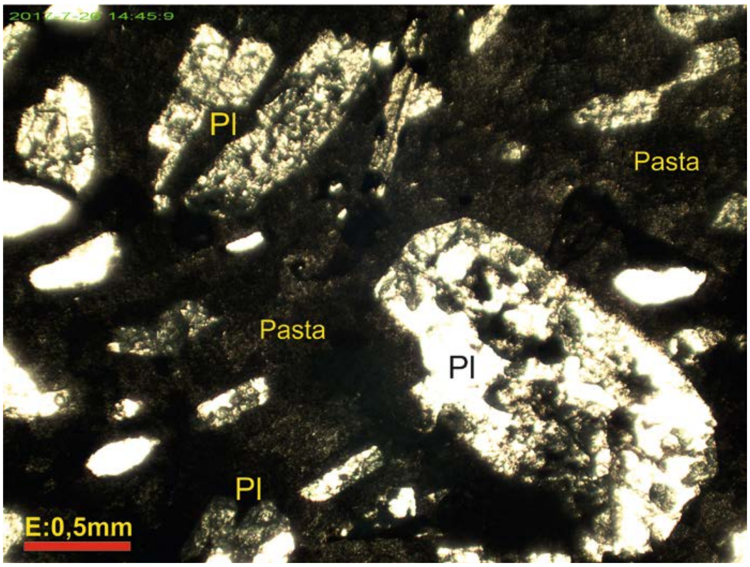

Fig. 11. Muestra 7720, aumento 4x, polarizadores ll. Lava Andesítica, con fenocristales de plagioclasas (Pl), óxidos de hierro, y pasta con microlitos de plagioclasas y vidrio volcánico.

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FECHA: 24 de Julio de 2017
Nº LAB: SGM-125/17 Muestra 7721.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (toba), de color marrón con tono grisáceo, tiene superficies de meteorización, de composición ácida, muestra estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, cuarzo, biotita oxidad, litoclastos y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderada dureza y grado de soldadura.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 2 mm de largo, muestran fracturas, zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Oligoclasa (An: 25) (Fig. 12).

Feldespato potásico.- Se observan en reducido porcentaje, fenocristales anhedrales y subhedrales tabulares de feldespatos potásicos, con maclas tipo Carlsbad, de hasta 1,5 mm de largo (posiblemente de la variedad sanidina).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares y prismáticos que alcanzan hasta 3 mm de largo, de color marrón-rojizo por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas (Fig. 12).

Pasta.- La pasta de la toba es abundante, está formada principalmente por vidrio volcánico de textura masiva y localmente esferulítica y en menor porcentaje por óxidos de hierro diseminados de tono marrón oscuro del tipo limonita (Fig. 12).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita, que corresponderían a las variedades limonita y hematita.

Litoclastos.- Se observan algunos litoclastos formados por rocas volcánicas con cristales de plagioclasas y óxidos de hierro, así como de rocas ferruginosas de tono rojizo, alcanzan hasta 2 mm de largo.

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Composición porcentual observada.-

Cuarzo (SiO_2)……	13-15 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$……	23-25 %
Feldespato Potásico $(K)AlSi_3O_8$……	2-3 %
Biotita $(K_2(Mg,Fe)_2(OH)_2(AlSiO_{10}))$……	4-5 %
Pasta (vidrio volcánico)……	45-47 %
Óxidos de Hierro (limonita, hematita,)……	2-3 %
Litoclastos (volcánicos y ferruginosos)……	1-2 %
Total……	**100 %**

Textura y estructura.- Presenta estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), con pasta vítrea y litoclastos (Fig. 12).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una toba vitro-cristalina de composición ácida, que corresponde a una **DACITA Biotítica**, débilmente oxidada.

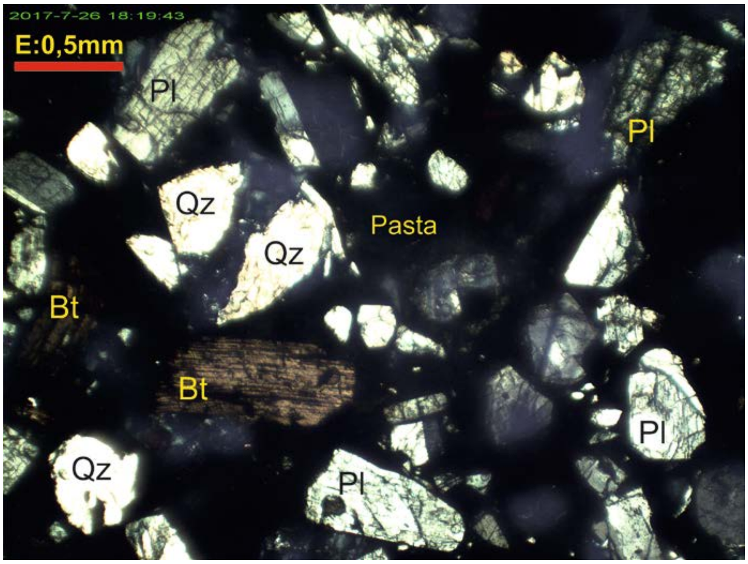

Fig. 12. Muestra , aumento 4x, polarizadores X. Toba Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), biotita oxidada (Bt), y pasta vítrea de textura masiva.

Analizado por: Ing. José Luis Argandoña C.
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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 25 de Julio de 2017
Nº LAB: SGM-126/17 Muestra 7801.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, biotita y anfíboles muy oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra moderada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, se hallan ligeramente argilizadas y corresponden a la variedad Andesina (An: 40) (Fig. 13).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares y prismáticos que alcanzan hasta 2 mm de largo, de color marrón-rojizo por la intensa oxidación de sus bordes y planos de exfoliación (Fig. 13).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales romboédricos de color marrón-rojizo reemplazados parcialmente por limonita, de hasta 1,5 mm de largo (Fig. 13).

Clinopiroxenos.- Se observan en reducido porcentaje, fenocristales subhedrales y prismáticos, de tono verdoso pálido de hasta 0,5 mm de largo, se trata de la variedad augita (Fig. 13).

Pasta.- La pasta es abundante y está formada principalmente por microlitos de plagioclasas con textura afieltrada que muestran orientación, y en menor porcentaje por vidrio volcánico de textura masiva (Fig. 13).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$……………………	23-25 %
Biotita $(K_2(Mg,Fe)_2(OH)_2(AlSiO_{10}))$……………………	4-6 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……………………	2-3 %

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Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$.………...….	2-3 %
Pasta (Microlitos de plagioclasas).………….………………………......……...	58-60 %
Óxidos de Hierro (Hematita, limonita, magnetita).………………..…….…...….	2-3 %
Total………………………………………………...…………………..………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta microlítica y vítrea (Fig. 13).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Biotítica**, débilmente oxidada.

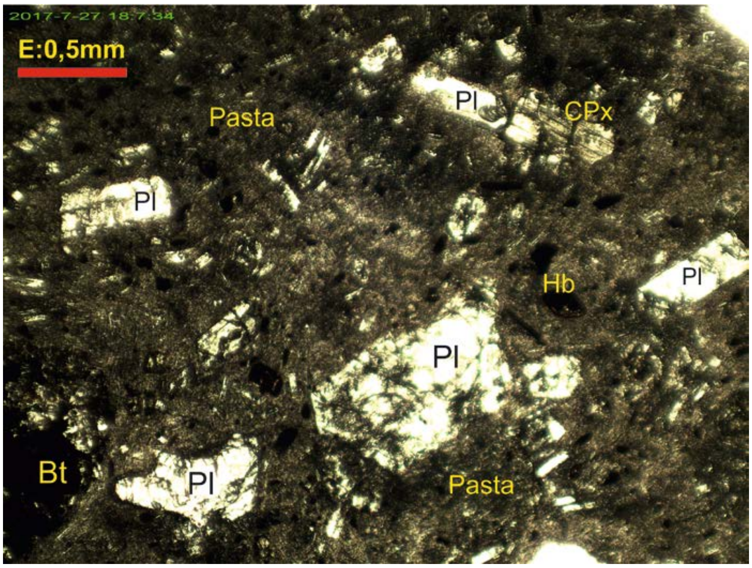

Fig. 13. Muestra 7801, aumento 4x, polarizadores ll. Lava Andesítica, con fenocristales de plagioclasas (Pl), biotita (Bt), hornblenda (Hb), clinopiroxenos (CPx) y pasta con microlitos de plagioclasas y vidrio volcánico.

Analizado por: Ing. José Luis Argandoña C.
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LABORATORIO DE PETROGRAFÍA-MINERAGRAFÍA

SERGEOMIN
SERVICIO GEOLÓGICO MINERO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 25 de Julio de 2017
Nº LAB: SGM-127/17 Muestra 7802.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (toba), de color marrón con tono rosáceo, tiene superficies de meteorización, de composición ácida, muestra estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, biotita muy oxidada, anfíboles, pómez alargadas de tono blanquecino y óxidos de hierro, rodeados por una pasta vítrea y ferruginosa, muestra moderada dureza y grado de soldadura.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente reducido de la toba, presente como fenocristales anhedrales y subhedrales con bordes sub-redondeados, de hasta 1 mm de largo, muestran fracturas.

Plagioclasas.- Se presentan en abundante porcentaje como fenocristales subhedrales y prismáticos de tamaño muy variable, entre 0,5 a 4 mm de largo, predominando los de grano fino, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Oligoclasa (An: 20), se hallan fracturadas y orientadas (Fig. 14).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 2,5 mm de largo, de color marrón oscuro por la intensa oxidación de sus bordes y planos de exfoliación, muestran cierta orientación (Fig. 14).

Hornblenda.- Se observan en reducido porcentaje fenocristales subhedrales y euhedrales romboédricos de color marrón-rojizo, que se hallan reemplazados parcialmente en sus bordes por limonita, alcanzan hasta 1 mm de largo (Fig. 14).

Pasta.- La pasta de la toba es abundante y está formada principalmente por vidrio volcánico de textura masiva y en menor porcentaje por óxidos de hierro diseminados (ferruginosa) de tono marrón oscuro del tipo limonita (Fig. 14).

Óxidos de Hierro.- Se presentan en moderado porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, que corresponden a las variedades limonita y hematita.

Pómez.- Se observan pómez blanquecinas y deformadas (alargadas), formadas por esquirlas de vidrio volcánico y micro-cristales de plagioclasas y biotita oxidada, que se observan mejor en la muestra de mano, alcanzando varios cm de largo.

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Composición porcentual observada.-

Cuarzo (SiO_2)……	3-5 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$……	30-32 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……	4-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……	2-3 %
Pasta (vidrio volcánico y limonita)……	45-47 %
Óxidos de Hierro (Limonita y hematita)……	2-3 %
Pómez (vidrio y micro-cristales)……	3-5 %
Total……	**100 %**

Textura y estructura.- Presenta estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), con pasta vítrea-ferruginosa y pómez alargadas (Fig. 14).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una toba vitro-cristalina de composición ácida, que corresponde a una **DACITA Biotítica**, moderadamente oxidada.

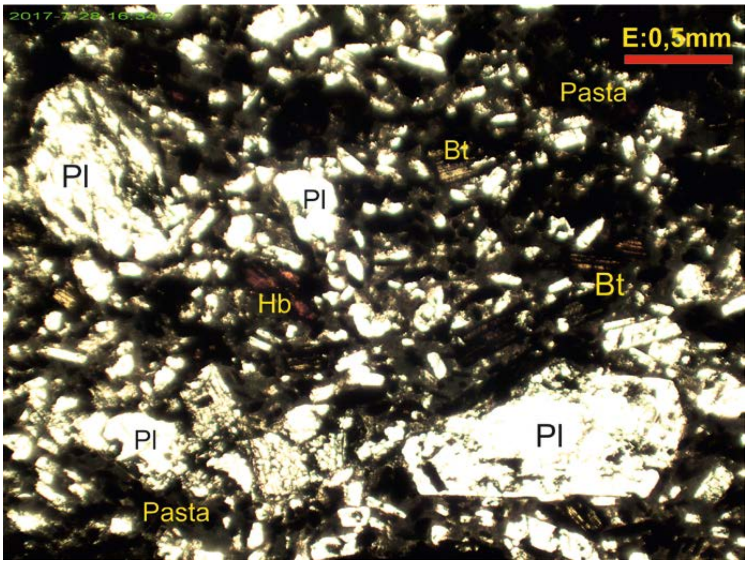

Fig. 14. Muestra 7802, aumento 4x, polarizadores ll. Toba Dacítica, con fenocristales de plagioclasas (Pl), biotita (Bt) y hornblenda (Hb) oxidadas, y una pasta vítrea-ferruginosa.

Analizado por: Ing. José Luis Argandoña C.
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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 26 de Julio de 2017
Nº LAB: SGM-128/17 Muestra 7803.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos orientados, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino. La lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Andesina (An: 35), se hallan fracturadas y orientadas (Fig. 15).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales y tabulares que alcanzan hasta 2 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas (Fig. 15).

Hornblenda.- Se observan en reducido porcentaje fenocristales subhedrales y anhedrales de color marrón-rojizo, que se hallan reemplazados parcialmente en sus bordes por limonita, alcanzan hasta 1 mm de largo.

Clinopiroxenos.- Se observan en moderado porcentaje, en forma de fenocristales subhedrales de hábito prismático y de tono verdoso pálido, de hasta 1,5 mm de largo, se hallan fracturados, con maclas de dos individuos, se trata del tipo augita (Fig. 15).

Pasta.- La pasta de la lava es abundante y está formada principalmente por micro-cristales y microlitos de plagioclasas marcadamente orientados de acuerdo al flujo de la lava, con textura afieltrada, rodeando a los fenocristales, y en menor porcentaje por óxidos de hierro diseminados de tono marrón oscuro del tipo limonita, hematita y magnetita (Fig. 15).

Óxidos de Hierro.- Se presentan en moderado porcentaje, como pequeños minerales opacos de hábito anhedral y cúbico, diseminados en la pasta y alterando a fenocristales de biotita, que corresponderían a las variedades hematita, limonita y probablemente magnetita.

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Composición porcentual observada.-

Plagioclasas (Andesina) NaCaAl(Si_3O_8)…………………………………………..	28-30 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……………………………………………...	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………………………..	1-2 %
Clinopiroxenos (Augita) (Mg,Fe)(SiO_3)…………………………………………	4-5 %
Pasta (microlitos de plagioclasas)………………………………………………..	55-57 %
Óxidos de Hierro (Hematita, limonita, magnetita)…………………………………	2-3 %
Total………………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>1 mm), con pasta microlítica de textura afieltrada y diseminación de óxidos de hierro (Fig. 15).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**, ligeramente oxidada.

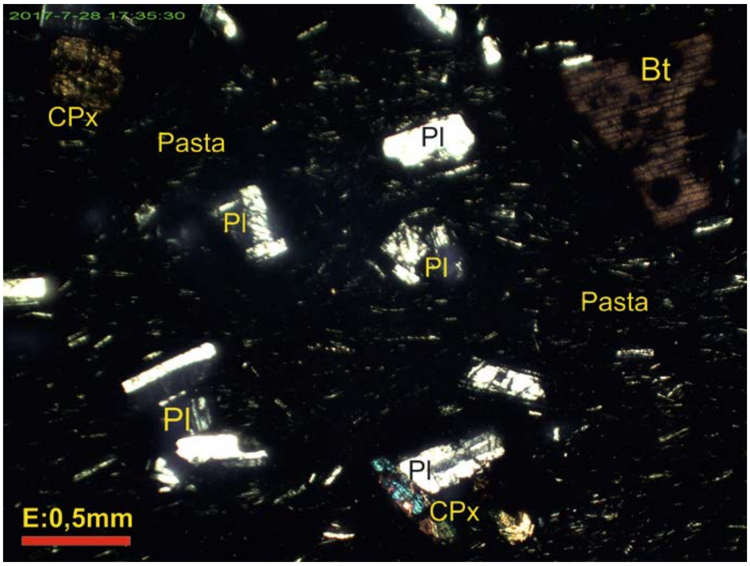

Fig. 15. Muestra 7803, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx), biotita (Bt) y pasta con microlitos de plagioclasas orientadas.

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FECHA: 26 de Julio de 2017
Nº LAB: SGM-129/17 Muestra 7806.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos orientados, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en muy abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de tamaño variable, entre 0,3 hasta 2 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Oligoclasa (An: 25), se hallan fracturadas y orientadas (Fig. 16).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales y tabulares que alcanzan hasta 1 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación (Fig. 16).

Hornblenda.- Se observan en muy reducido porcentaje fenocristales subhedrales y anhedrales de color marrón-rojizo por la oxidación de sus bordes, alcanzan hasta 0,5 mm de largo.

Clinopiroxenos.- Se observan en moderado porcentaje, en forma de fenocristales subhedrales de hábito prismático y euhedrales poligonales de tono verdoso pálido, de hasta 1 mm de largo, se hallan fracturados, de la variedad augita (Fig. 16).

Pasta.- La pasta de la lava es abundante y está formada principalmente por micro-cristales y microlitos de plagioclasas marcadamente orientados de acuerdo al flujo de la lava, con textura afieltrada, y en menor porcentaje por óxidos de hierro diseminados de tono marrón oscuro del tipo limonita, hematita y magnetita (Fig. 16).

Óxidos de Hierro.- Se presentan en moderado porcentaje, como pequeños minerales opacos de hábito anhedral y cúbico, diseminados en la pasta y alterando a fenocristales de biotita, que corresponderían a las variedades hematita, limonita y magnetita.

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Composición porcentual observada.-

Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………………………………………	25-27 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……………………………………………	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$………………………………	1-2 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	3-5 %
Pasta (microlitos de plagioclasas)…………………………………………	58-60 %
Óxidos de Hierro (Hematita, limonita, magnetita)………………………………	2-3 %
Total…………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>1 mm), con pasta microlítica de textura afieltrada y diseminación de óxidos de hierro (Fig. 16).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**, ligeramente oxidada.

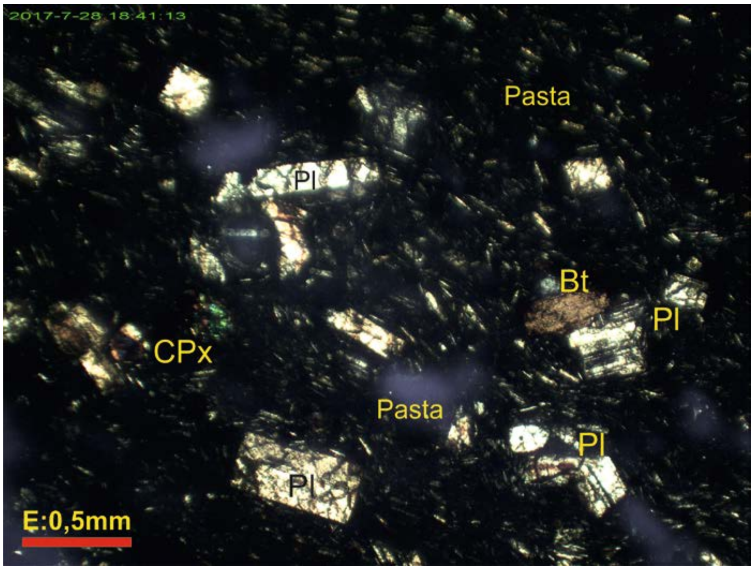

Fig. 16. Muestra 7806, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx), biotita (Bt) y pasta con microlitos de plagioclasas orientadas.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 26 de Julio de 2017
Nº LAB: SGM-130/17 Muestra 7808.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba ignimbrítica) de composición intermedia, muestra estructura bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de tono gris oscuro y bandas de color marrón-rojizo, ambas muestran cristales de feldespatos blanquecinos, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta ferruginosa y vítrea, con más presencia de hierro en las bandas grises. La toba presenta alto grado de soldadura (ignimbrita), por lo que muestra elevada dureza y compactación, también es llamada toba soldada.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos de hasta 1,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción e inclusiones de la pasta, corresponden a la variedad Oligoclasa (An: 25) (Fig. 17).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 0,5 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación (Fig. 17).

Clinopiroxenos.- Se observan en moderado porcentaje, fenocristales subhedrales de hábito prismático y euhedrales poligonales de tono verdoso pálido con maclas de dos individuos, alcanzan hasta 0,8 mm de largo, se trata de la variedad augita (Fig. 17).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales romboédricos y subhedrales prismáticos de color marrón-rojizo, que se hallan reemplazados parcialmente en sus bordes por limonita, alcanzan hasta 0,5 mm de largo.

Pasta.- La pasta de la toba es abundante, está formada principalmente por microlitos de plagioclasas ligeramente orientados y en menor porcentaje por esquirlas de vidrio volcánico de tono pardo oscuro y de textura masiva, junto a óxidos de hierro diseminados de tono marrón del tipo limonita y hematita (Fig. 17).

Óxidos de Hierro.- Se presentan en moderado porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, que corresponderían a las variedades limonita, hematita y magnetita.

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Composición porcentual observada.-

Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………………………………………	30-32 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………………	2-3 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$……………………………………………	3-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……………………………………	1-2 %
Pasta (Microlitos y vidrio volcánico)………………………………………………	53-55 %
Óxidos de Hierro (Hematita, limonita y magnetita)…………………………………	2-3 %
Total……………………………………………………………………………	**100 %**

Textura y estructura.- Presenta estructura bandeada y lenticular, y textura porfídica de grano medio (>1 mm), con pasta microlítica y vítrea masiva, y en menor grado ferruginosa. La toba muestra elevado grado de soldadura y dureza (Fig. 17).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una roca piroclástica (toba cristalo-vítrea soldada) de composición intermedia, que corresponde a una **Ignimbrita ANDESÍTICA**.

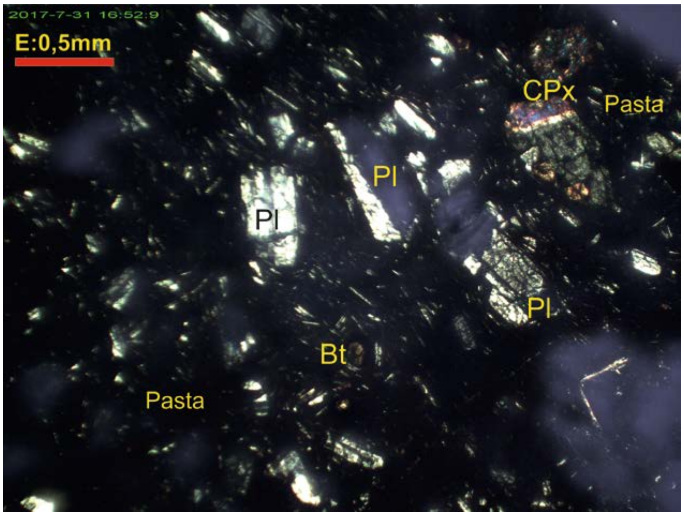

Fig. 17. Muestra 7808, aumento 4x, polarizadores X. Ignimbrita Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx), biotita (Bt) y pasta con microlitos de plagioclasas, vidrio y óxidos de hierro.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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SERVICIO GEOLÓGICO MINERO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 21 de Agosto de 2017
Nº LAB: SGM-142/17 Muestra 7722.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba vitro-cristalina), de color gris-blanquecino con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos, cuarzo, biotita con orientación, litoclastos de rocas volcánicas y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra reducido grado de dureza y soldadura, por lo que es deleznable.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente abundante de la toba, presente en forma de fenocristales anhedrales con bordes sub-angulosos de hasta 1,5 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes angulosos (Fig. 18).

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2 mm de largo, con zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Oligoclasa (An: 25), se hallan también como fragmentos angulosos, y muestran meteorización (Fig. 18).

Biotita.- Se presenta en moderada proporción, como fenocristales subhedrales prismáticos y tabulares que alcanzan hasta 1 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con pequeñas inclusiones de apatito y muestran orientación preferencial (Fig. 18).

Pasta.- La pasta de la toba es muy abundante y está formada principalmente por esquirlas de vidrio volcánico de tono pardo oscuro que muestran textura masiva, junto a pequeños fragmentos de cuarzo y feldespatos (Fig. 18).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita, que corresponderían a la variedad limonita.

Litoclastos.- Se observan en reducido porcentaje, litoclastos de bordes sub-redondeados formados por rocas volcánicas de grano fino, con cristales de cuarzo, plagioclasas y biotita, alcanzan hasta 2,5 mm de largo.

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Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………	13-15 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$………………………	18-20 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………	4-6 %
Pasta (Vidrio volcánico)…………………………………………	53-55 %
Óxidos de Hierro (Limonita).………………………………………	1-2 %
Litoclastos (rocas volcánicas)……………………………………	1-2 %
Total………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura hipocristalina y textura porfídica de grano medio (>1 mm), con pasta vítrea de textura masiva y algunos litoclastos (Fig. 18).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una toba vitro-cristalina de composición ácida, que corresponde a una **DACITA Biotítica**, con pasta vítrea.

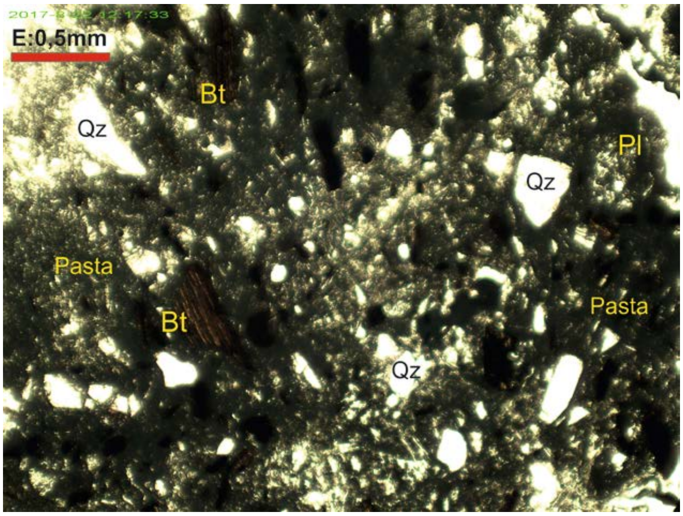

Fig. 18. Muestra 7722, aumento 4x, polarizadores X. Toba Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), biotita oxidada (Bt), y pasta vítrea de textura masiva.

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FECHA: 21 de Agosto de 2017
Nº LAB: SGM-143/17 Muestra 7723.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba vitro-cristalina), de color gris-blanquecino con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos, cuarzo, biotita con orientación y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderado grado de dureza y soldadura.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente muy abundante de la toba, presente en forma de fenocristales anhedrales con bordes sub-angulosos de hasta 2 mm de largo, muestran fracturas, engolfamientos e inclusiones de la pasta vítrea, también se presentan como fragmentos de bordes angulosos (Fig. 19).

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, con zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, corresponden a la variedad Oligoclasa (An: 25-30), se hallan también como pequeños fragmentos angulosos (Fig. 19).

Biotita.- Se presenta en moderada proporción, como fenocristales subhedrales prismáticos y tabulares que alcanzan hasta 1,5 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con pequeñas inclusiones de apatito y muestran orientación preferencial (Fig. 19).

Hornblenda.- Se observan en reducido porcentaje fenocristales anhedrales y subhedrales de color marrón-verdoso, se hallan ligeramente oxidados, alcanzan hasta 1 mm de largo.

Pasta.- La pasta de la toba es abundante y está formada principalmente por esquirlas de vidrio volcánico de tono pardo oscuro que muestran una textura masiva, junto a pequeños fragmentos de cuarzo, feldespatos y circón (Fig. 19).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, que corresponden a la variedad limonita.

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Composición porcentual observada.-

Cuarzo (SiO_2)……………………………………………………………	20-22 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$………………………………	18-20 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………………………………	4-6 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……………………	1-2 %
Pasta (Vidrio volcánico)……………………………………………………	46-48 %
Óxidos de Hierro (Limonita)………………………………………………	1-2 %
Total………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura hipocristalina y textura porfídica de grano medio (>1 mm), con pasta vítrea de textura masiva (Fig. 19).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una toba vitro-cristalina de composición ácida, que corresponde a una **DACITA Biotítica**, con pasta vítrea.

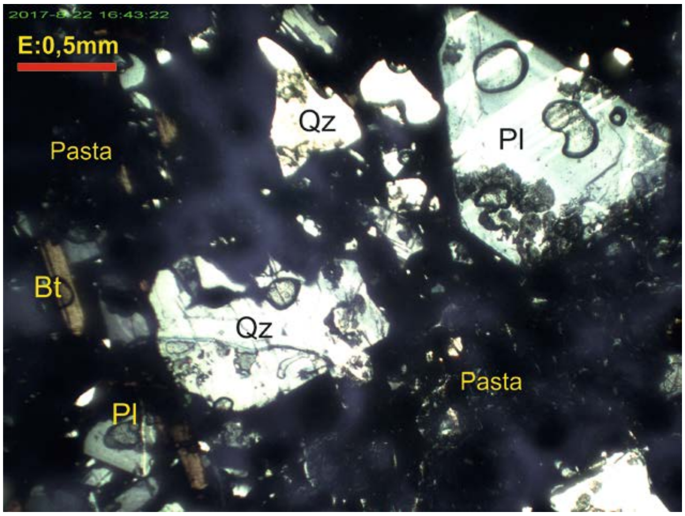

Fig. 19. Muestra 7723, aumento 4x, polarizadores X. Toba Dacítica, con fenocristales de plagioclasas (Pl), cuarzo (Qz), biotita oxidada (Bt), y pasta vítrea de textura masiva.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 21 de Agosto de 2017
Nº LAB: SGM-144/17 Muestra 7726.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con superficies de meteorización, composición relativamente ácida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan grandes cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, contiene agregados de calcita rellenando pequeñas cavidades, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente reducido de la lava, presente en forma de fenocristales anhedrales con bordes sub-redondeados de hasta 1 mm de largo, muestran fracturas y engolfamientos, también se presentan como fragmentos de bordes sub-angulosos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Oligoclasa (An: 25-30) (Fig. 20).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 2 mm de largo, de color marrón oscuro por la intensa oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas (Fig.20).

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de tono verdoso pálido, que alcanzan hasta 2 mm de largo, se trata del tipo augita. En escaso porcentaje se observan ortopiroxenos de hábito prismático (Fig. 20).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales poligonales de color marrón, se hallan reemplazados parcialmente por limonita, alcanzan hasta 3 mm de largo.

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas sin orientación y con textura afieltrada, y en menor porcentaje por vidrio volcánico de tono pardo y textura masiva (Fig. 20).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y sobre todo alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y magnetita.

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Calcita.- Se observan en escaso porcentaje, agregados anhedrales de calcita secundaria de grano fino y de color blanquecino, rellenando pequeñas cavidades de la lava.

Composición porcentual observada.-

Cuarzo (SiO_2)……	4-5 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$……	25-27 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……	4-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$……	3-4 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……	1-2 %
Pasta (microlitos de plagioclasas)……	50-52 %
Óxidos de Hierro (Limonita, hematita y magnetita)……	2-3 %
Calcita ($CaCO_3$)……	1-2 %
Total……	**100 %**

Textura y estructura.- Presenta estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta vítrea y microlítica de textura afieltrada (Fig. 20).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición ácida, que corresponde a una **DACITA de Biotita y Hornblenda**, cercana a una Andesita cuarzosa, ligeramente oxidada, con cavidades de calcita.

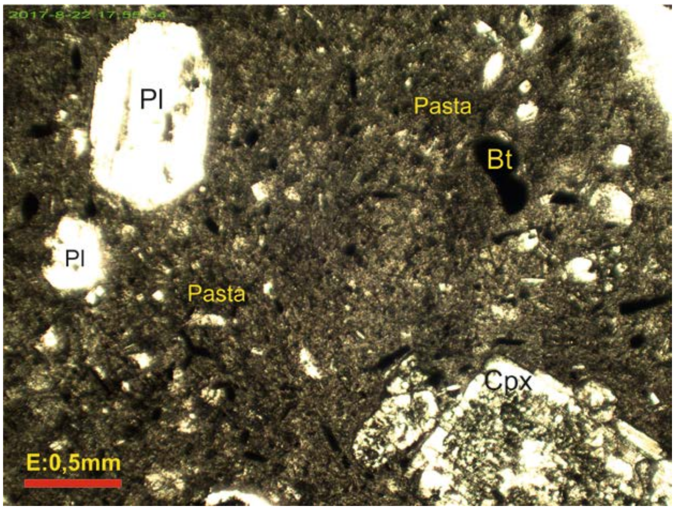

Fig. 20. Muestra 7726, aumento 4x, polarizadores ll. Lava Dacítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), biotita (Bt) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

INTERESADO: Ing. Adolfo Orsolini Campana
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FECHA: 22 de Agosto de 2017
Nº LAB: SGM-145/17 Muestra 7727.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro y superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente muy reducido de la lava, presente en forma de fenocristales anhedrales con bordes sub-redondeados de hasta 0,5 mm de largo, muestran fracturas y engolfamientos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, fracturas e inclusiones de la pasta, corresponden a la variedad Andesina (An: 35) (Fig. 21).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 1,5 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación (Fig. 21).

Clinopiroxenos.- Se observan en reducido porcentaje fenocristales subhedrales prismáticos de tono verdoso pálido, que alcanzan hasta 0,5 mm de largo, se trata del tipo augita.

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales poligonales de color marrón, están reemplazados parcialmente por limonita, alcanzan hasta 0,5 mm de largo.

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas con cierta orientación y textura afieltrada, y en menor porcentaje por vidrio volcánico de tono pardo y textura masiva (Fig. 21).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………………………	1-2 %
Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………………………………………	23-25 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………	4-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$………………………………	1-2 %
Pasta (microlitos de plagioclasas)………………………………………………	58-60 %
Óxidos de Hierro (Limonita, hematita y magnetita)…………………………	2-3 %
Total………………………………………………………………………………	**100 %**

Textura y estructura.- Presenta estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta vítrea y microlítica de textura afieltrada (Fig. 21).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia que corresponde a una **ANDESITA Biotítica**, ligeramente oxidada.

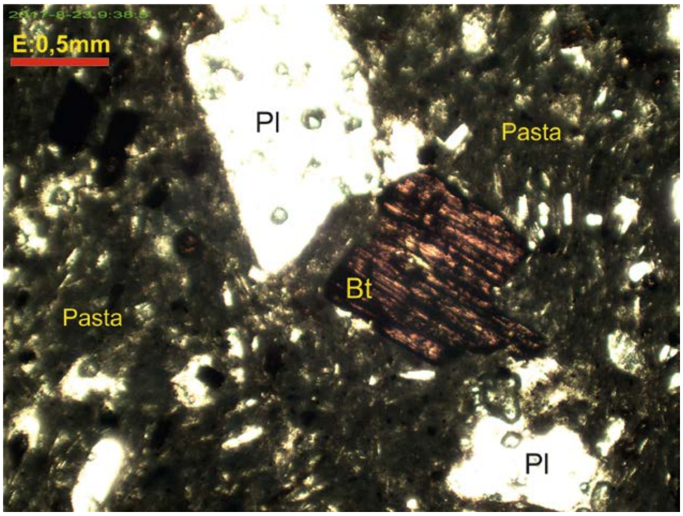

Fig. 21. Muestra 7727, aumento 4x, polarizadores ll. Lava Andesítica, con fenocristales de plagioclasas (Pl), biotita oxidada (Bt), y una pasta con microlitos de plagioclasas y vidrio.

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FECHA: 22 de Agosto de 2017
Nº LAB: SGM-146/17 Muestra 7729.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, presenta superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita oxidada y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra moderada dureza y compactación, por lo que es ligeramente deleznable.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente escaso de la lava, presente en forma de fenocristales anhedrales con bordes sub-redondeados de hasta 1 mm de largo, muestran fracturas y engolfamientos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 4 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, muchas fracturas e inclusiones de la pasta, corresponden al límite entre las variedades Andesina-Oligoclasa (An: 30) (Fig. 22).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 2 mm de largo, de color marrón oscuro por la fuerte oxidación de sus bordes y planos de exfoliación; es posible que algunos cristales correspondan a hornblenda, los que no pueden ser diferenciados de la biotita por su intensa oxidación (Fig. 22).

Clinopiroxenos.- Se observan en escaso porcentaje fenocristales subhedrales prismáticos de tono verdoso pálido, que alcanzan menos de 0,5 mm de largo, se trata del tipo augita (Fig. 22).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas sin orientación y con textura afieltrada, y en menor porcentaje por vidrio volcánico de tono pardo y textura masiva (Fig. 22.

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita, corresponderían a las variedades limonita y hematita (Fig. 22).

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Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………………	1-2 %
Plagioclasas (Andesina-Oligoclasa) $NaCaAl(Si_3O_8)$……………………	24-26 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………………………………	4-6 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$…………………………………	1-2 %
Pasta (microlitos de plagioclasas y vidrio)………………………………	58-60 %
Óxidos de Hierro (Limonita y hematita)…………………………………	3-4 %
Total…………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta microlítica de textura afieltrada y vidrio volcánico (Fig. 22).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia que corresponde a una **ANDESITA Biotítica**, moderadamente oxidada.

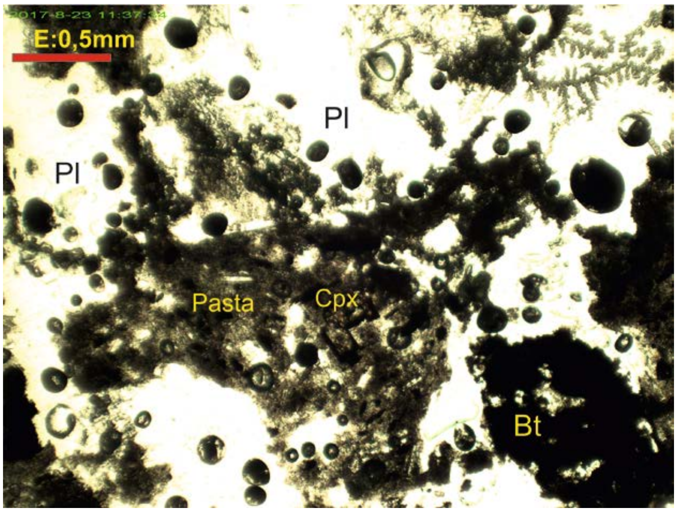

Fig.22. Muestra 7729, aumento 4x, polarizadores ll. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), biotita oxidada (Bt) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 22 de Agosto de 2017
Nº LAB: SGM-147/17 Muestra 7732.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro, presenta superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente escaso de la lava, presente en forma de fenocristales anhedrales con bordes sub-redondeados de hasta 0,5 mm de largo, muestran fracturas y engolfamientos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, muchas fracturas e inclusiones de la pasta, corresponden a la variedad Oligoclasa (An: 25) (Fig. 23).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 1,5 mm de largo, de color marrón oscuro por la fuerte oxidación de sus bordes y planos de exfoliación, muestran cierta orientación preferencial (Fig. 23).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón-rojizo, están reemplazados parcialmente por limonita, y alcanzan hasta 0,5 mm de largo (Fig. 23).

Clinopiroxenos.- Se observan en escaso porcentaje fenocristales anhedrales de tono pardo pálido, que alcanzan hasta 0,5 mm de largo, se trata del tipo augita, y se encuentran rodeados por micro-cristales de hornblenda formando aureolas de alteración (Fig. 23).

Pasta.- La pasta de la lava es abundante y está formada principalmente por vidrio volcánico de tono pardo y textura fluidal, junto a pequeños fragmentos de plagioclasas (Fig. 23).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y magnetita.

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Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………………………	1-2 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$………………………………	23-25 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………	4-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………………	1-2 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	1-2 %
Pasta (vidrio volcánico)………………………………………………………	58-60 %
Óxidos de Hierro (Limonita, hematita y magnetita)…………………………	3-4 %
Total…………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta vítrea de textura fluidal (Fig. 23).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia que corresponde a una **ANDESITA Biotítica**, moderadamente oxidada.

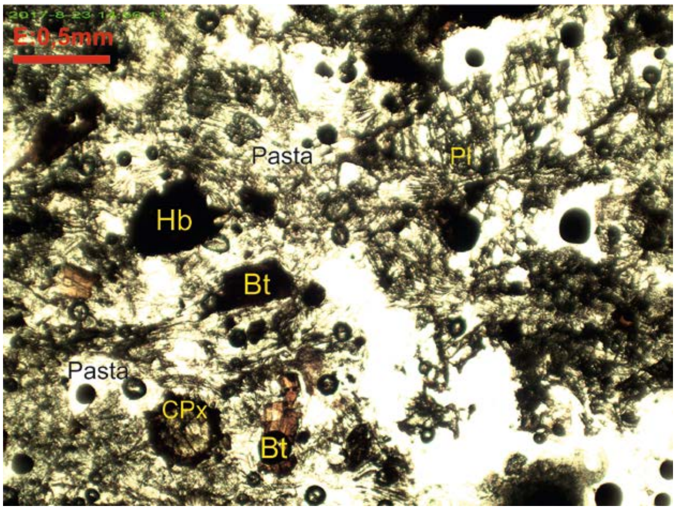

Fig. 23. Muestra 7732, aumento 4x, polarizadores ll. Lava Andesítica, con fenocristales de plagioclasas (Pl), biotita (Bt) y hornblenda (Hb) oxidadas, clinopiroxeno (CPx) y pasta vítrea.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 23 de Agosto de 2017
Nº LAB: SGM-148/17 Muestra 7809.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente escaso de la lava, presente en forma de fenocristales anhedrales con bordes sub-redondeados inferiores a 0,5 mm de largo, muestran fracturas y engolfamientos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, fracturas e inclusiones de la pasta, corresponden a la variedad Andesina (An: 30-35) (Fig. 24).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 2 mm de largo, de color marrón oscuro por la fuerte oxidación de sus bordes y planos de exfoliación, muestran cierta orientación preferencial (Fig.24).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón-rojizo, están reemplazados parcialmente por limonita, y alcanzan hasta 0,5 mm de largo (Fig. 7).

Clinopiroxenos.- Se observan en escaso porcentaje, fenocristales subhedrales y prismáticos de tono pardo pálido, que alcanzan hasta 0,5 mm de largo, se trata del tipo augita.

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas, junto a vidrio volcánico de tono pardo y textura masiva (Fig. 24).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como minerales opacos de hábito anhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y magnetita.

Calcita.- Se observan en reducido porcentaje, agregados anhedrales de calcita secundaria de grano muy fino y de color blanquecino, rellenando pequeñas cavidades de la lava.

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Composición porcentual observada.-

Cuarzo (SiO_2)…………………………………………………………………	1-2 %
Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$…………………………………	25-27 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………………………………	4-6 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………………	2-3 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………	1-2 %
Pasta (Microlitos de plagioclasas y vidrio)…………………………………	53-55 %
Óxidos de Hierro (Limonita, hematita y magnetita)…………………………	2-3 %
Calcita ($CaCO_3$)…………………………………………………………	1-2 %
Total…………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), con pasta de microlitos de plagioclasas y vidrio de textura masiva (Fig. 24).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia que corresponde a una **ANDESITA Biotítica**, meteorizada.

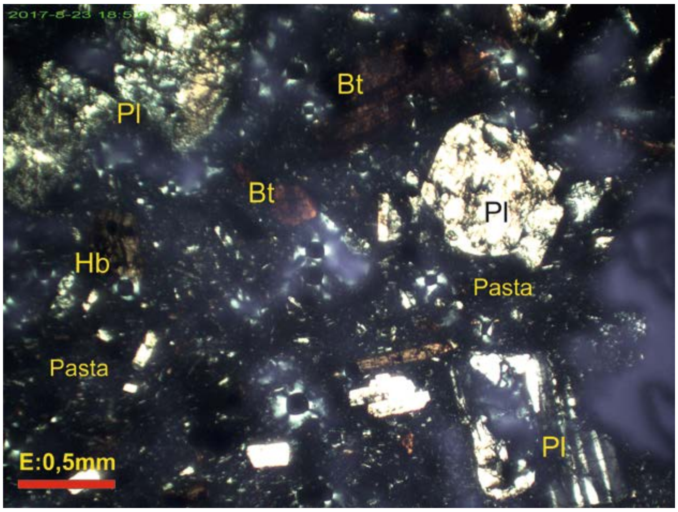

Fig. 24. Muestra 7809, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), biotita (Bt), hornblenda (Hb), y pasta con microlitos de plagioclasas y vidrio.

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 23 de Agosto de 2017
Nº LAB: SGM-149/17 Muestra 7810.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono negruzco, presenta superficies de meteorización y composición básica, muestra estructura holocristalina y textura porfídica de grano medio a fino (>1 mm), donde se observan cristales de feldespatos blanquecinos con orientación, minerales máficos muy oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación, así como numerosas cavidades o amígdalas vacías.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Son los principales componentes de la lava, se presentan en forma de fenocristales subhedrales de hábito tabular y prismático, alcanzan hasta 2 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con orientación preferencial que sigue el flujo de la lava, bordes de reacción, e inclusiones de la pasta, corresponden a la variedad Andesina (An: 40) (Fig. 25).

Minerales Máficos oxidados.- Se presenta en reducida proporción, en forma de pseudomorfos de fenocristales subhedrales de hasta 0,5 mm de largo, tienen color marrón oscuro por la completa oxidación de los cristales, probablemente correspondían a hornblendas originales.

Clinopiroxenos.- Se observan en escaso porcentaje, fenocristales anhedrales y subhedrales de hábito prismático y de tono pardo pálido, que alcanzan menos de 0,5 mm de largo, se trata de la variedad augita (Fig. 25).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos muy finos de plagioclasas, junto a vidrio volcánico de tono pardo y textura masiva (Fig. 25).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como minerales opacos de hábito anhedral, diseminados en la pasta y reemplazando a cristales de minerales máficos, corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………………………..……..………	31-33 %
Minerales Máficos muy oxidados……….…………………..…………………..	1-2 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$..……..……	2-3 %
Pasta (Microlitos de plagioclasas y vidrio)………...............…………..……...	58-60 %

Óxidos de Hierro (Limonita, hematita y magnetita)……………………………	1-2 %
Total………………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y cavernosa con textura porfídica de grano medio a fino (>1 mm), con pasta de microlitos de plagioclasas y vidrio de textura masiva (Fig. 25).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición básica que corresponde a un **BASALTO Piroxénico**.

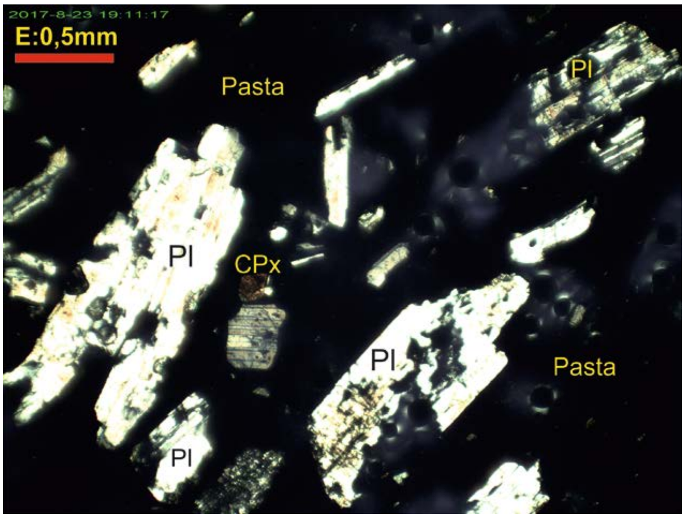

Fig. 25. Muestra 7810, aumento 4x, polarizadores X. Lava Basáltica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx) y una pasta con microlitos de plagioclasas y vidrio.

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LABORATORIO DE PETROGRAFÍA-MINERAGRAFÍA

SERGEOMIN
SERVICIO GEOLÓGICO MINERO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 24 de Agosto de 2017
Nº LAB: SGM-151/17 Muestra 7813.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava andesitica) de composición intermedia, muestra estructura bandeada o fluidal y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de color marrón-rojizo y bandas de tono negruzco, ambas muestran cristales de feldespatos blanquecinos, muy escaso cuarzo, piroxenos, rodeados por una pasta ferruginosa y vítrea, con mayor presencia de hierro en las bandas negruzcas. La roca presenta coloracion verdusca oscura y elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinada Albita-Carlsbad, con inclusiones de la pasta, corresponden al tipo Andesina (An: 35-40), se hallan muy fracturadas y también como fragmentos angulosos (Fig. 26).

Clinopiroxenos.- Se observan en moderado porcentaje, como fenocristales anhedrales y subhedrales de hábito prismático y tabular de clinopiroxenos de tono pardo pálido, algunos con maclas polisintéticas, alcanzan hasta 0,7 mm de largo y se tratan del tipo augita (Fig. 26).

Cuarzo.- Es un componente muy escaso, presente en forma de cristales anhedrales con bordes sub-angulosos, inferiores a 0,5 mm de largo, muestran fracturas y engolfamientos.

Pasta.- La pasta es abundante y está conformada principalmente por óxidos de hierro de tono marrón-rojizo del tipo limonita-goethita (ferruginosa), que es más abundante en las bandas lenticulares oscuras, junto a vidrio volcánico de tono pardo oscuro que muestra textura masiva con esquirlas aplanadas por el alto grado de soldadura de la roca, y en escaso porcentaje por microlitos de plagioclasas (Fig. 26).

Litoclastos.- Se observan litoclastos de bordes angulosos, formados por rocas volcánicas de similar composición que la roca hospedante, con mayor contenido de plagioclasas, pocos piroxenos y óxidos de hierro diseminados, alcanzan hasta 1 cm de largo.

Composición porcentual observada.-

Cuarzo (SiO_2)………………………………………………………………………… 0,5-1 %
Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$……………………………………………….. 28-30 %

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Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$..	3-5 %
Pasta (Óxidos de hierro y Vidrio volcánico)..	58-60 %
Litoclastos (rocas volcánicas)..	3-4 %
Total..	**100 %**

Textura y estructura.- La roca presenta estructura bandeada (lenticular) o fluidal y textura porfídica de grano medio (>1 mm), con abundante pasta ferruginosa y vítrea de textura masiva (Fig. 26).

Nombre de la roca.- De acuerdo al análisis petrográfico, se trataría de un flujo de lava de composición intermedia, que correspondería a una **roca ANDESÍTICA**. Si bien es muy similar a una lava, por las esquirlas de vidrio deformadas y aplanadas, junto a la textura bandeada lenticular puede constituirse en parte de una brecha basal de flujo volcanico.

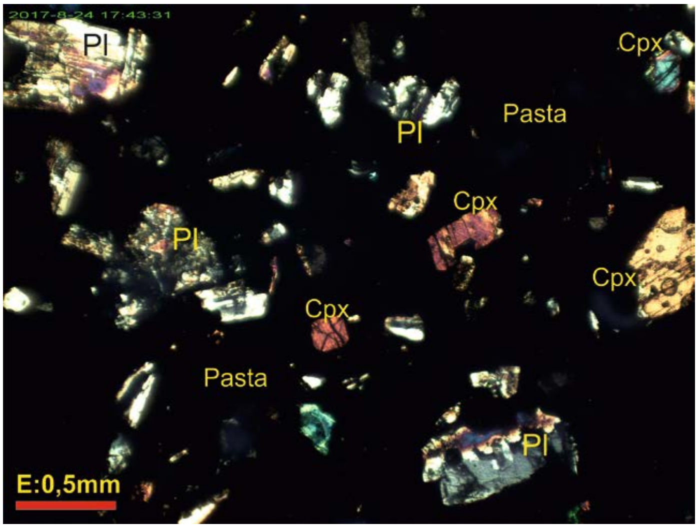

Fig. 26. Muestra 7813, aumento 4x, polarizadores X. Toba Ignimbrítica Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxenos (CPx), y abundante pasta ferruginosa (limonita-goethita) y vítrea.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 24 de Agosto de 2017
Nº LAB: SGM-150/17 Muestra 7811.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico de composición intermedia y color violáceo oscuro, muestra estructura aglomerada y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, piroxenos y grandes litoclastos de rocas volcánicas de tono gris, rodeados por una pasta ferruginosa de tono violáceo. La roca presenta moderado grado de dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinada Albita-Carlsbad, con inclusiones de la pasta, corresponden a la variedad Andesina (An: 35), se hallan fracturadas y también como fragmentos angulosos (Fig. 27).

Clinopiroxenos.- Se observan en moderado porcentaje, como fenocristales anhedrales y subhedrales de hábito prismático y tabular de clinopiroxenos de tono pardo pálido, algunos con maclas polisintéticas, alcanzan hasta 1,5 mm de largo y se tratan del tipo augita.

Pasta.- La pasta es abundante y está conformada fundamentalmente por óxidos de hierro de tono marrón-rojizo y hábito terroso del tipo limonita-goethita (ferruginosa), probablemente junto a pequeños contenidos de vidrio volcánico de textura masiva, enmascarado por los óxidos de hierro que se observan como minerales opacos (Fig. 27).

Litoclastos.- Se observan grandes litoclastos de bordes angulosos, formados por rocas volcánicas de tono gris y similar composición que la roca hospedante, con mayor contenido de plagioclasas, pocos piroxenos y óxidos de hierro diseminados de habito anhedral y cúbico que corresponderían a hematita, magnetita y limonita, alcanzan hasta 2 cm de largo en la sección delgada y hasta 4 cm en la muestra de mano (Fig. 27).

Composición porcentual observada.-

Plagioclasas (Andesina) NaCaAl(Si_3O_8)…………………………………………..	25-27 %
Clinopiroxenos (Augita) (Mg,Fe)(SiO_3)………………………………………	3-5 %
Pasta (Óxidos de hierro)…………………………………………………	56-58 %
Litoclastos (rocas volcánicas)……………………………………………..	8-10 %
Total………………………………………………………………	**100 %**

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Textura y estructura.- La roca presenta estructura aglomerada y textura porfídica de grano medio (>2 mm), con abundante pasta ferruginosa de limonita-goethita (Fig. 27).

Nombre de la roca.- De acuerdo al análisis petrográfico, se trataría probablemente de una roca de composición intermedia, que correspondería a una **ANDESITA Piroxénica** con pasta muy ferruginosa. y por los contenidos de litoclastos de una brecha basal de un flujo de lava andesitico.

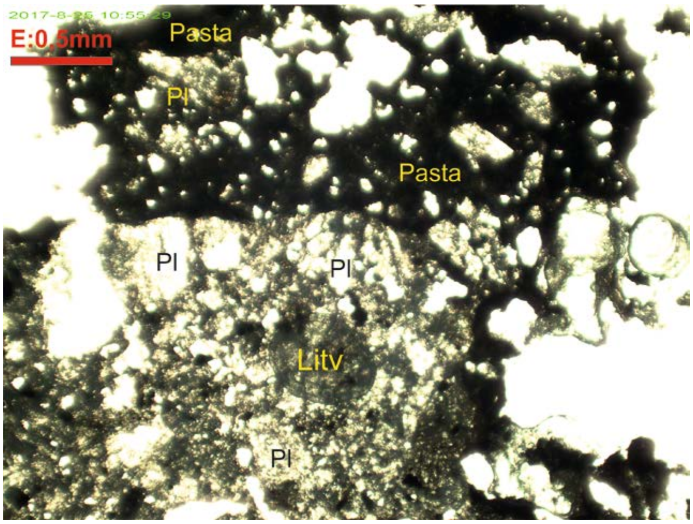

Fig. 27. Muestra 7811, aumento 4x, polarizadores ll. Toba Lítica Andesítica, con fenocristales de plagioclasas (Pl), litoclasto volcánico (Litv) y abundante pasta ferruginosa (limonita-goethita).

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

INTERESADO: Ing. Adolfo Orsolini Campana
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FECHA: 24 de Agosto de 2017
Nº LAB: SGM-152/17 Muestra 7814.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen piroclástico (toba), de color gris con tono rosáceo, muestra superficies de meteorización, composición acida, con estructura masiva y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos blanquecinos, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra moderada dureza y compactación, y presenta costras delgadas de malaquita.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 1,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Andesina (An: 35) (Fig. 28).

Clinopiroxenos.- Se observan en reducido porcentaje pequeños fenocristales anhedrales y subhedrales prismáticos de tono verdoso pálido, que alcanzan hasta 0,5 mm de largo, se trata del tipo augita (Fig. 28).

Hornblenda.- Se observan en moderado porcentaje fenocristales euhedrales poligonales de color marrón, se hallan reemplazados parcialmente por limonita en los bordes, alcanzan hasta 1 mm de largo (Fig. 28).

Pasta.- La pasta es abundante y está formada principalmente por microlitos de plagioclasas sin orientación, en menor porcentaje por vidrio volcánico de tono pardo y textura masiva, y óxidos de hierro de grano muy fino (Fig. 28).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como minerales opacos anhedrales, diseminados en la pasta y alterando cristales de hornblenda, corresponden al tipo limonita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………………………………………	23-25 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………………	<1 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$………………………………	3-5 %
Pasta (microlitos de plagioclasas y vidrio)………………………………	63-65 %
Óxidos de Hierro (Limonita)………………………………………………	2-3 %
Total………………………………………………………………………	**100 %**

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Textura y estructura.- Presenta estructura masiva y textura porfídica de grano medio (>1 mm), con pasta vítrea y microlitos de plagioclasas, presenta delgadas costras superficiales de malaquita verdosa (Fig. 28).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una toba de composición acida, que corresponde a una **DACITA Hornbléndica**, ligeramente oxidada.

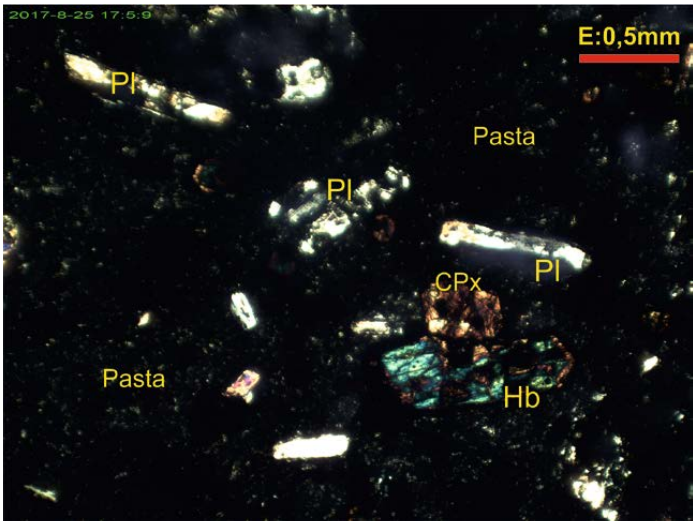

Fig. 28. Muestra 7814, aumento 4x, polarizadores X. Toba Andesítica, con fenocristales de plagioclasas (Pl), hornblenda (Hb), clinopiroxeno (CPx), y una pasta con microlitos y vidrio.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 25 de Agosto de 2017
Nº LAB: SGM-153/17 Muestra 7816.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos blanquecinos, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino, contiene agregados de calcita rellenando pequeñas cavidades, la roca muestra elevada dureza y compactación, y contiene algunos litoclastos de rocas volcánicas.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Andesina (An: 35), se hallan débilmente alterados a calcita (Fig. 29).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 1 mm de largo, de color marrón oscuro por la oxidación de sus bordes y planos de exfoliación, con inclusiones de plagioclasas.

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de tono verdoso pálido, que alcanzan hasta 1 mm de largo, se trata del tipo augita, algunos presentan maclas polisintéticas (Fig. 29).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas con marcada orientación y textura traquítica, y en menor porcentaje por vidrio volcánico de tono pardo y textura masiva (Fig. 29).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita, corresponderían a las variedades limonita, hematita y magnetita.

Calcita.- Se observan en escaso porcentaje, agregados anhedrales de calcita secundaria de grano fino y de color blanquecino, rellenando pequeñas cavidades de la lava.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………………………..……….…..……… 28-30 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………....…………………………………….... 2-3 %

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Clinopiroxenos (Augita) (Mg,Fe)(SiO_3)..	5-7 %
Pasta (microlitos de plagioclasas)..	53-55 %
Óxidos de Hierro (Limonita, hematita y magnetita)......................................	2-3 %
Calcita ($CaCO_3$)..	1-2 %
Total..	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>1 mm), con pasta microlítica de textura traquítica (Fig. 29).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**, débilmente carbonatada.

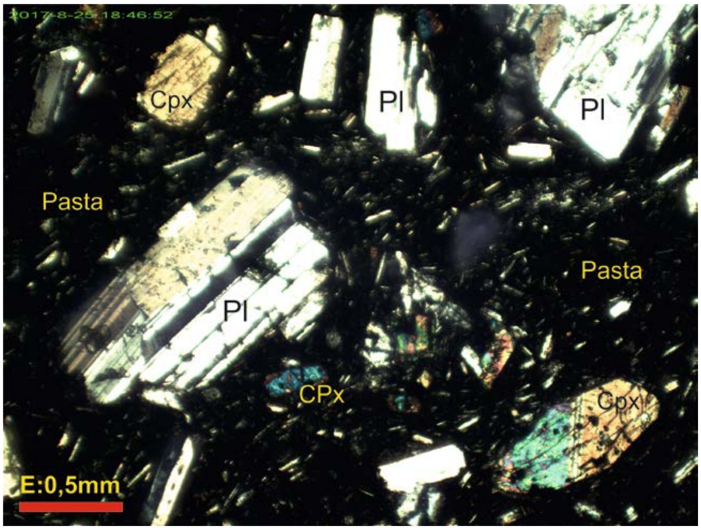

Fig. 29 Muestra 7816, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), y pasta con microlitos de plagioclasas y vidrio.

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FECHA: 25 de Agosto de 2017
Nº LAB: SGM-154/17 Muestra 7817.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos blanquecinos, biotita y anfíboles muy oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra moderada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 4 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Oligoclasa (An: 25-30), muestran ligera orientación preferencial (Fig. 30).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 0,7 mm de largo, de color marrón oscuro por la intensa oxidación de sus bordes y planos de exfoliación (Fig. 30).

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de tono verdoso pálido, que alcanzan hasta 2 mm de largo, se trata del tipo augita, algunos cristales muestran cierta oxidación de los bordes (Fig. 30).

Hornblenda.- Se observan en moderado porcentaje como fenocristales euhedrales poligonales y subhedrales de color marrón, se hallan intensamente oxidados en los bordes, alcanzan hasta 1 mm de largo (Fig. 30).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas con marcada orientación y textura traquítica, y en menor porcentaje por vidrio volcánico de tono pardo y textura masiva (Fig. 30).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita, corresponderían a las variedades limonita, hematita y escasa magnetita.

Composición porcentual observada.-

Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$………………….……..……..……..……. 30-32 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………...……………………………….….... 1-2 %

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Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$………………………………	4-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$………………………………	2-3 %
Pasta (microlitos de plagioclasas)………………………………	53-55 %
Óxidos de Hierro (Limonita, hematita y magnetita)………………………………	2-3 %
Total………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>1 mm), con pasta microlítica de textura traquítica (Fig. 30).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**, débilmente oxidada.

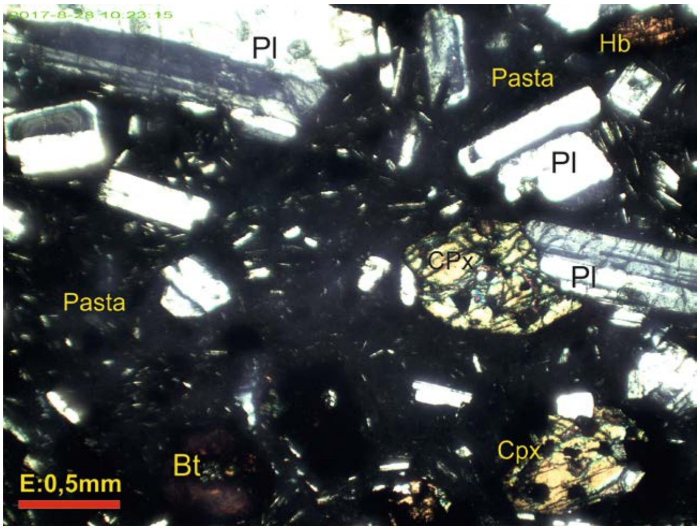

Fig. 30. Muestra 7817, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), hornblenda (Hb), biotita (Bt) y pasta con microlitos.

Analizado por: Ing. José Luis Argandoña C.
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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 28 de Agosto de 2017
Nº LAB: SGM-155/17 Muestra 7818.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y cavernosa, con textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Andesina (An: 35), muestran ligera orientación preferencial (Fig. 31).

Biotita.- Se presenta en reducida proporción, como fenocristales subhedrales tabulares que alcanzan hasta 1 mm de largo, de color marrón oscuro por la oxidación de sus bordes (Fig. 31).

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 2 mm de largo, se trata del tipo augita, algunos cristales muestran fracturas y oxidación de los bordes (Fig. 31).

Pasta.- La pasta de la lava es abundante y está formada principalmente por micro-cristales y microlitos de plagioclasas sin orientación, y en menor porcentaje por vidrio volcánico de tono pardo y textura fluidal (Fig. 31).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita, corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………….………..………..……..	30-32 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)……….....………………………………....	3-4 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$..……...............................….….	4-6 %
Pasta (microlitos de plagioclasas y vidrio)…..……........………….....…….	53-55 %
Óxidos de Hierro (Limonita, hematita y magnetita).……….……….…..……	2-3 %
Total…………………………………………………...……………………..………	**100 %**

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Textura y estructura.- Presenta una estructura holocristalina y cavernosa, con textura porfídica de grano medio (>1 mm), la pasta es microlítica y vítrea (Fig. 31).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**.

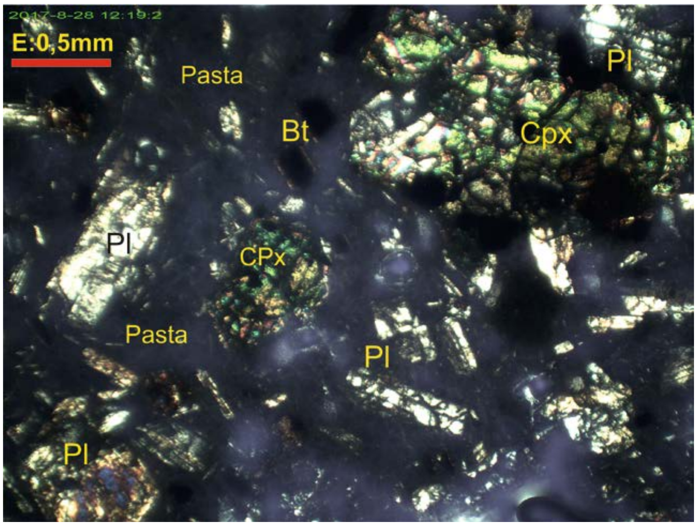

Fig. 31. Muestra 7818, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), biotita oxidada (Bt) y pasta con microlitos y vidrio fluidal.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 28 de Agosto de 2017
Nº LAB: SGM-156/17 Muestra 7820.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, tiene superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita y anfíboles oxidados, piroxenos, óxidos de hierro diseminados y pequeños litoclastos de rocas volcánicas, rodeados por una pasta de grano fino, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden al límite entre Oligoclasa-Andesina (An: 30), muestran ligera orientación preferencial (Fig. 32).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales y tabulares que alcanzan hasta 0,5 mm de largo, de color marrón oscuro por una débil oxidación de sus bordes.

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 1 mm de largo del tipo augita, algunos cristales muestran fracturas y oxidación de los bordes (Fig. 32).

Hornblenda.- Se observan en reducido porcentaje como fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, se hallan oxidados en los bordes, alcanzan hasta 0,5 mm de largo (Fig. 32).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas sin orientación, y en menor porcentaje por óxidos de hierro de grano fino (Fig. 32).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y poca magnetita.

Litoclastos.- Se observan pequeños litoclastos de bordes sub-angulosos, formados por rocas volcánicas de tono gris y similar composición que la roca hospedante, contienen plagioclasas, piroxenos y anfíboles oxidados, alcanzan hasta 2 mm de largo.

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Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………….……….…..………...………	30-32 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………....……………………………….…..	1-2 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$..……...……	3-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………….……….……..	2-3 %
Pasta (microlitos de plagioclasas)…...……........………………………......……	51-53 %
Óxidos de Hierro (Limonita, hematita y magnetita)..…….….…….….…...……	2-3 %
Litoclastos (rocas volcánicas)…...……..........………………………….......……	1-2 %
Total……………………………………………...……………….…………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es microlítica (Fig. 32).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**, débilmente oxidada.

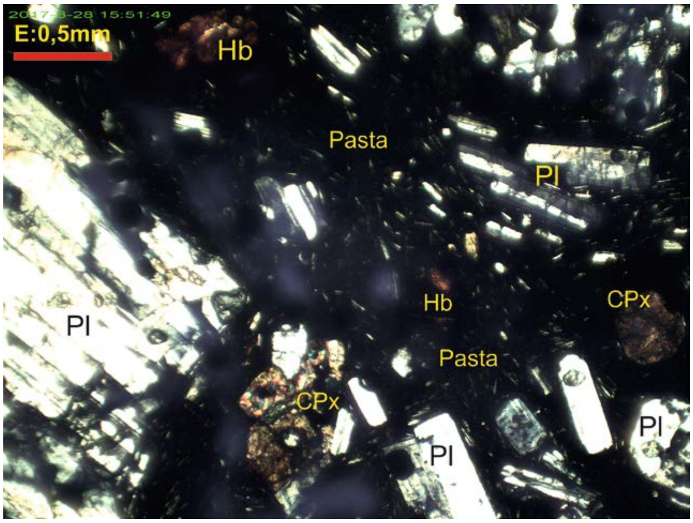

Fig. 32. Muestra 7820, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), hornblenda (Hb) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

INTERESADO: Ing. Adolfo Orsolini Campana
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FECHA: 28 de Agosto de 2017
Nº LAB: SGM-157/17 Muestra 7821.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita y anfíboles oxidados, escaso cuarzo y piroxenos, y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra elevada dureza y compactación, en general se halla fresca.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente escaso, presente en forma de fenocristales anhedrales con bordes sub-angulosos, de hasta 1 mm de largo, muestran fracturas y engolfamientos.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 4 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden al tipo Oligoclasa (An: 25-30) (Fig. 33).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales y tabulares que alcanzan hasta 2,5 mm de largo, de color marrón oscuro por una débil oxidación de sus bordes, contienen pequeñas inclusiones de plagioclasas.

Clinopiroxenos.- Se observan en reducido porcentaje como fenocristales anhedrales de tono verdoso pálido, que alcanzan hasta 0,5 mm de largo del tipo augita, algunos cristales muestran fracturas y oxidación de los bordes (Fig. 33).

Hornblenda.- Se observan en moderado porcentaje como fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, se hallan oxidados en los bordes, alcanzan hasta 1,5 mm de largo (Fig. 33).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas sin orientación, y en menor porcentaje por vidrio volcánico de textura masiva y óxidos de hierro de grano muy fino (Fig. 33).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y magnetita.

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Composición porcentual observada.-

Cuarzo (SiO_2)…………	1-2 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………	20-22 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………	2-3 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$…………	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………	4-5 %
Pasta (microlitos de plagioclasas)…………	60-62 %
Óxidos de Hierro (Limonita, hematita y magnetita)…………	2-3 %
Total…………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es principalmente microlítica (Fig. 33).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Hornbléndica**.

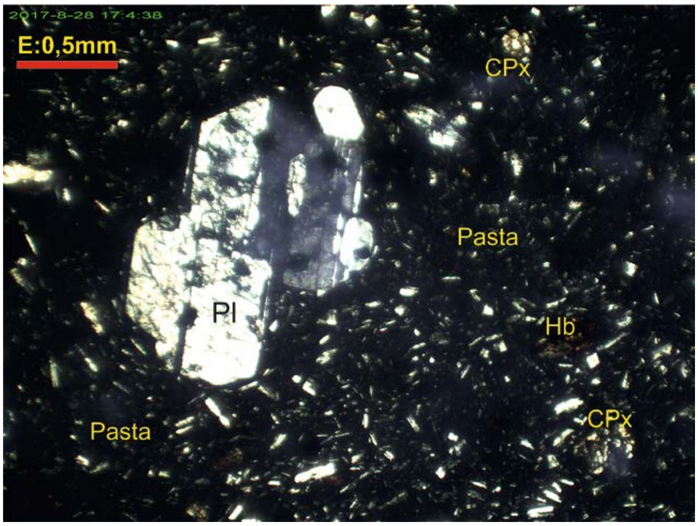

Fig. 33. Muestra 7821, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), hornblenda (Hb) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 28 de Agosto de 2017
Nº LAB: SGM-158/17 Muestra 7822.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita y anfíboles oxidados, escaso cuarzo y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra moderada dureza y compactación, en general se halla meteorizada.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente reducido, presente en forma de fenocristales anhedrales con bordes sub-redondeados, de hasta 1,5 mm de largo, muestran fracturas y bordes de reacción.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y muchas fracturas, corresponden al tipo Oligoclasa (An: 25-30) (Fig. 34).

Biotita.- Se presenta en moderada proporción, en forma de fenocristales subhedrales y tabulares que alcanzan hasta 1,5 mm de largo, de color marrón oscuro por una débil oxidación de sus bordes, contienen pequeñas inclusiones de plagioclasas (Fig. 34).

Hornblenda.- Se observan en reducido porcentaje como fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, se hallan oxidados en los bordes y alcanzan hasta 1 mm de largo (Fig. 34).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas sin orientación, y en menor porcentaje por vidrio volcánico de textura masiva y óxidos de hierro de grano muy fino (Fig. 34).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y alterando a cristales de biotita y hornblenda, corresponderían a las variedades limonita, hematita y escasa magnetita.

Composición porcentual observada.-

Cuarzo (SiO_2)……………………………………………………………………… 2-3 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$………………………………………… 25-27 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………………………………………… 5-7 %

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Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……………………………………….	2-3 %
Pasta (microlitos de plagioclasas)…...……........…………………………......………	55-57 %
Óxidos de Hierro (Limonita, hematita y magnetita).…….….………..….....……	2-3 %
Total………………………………………………...…………………….…………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es principalmente microlítica (Fig. 34).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Biotítica** (con escaso Cuarzo).

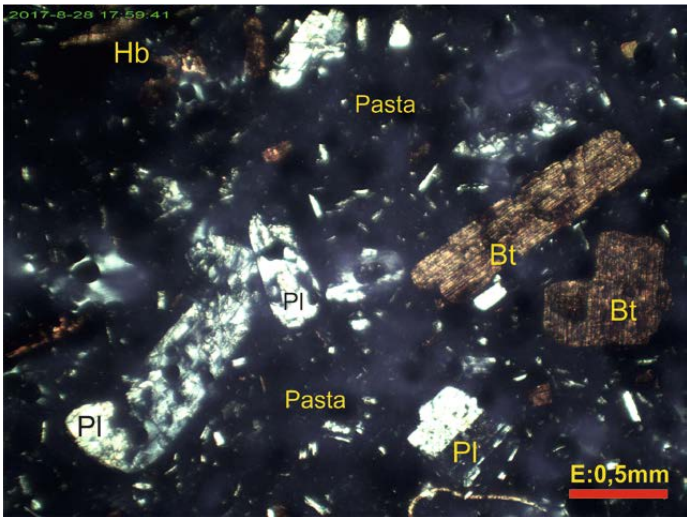

Fig. 34. Muestra 7822, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), biotita (Bt), hornblenda (Hb), y una pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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FECHA: 28 de Agosto de 2017
Nº LAB: SGM-159/17 Muestra 7824.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca sedimentaria pelítica (probablemente una arcillita) y color marrón-grisáceo, presenta una estructura masiva y terrosa con indicios de estratificación y textura clástica de grano muy fino (<0,5 mm), donde se observan bandas formadas por abundantes limos y arcillas, junto a óxidos de hierro y probablemente polvo de vidrio volcánico, por lo que la roca es muy suave, con reducida compactación y es deleznable.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en escaso porcentaje, en forma de micro-clastos anhedrales de bordes angulosos, con tamaño variable de 0,1 a 0,5 mm de largo, muestran zonación y maclas polisintéticas tipo Albita, diseminados dentro de un abundante material arcilloso-limoso (Fig. 35).

Cuarzo.- Se presenta en muy escaso porcentaje, como micro-clastos anhedrales con bordes angulosos de grano muy fino, entre 0,1 a 0,4 mm de largo, diseminados dentro del abundante material arcilloso-limoso (Fig. 35).

Piroxenos.- Se observan diseminados en muy escaso porcentaje, como micro-clastos subhedrales de tono verdoso pálido, que alcanzan hasta 0,5 mm de largo, del tipo augita.

Arcillas y Limos.- Son los principales componentes de la roca argilácea, se observan en forma de agregados de grano muy fino (<0,1 mm) y de tono marrón-rojizo, estrechamente asociados con micro-cristales de limonita y probablemente de polvo de vidrio volcánico pardo (Fig. 18).

Óxidos de Hierro.- Ocurren como pequeños minerales opacos diseminados en moderado porcentaje dentro del material arcillosos-limoso, muestran hábito terroso, tono marrón-rojizo y corresponderían a la variedad limonita (Fig. 35).

Composición porcentual observada.-

Plagioclasas NaCaAl(Si_3O_8)…………………………………………………………	1-2 %
Cuarzo (SiO_2)…………………………………………………………………	<1 %
Piroxenos (Augita) (Mg,Fe)(SiO_3)…………………………………………	<1 %
Arcillas y Limos …………………………………………………………………	92-94 %
Óxidos de Hierro (Limonita)………………………………………………………	4-5 %
Total……………………………………………………………………………	**100 %**

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Textura y estructura.- La roca argilácea presenta estructura masiva y terrosa con textura clástica de grano muy fino (<0,1 mm), con escasos micro-clastos de plagioclasas cuarzo y piroxenos. Es deleznable y muestra escasa dureza y cohesión por el abundante contenido de arcillas y limos (Fig. 35).

Nombre de la roca.- De acuerdo al análisis petrográfico, corresponde a una roca sedimentaria o volcano-sedimentaria de composición pelítica (argilácea), clasificada como una **ARCILLITA**, cuyos escasos micro-clastos corresponden a minerales originales que fueron erosionados de rocas volcánicas; probablemente se trata de una roca de edad cuaternaria.

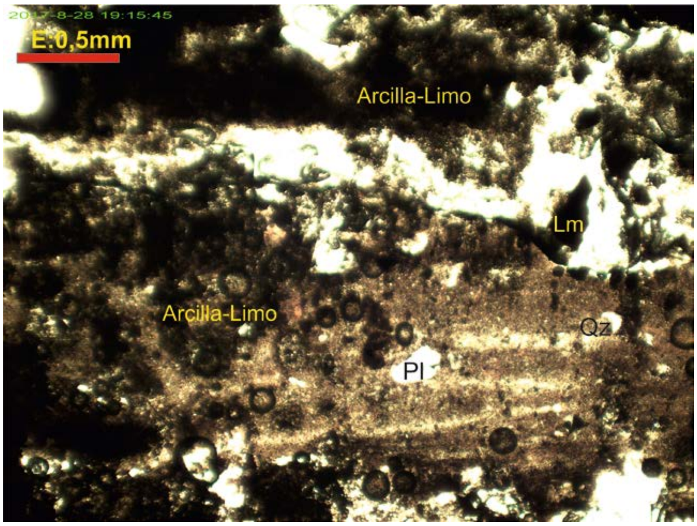

Fig. 35. Muestra 7824, aumento 4x, polarizadores ll. Arcillita, formada fundamentalmente por arcillas y limos de tono marrón, con escasos micro-clastos de plagioclasas (Pl), cuarzo (Qz) y limonita (Lm).

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 28 de Agosto de 2017
Nº LAB: SGM-160/17 Muestra 7825.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura cavernosa con cavidades vacías y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita muy oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra moderada dureza y compactación y un aspecto escoriáceo por sus numerosas cavidades.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Andesina (An: 30-35), muestran ligera orientación preferencial (Fig. 36).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales anhedrales y subhedrales tabulares que alcanzan hasta 1 mm de largo, de color marrón oscuro por la intensa oxidación de gran parte de sus cristales.

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 0,7 mm de largo del tipo augita, algunos cristales muestran fracturas y oxidación de los bordes (Fig. 36).

Pasta.- La pasta de la lava es abundante y está formada principalmente por micro-cristales y microlitos de plagioclasas con cierta orientación, y en menor porcentaje por vidrio volcánico masivo y óxidos de hierro de grano fino (Fig. 36).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral (cúbico), diseminados en la pasta y alterando a cristales de biotita, corresponderían a las variedades limonita, hematita y poca magnetita.

Composición porcentual observada.-

Plagioclasas (Andesina) $NaCaAl(Si_3O_8)$………….……….…...……….....……..	32-34 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………....…………………………………...	2-3 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$..……...……	4-5 %
Pasta (microlitos de plagioclasas)…...……..........…………………….......……	53-55 %

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Óxidos de Hierro (Limonita, hematita y magnetita)……………………………	2-3 %
Total…………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura cavernosa y textura porfídica de grano medio (>2 mm), la pasta es microlítica y vítrea (Fig. 36).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Piroxénica**, débilmente oxidada.

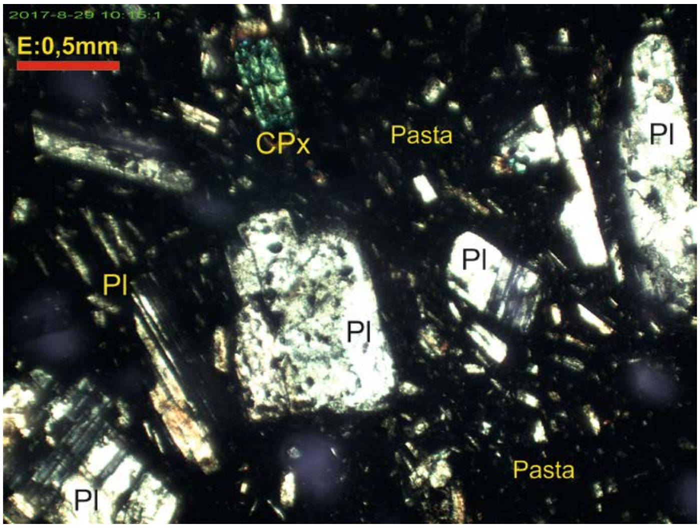

Fig. 36. Muestra 7825, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), y pasta con microlitos de plagioclasas y vidrio.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 29 de Agosto de 2017
Nº LAB: SGM-161/17 Muestra 7827.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris, muestra superficies de meteorización, composición relativamente ácida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, cuarzo, biotita muy oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente presente en moderado porcentaje forma de cristales anhedrales y subhedrales con bordes sub-angulosos, que alcanzan hasta 2 mm de largo, muestran fracturas, engolfamientos e inclusiones de la pasta (Fig. 37).

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Oligoclasa (An: 25-30) (Fig. 37).

Biotita.- Se presenta en moderada proporción en forma de fenocristales euhedrales poligonales y subhedrales tabulares que alcanzan hasta 2 mm de largo, de color marrón oscuro por la intensa oxidación de gran parte de sus cristales.

Clinopiroxenos.- Se observan en moderado porcentaje fenocristales subhedrales prismáticos y euhedrales poligonales de tono verdoso pálido, que alcanzan hasta 1,5 mm de largo del tipo augita, algunos muestran fracturas y maclas polisintéticas (Fig. 37).

Pasta.- La pasta es abundante y está formada principalmente por microlitos de plagioclasas con cierta orientación, y en menor porcentaje por óxidos de hierro de grano muy fino (Fig. 37).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral (trapezoidal), diseminados en la pasta y alterando a cristales de biotita, corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Cuarzo (SiO_2)……………………………………………………………	5-7 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$……………………………………	20-22 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………	3-4 %

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Clinopiroxenos (Augita) (Mg,Fe)(SiO_3)..	4-6 %
Pasta (microlitos de plagioclasas)..	56-58 %
Óxidos de Hierro (Limonita, hematita y magnetita)..	2-3 %
Total..	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es microlítica (Fig. 37).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición ácida, que corresponde a una **DACITA Piroxénica**, débilmente oxidada.

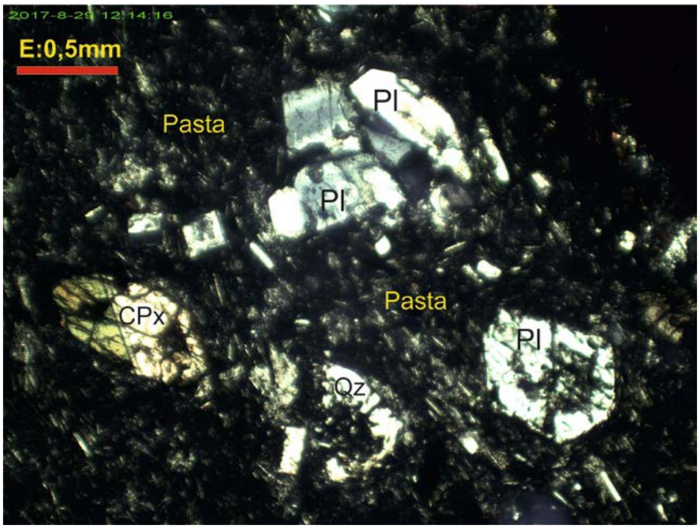

Fig. 37. Muestra 7827, aumento 4x, polarizadores X. Lava Dacítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), cuarzo (Qz) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
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FECHA: 29 de Agosto de 2017
Nº LAB: SGM-162/17 Muestra 7830.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, anfíboles, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 3,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Oligoclasa (An: 25), muestran ligera orientación preferencial (Fig. 38).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales anhedrales y subhedrales tabulares que alcanzan hasta 1 mm de largo, de color marrón (Fig. 38).

Hornblenda.- Se observan en moderado porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, con maclas y se hallan reemplazados parcialmente por limonita en los bordes, alcanzan hasta 1,5 mm de largo (Fig. 38).

Clinopiroxenos.- Se observan en reducido porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 1 mm de largo del tipo augita, algunos cristales muestran oxidación de los bordes (Fig. 38).

Pasta.- La pasta de la lava es abundante y está formada principalmente por microlitos de plagioclasas con cierta orientación, y en menor porcentaje por vidrio volcánico masivo y óxidos de hierro de grano fino (Fig. 38).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta, corresponderían a las variedades limonita, hematita y magnetita.

Composición porcentual observada.-

Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………………………………………	28-30 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)………………………………………………	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………………………	3-5 %

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Clinopiroxenos (Augita) (Mg,Fe)(SiO_3)…………………………………………	2-3 %
Pasta (microlitos de plagioclasas)…………………………………………	54-56 %
Óxidos de Hierro (Limonita, hematita y magnetita)………………………………	2-3 %
Total……………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es microlítica y vítrea (Fig. 38).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Hornbléndica**.

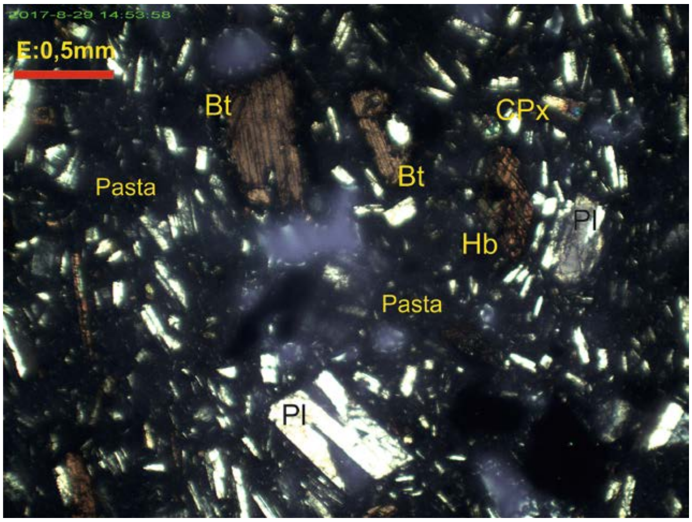

Fig. 38. Muestra 7830, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), hornblenda (Hb), biotita (Bt) y pasta con microlitos de plagioclasas y poco vidrio.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 29 de Agosto de 2017
Nº LAB: SGM-163/17 Muestra 7833.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro, tiene superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos, anfíboles, biotita, piroxenos, poco cuarzo y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra moderada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Cuarzo.- Es un componente presente en reducido porcentaje forma de cristales anhedrales y subhedrales con bordes sub-angulosos, que alcanzan hasta 0,5 mm de largo, muestran fracturas, engolfamientos e inclusiones de la pasta.

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Oligoclasa (An: 25), muestran ligera orientación preferencial (Fig. 39).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales euhedrales poligonales y subhedrales tabulares que alcanzan hasta 2 mm de largo, de color marrón, contienen pequeñas inclusiones de plagioclasas (Fig. 39).

Hornblenda.- Se observan en moderado porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, se hallan reemplazados parcialmente por limonita en los bordes, alcanzan hasta 2,5 mm de largo.

Clinopiroxenos.- Se observan en reducido porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 1,5 mm de largo del tipo augita, algunos cristales muestran oxidación de los bordes y maclas (Fig. 4).

Pasta.- La pasta es abundante y está formada principalmente por microlitos de plagioclasas con cierta orientación, y en menor porcentaje por vidrio volcánico masivo y óxidos de hierro de grano fino (Fig. 39).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral, diseminados en la pasta y como alteración de hornblendas y biotitas, corresponderían a las variedades limonita, hematita y magnetita.

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Composición porcentual observada.-

Cuarzo (SiO_2)…………	1-2 %
Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………	26-28 %
Biotita ($K_2(Mg,Fe)_2(OH)_2(AlSiO_{10})$)…………	2-3 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………	4-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$…………	2-3 %
Pasta (microlitos de plagioclasas)…………	53-55 %
Óxidos de Hierro (Limonita, hematita y magnetita)…………	3-4 %
Total…………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es mayoritariamente microlítica (Fig. 39).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Hornbléndica**, débilmente oxidada.

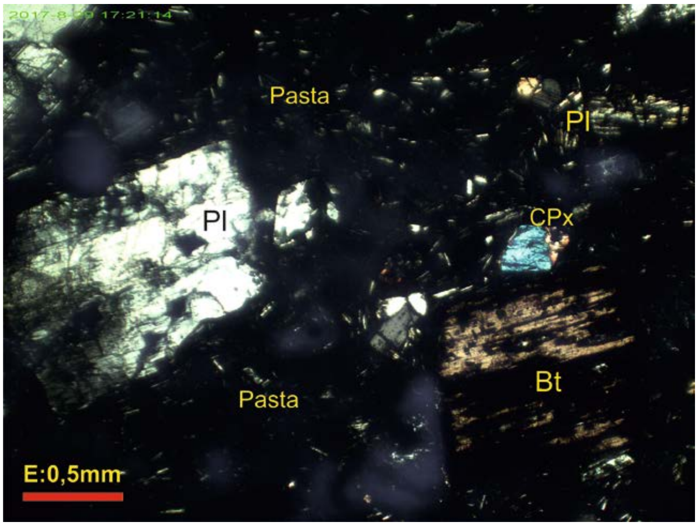

Fig. 39. Muestra 7833, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), biotita (Bt) y pasta con microlitos de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 29 de Agosto de 2017
Nº LAB: SGM-164/17 Muestra 7737.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, composición acida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes y grandes cristales de feldespatos, anfíboles, biotita, escasos piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 2,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción y fracturas, corresponden a la variedad Oligoclasa (An: 25-30) (Fig. 40).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 1 mm de largo, de color marrón, contienen pequeñas inclusiones de plagioclasas, están ligeramente oxidados (Fig. 40).

Hornblenda.- Se observan en reducido porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, se hallan reemplazados parcialmente por limonita en los bordes, alcanzan hasta 1 mm de largo.

Clinopiroxenos.- Se observan en escaso porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 2 mm de largo del tipo augita, algunos cristales muestran oxidación de los bordes y se hallan aglomerados en grupos (Fig. 5).

Pasta.- La pasta es muy abundante y está formada principalmente por vidrio volcánico de textura masiva y perlítica, y en menor porcentaje por microlitos de plagioclasas y óxidos de hierro de grano muy fino (Fig. 40).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral (cúbico), diseminados en la pasta y como alteración de hornblendas y biotitas, corresponderían a las variedades limonita, hematita y magnetita.

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Composición porcentual observada.-

Plagioclasas (Oligoclasa) $NaCaAl(Si_3O_8)$…………………………………………	23-25 %
Biotita $(K_2(Mg,Fe)_2(OH)_2(AlSiO_{10}))$…………………………………………	4-5 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$…………………………………	1-2 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$…………………………………………	<1%
Pasta (vidrio volcánico)…………………………………………………………	58-60 %
Óxidos de Hierro (Limonita, hematita y magnetita)…………………………	2-3 %
Total…………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura holocristalina y textura porfídica de grano medio (>2 mm), la pasta es vítrea con textura perlítica (Fig. 40).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición acida, que corresponde a una **DACITA Biotitica**.

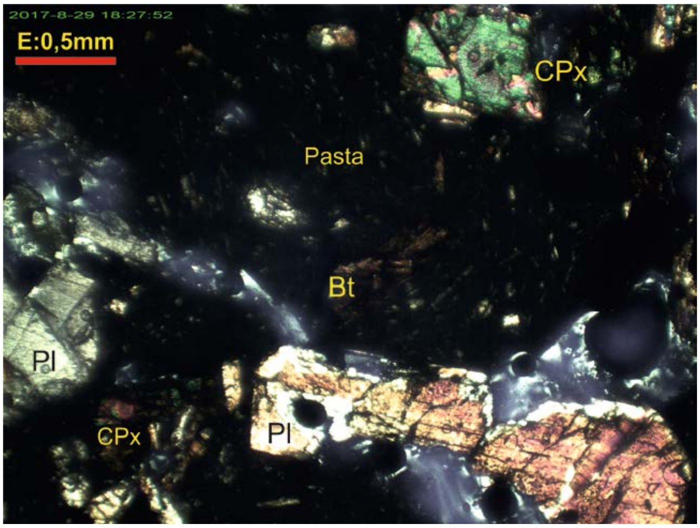

Fig. 40. Muestra 7737, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), biotita (Bt) y pasta vítrea con textura perlítica.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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SERVICIO GEOLÓGICO MINERO

INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 29 de Agosto de 2017
Nº LAB: SGM-165/17 Muestra 7743.

ANÁLISIS PETROGRÁFICO

Descripción Macroscópica.-

Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura bandeada o fluidal y textura porfídica de grano medio a fino (>1 mm), donde se observan abundantes cristales de feldespatos, anfíboles, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación.

Descripción Microscópica.-

Mineralogía.-

Plagioclasas.- Se presentan en abundante porcentaje, en forma de fenocristales subhedrales tabulares y prismáticos, de hasta 1,5 mm de largo, muestran zonación, maclas polisintéticas tipo Albita y combinadas Albita-Carlsbad, con bordes de reacción, fracturas y tienen orientación preferencial, corresponden al límite entre las variedades Oligoclasa-Andesina (An: 30) (Fig. 41).

Biotita.- Se presenta en reducida proporción, en forma de fenocristales subhedrales tabulares que alcanzan hasta 0,8 mm de largo, de color marrón, están ligeramente oxidados en los bordes.

Hornblenda.- Se observan en moderado porcentaje fenocristales euhedrales poligonales y subhedrales prismáticos de color marrón, se hallan reemplazados parcialmente por limonita en los bordes, alcanzan hasta 1 mm de largo (Fig. 41).

Clinopiroxenos.- Se observan en reducido porcentaje fenocristales subhedrales prismáticos y anhedrales de tono verdoso pálido, que alcanzan hasta 0,5 mm de largo del tipo augita, algunos cristales muestran oxidación de los bordes (Fig. 41).

Pasta.- La pasta es abundante y está formada principalmente por microlitos de plagioclasas con orientación preferencial siguiendo la dirección de flujo de la lava (textura eutáxica), y en menor porcentaje por vidrio volcánico de textura masiva, junto a óxidos de hierro de grano muy fino (Fig. 41).

Óxidos de Hierro.- Se presentan en reducido porcentaje, como pequeños minerales opacos de hábito anhedral y subhedral (cúbico), diseminados en la pasta y como alteración de hornblendas y biotitas, corresponderían a las variedades limonita, hematita y poca magnetita.

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Composición porcentual observada.-

Plagioclasas (Oligoclasa-Andesina) $NaCaAl(Si_3O_8)$……………………………	25-27 %
Biotita $(K_2(Mg,Fe)_2(OH)_2(AlSiO_{10}))$……………………………………………	1-2 %
Hornblenda $Ca_2(Mg,Fe,Al)_5(OH)_2\{(Si,Al)_4O_{11}\}_2$……………………………	4-5 %
Clinopiroxenos (Augita) $(Mg,Fe)(SiO_3)$……………………………………	2-3 %
Pasta (microlitos de plagioclasas)……………………………………………	58-60 %
Óxidos de Hierro (Limonita, hematita y magnetita)………………………………	2-3 %
Total………………………………………………………………………	**100 %**

Textura y estructura.- Presenta una estructura bandeada o fluidal y textura porfídica de grano medio a fino (>1 mm), la pasta es microlítica de textura pilotáxica (Fig. 41).

Nombre de la roca.- De acuerdo al análisis petrográfico, es una lava de composición intermedia, que corresponde a una **ANDESITA Hornbléndica**.

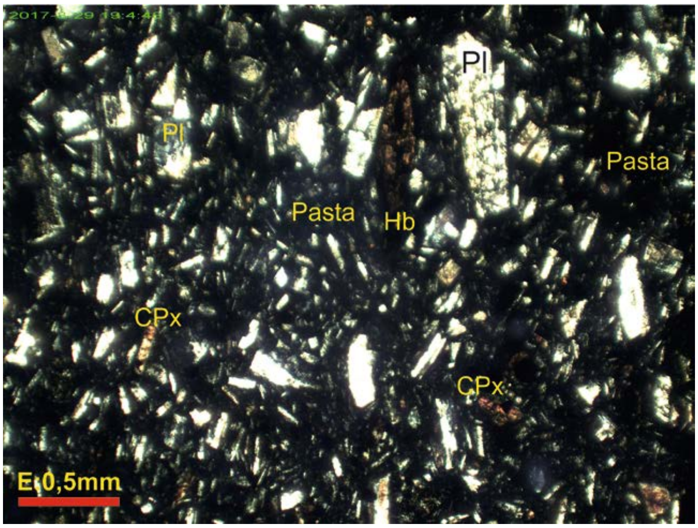

Fig. 41. Muestra 7743, aumento 4x, polarizadores X. Lava Andesítica, con fenocristales de plagioclasas (Pl), clinopiroxeno (CPx), hornblenda (Hb), y pasta microlítica de plagioclasas.

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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RESULTADOS
ANÁLISIS DE MINERAGRAFÍA

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 27 de Julio de 2016
Nº LAB: SGM-131/17 Muestra 7807.

ANÁLISIS MINERAGRÁFICO

DESCRIPCIÓN MACROSCÓPICA

Fragmento de una roca piroclástica (toba ignimbrítica) de composición intermedia, muestra estructura bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de color marrón-rojizo y bandas de tono gris oscuro, ambas muestran cristales de feldespatos, biotita, piroxenos y óxidos de hierro del tipo hematita y magnetita diseminados, rodeados por una pasta ferruginosa y vítrea, con más presencia de hierro en las bandas grises. La toba presenta alto grado de soldadura (ignimbrita), muestra elevada dureza y compactación, y también es llamada toba soldada.

MINERALES OBSERVADOS EN SECCIÓN PULIDA

En la muestra se observan los siguientes minerales y sus porcentajes aproximados (Fig. 1).

Minerales Observados	Porcentaje
Hematita (Fe_2O_3)	2-3 %
Magnetita (Fe_3O_4)	<1 %
Limonita (FeOOH) (pasta de la toba)	1-2 %
Feldespatos de la toba soldada	93-95 %
Total	**100 %**

DESCRIPCIÓN DE MINERALES

Hematita
Está presente en reducido porcentaje como cristales anhedrales de grano muy fino (<0,1 a 0,5 mm), diseminados en la toba soldada y asociados con magnetita y limonita. Este óxido de hierro cristaliza en el sistema hexagonal, de color gris en la muestra de mano y gris-blanquecino en sección pulida, con brillo metálico, reflectancia media a alta, débil pleocroísmo, moderada anisotropía y dureza alta al pulido, muestra texturas de reemplazamiento de magnetita (Fig. 1).

Magnetita
La magnetita está presente en escaso porcentaje, muestra texturas de reemplazamiento por cristales de hematita, rellenando sus planos de clivaje. Este óxido de hierro es magnético, muestra color gris opaco en la muestra de mano, y gris con tinte marrón pálido en sección pulida, tiene brillo metálico, reflectancia media, es isótropo, con dureza alta al pulido (Fig. 1).

Limonita
La limonita es un óxido de hierro presente en la pasta de la toba soldada, muestra hábito masivo, color marrón-rojizo en la muestra de mano y gris-oscuro en sección pulida, brillo opaco, reflectancia baja, moderada anisotropía, reflejos internos rojos y dureza media al pulido.

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ASOCIACIONES MINERALES

Se observan asociaciones minerales entre: Hematita-Magnetita-Limonita.

SECUENCIA PARAGENETICA

Primera Fase: Magnetita- Hematita.
Segunda Fase: Limonita.

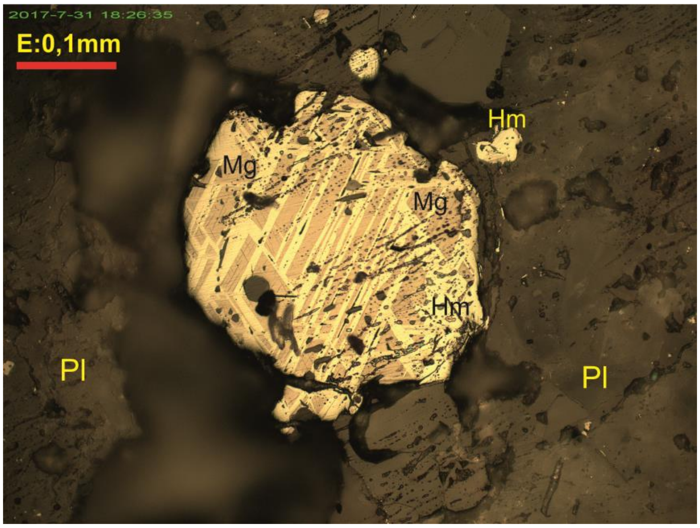

Fig. 1. Muestra 7807. Aumento 20X, Polarizadores ll. Toba Ignimbrítica, con plagioclasas (Pl) y diseminación de micro-cristales de magnetita (Mg) reemplazados parcialmente por hematita (Hm).

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

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INTERESADO: Ing. Adolfo Orsolini Campana
UBICACIÓN: Proyecto Mapeo Geológico del Área del Manantial del Silala
FECHA: 27 de Julio de 2016
Nº LAB: SGM-132/17 Muestra 7808.

ANÁLISIS MINERAGRÁFICO

DESCRIPCIÓN MACROSCÓPICA

Fragmento de una roca piroclástica (toba ignimbrítica) de composición intermedia, muestra estructura bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de tono gris oscuro y bandas de color marrón-rojizo, ambas muestran cristales de feldespatos, biotita, piroxenos y óxidos de hierro diseminados de la variedad hematita y magnetita, rodeados por una pasta microlítica y vítrea, con más presencia de hierro en las bandas oscuras. La toba presenta alto grado de soldadura (ignimbrita), muestra elevada dureza y compactación, también es llamada toba soldada.

MINERALES OBSERVADOS EN SECCIÓN PULIDA

En la muestra se observan los siguientes minerales y sus porcentajes aproximados (Fig. 2).

Minerales Observados	Porcentaje
Hematita (Fe_2O_3)	2-3 %
Magnetita (Fe_3O_4)	<1 %
Limonita (FeOOH) (pasta de la toba)	2-3 %
Feldespatos de la toba soldada	92-94 %
Total	**100 %**

DESCRIPCIÓN DE MINERALES

Hematita
Está presente en reducido porcentaje como cristales anhedrales de grano muy fino (<0,1 a 0,5 mm), diseminados en la toba soldada y asociados con magnetita y limonita. Este óxido de hierro cristaliza en el sistema hexagonal, de color gris en la muestra de mano y gris-blanquecino en sección pulida, con brillo metálico, reflectancia media a alta, débil pleocroísmo, moderada anisotropía y alta dureza al pulido, muestra texturas de reemplazamiento de magnetita (Fig. 2).

Magnetita
La magnetita está presente en escaso porcentaje, muestra texturas de reemplazamiento por cristales de hematita, rellenando sus planos de clivaje. Este óxido de hierro es magnético, muestra color gris opaco en la muestra de mano, y gris con tinte marrón pálido en sección pulida, tiene brillo metálico, reflectancia media, es isótropo, con dureza alta al pulido (Fig. 2).

Limonita
La limonita es un óxido de hierro presente sobre todo en la pasta de la toba, muestra hábito masivo, color marrón-rojizo en la muestra de mano y gris-oscuro en sección pulida, brillo opaco, reflectancia baja, moderada anisotropía, reflejos internos rojos y dureza media al pulido (Fig. 2).

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ASOCIACIONES MINERALES

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SECUENCIA PARAGENETICA

Primera Fase: Magnetita- Hematita.
Segunda Fase: Limonita.

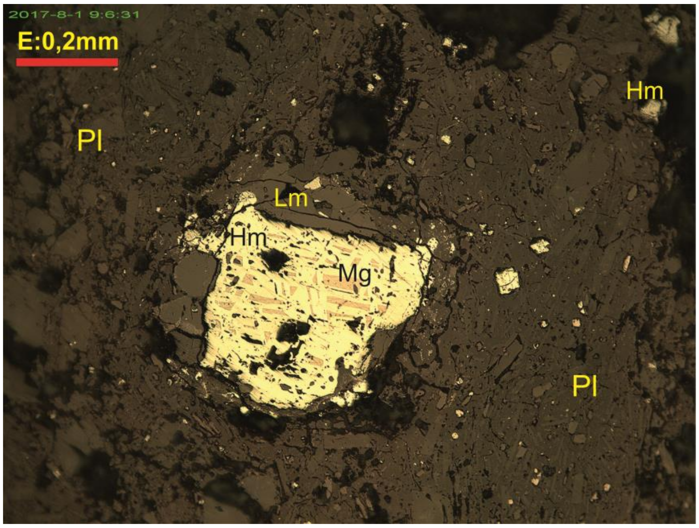

Fig. 2. Muestra 7808. Aumento 10X, Polarizadores ll. Toba Ignimbrítica, con plagioclasas (Pl) y micro-cristales de magnetita (Mg) reemplazados en gran parte por hematita (Hm) y limonita (Lm).

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FECHA: 27 de Julio de 2016
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ANÁLISIS MINERAGRÁFICO

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MINERALES OBSERVADOS EN SECCIÓN PULIDA

En la muestra se observan los siguientes minerales y sus porcentajes aproximados (Fig. 3).

Minerales Observados	Porcentaje
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DESCRIPCIÓN DE MINERALES

Hematita
Está presente en reducido porcentaje como cristales anhedrales de grano muy fino (<0,1 a 0,5 mm), diseminados en la toba soldada y asociados con magnetita y limonita. Este óxido de hierro cristaliza en el sistema hexagonal, de color gris en la muestra de mano y gris-blanquecino en sección pulida, con brillo metálico, reflectancia media a alta, débil pleocroísmo, moderada anisotropía y dureza alta al pulido, muestra texturas de reemplazamiento de magnetita (Fig. 3).

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ASOCIACIONES MINERALES

Se observan asociaciones minerales entre: Hematita-Magnetita-Limonita.

SECUENCIA PARAGENETICA

Primera Fase: Magnetita- Hematita.
Segunda Fase: Limonita.

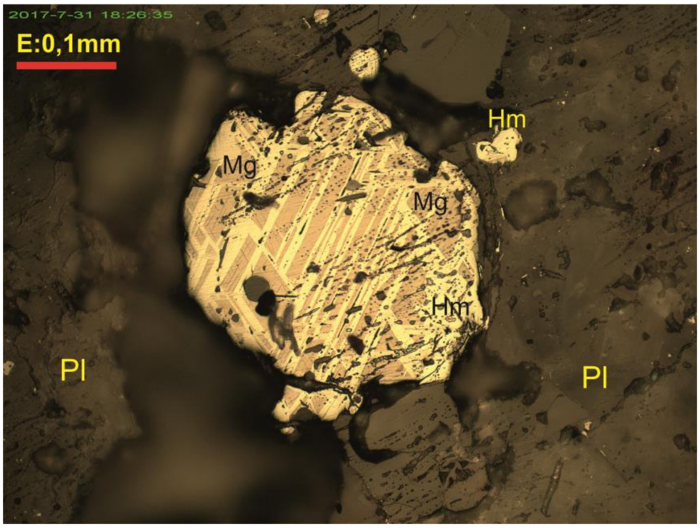

Fig. 3. Muestra 7807. Aumento 20X, Polarizadores II. Toba Ignimbrítica, con plagioclasas (Pl) y diseminación de micro-cristales de magnetita (Mg) reemplazados parcialmente por hematita (Hm).

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Fragmento de una roca piroclástica (toba ignimbrítica) de composición intermedia, muestra estructura bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre bandas lenticulares de tono gris oscuro y bandas de color marrón-rojizo, ambas muestran cristales de feldespatos, biotita, piroxenos y óxidos de hierro diseminados de la variedad hematita y magnetita, rodeados por una pasta microlítica y vítrea, con más presencia de hierro en las bandas oscuras. La toba presenta alto grado de soldadura (ignimbrita), muestra elevada dureza y compactación, también es llamada toba soldada.

MINERALES OBSERVADOS EN SECCIÓN PULIDA

En la muestra se observan los siguientes minerales y sus porcentajes aproximados (Fig. 4).

Minerales Observados	Porcentaje
Hematita (Fe_2O_3)	2-3 %
Magnetita (Fe_3O_4)	<1 %
Limonita (FeOOH) (pasta de la toba)	2-3 %
Feldespatos de la toba soldada	92-94 %
Total	**100 %**

DESCRIPCIÓN DE MINERALES

Hematita
Está presente en reducido porcentaje como cristales anhedrales de grano muy fino (<0,1 a 0,5 mm), diseminados en la toba soldada y asociados con magnetita y limonita. Este óxido de hierro cristaliza en el sistema hexagonal, de color gris en la muestra de mano y gris-blanquecino en sección pulida, con brillo metálico, reflectancia media a alta, débil pleocroísmo, moderada anisotropía y alta dureza al pulido, muestra texturas de reemplazamiento de magnetita (Fig.4).

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La magnetita está presente en escaso porcentaje, muestra texturas de reemplazamiento por cristales de hematita, rellenando sus planos de clivaje. Este óxido de hierro es magnético, muestra color gris opaco en la muestra de mano, y gris con tinte marrón pálido en sección pulida, tiene brillo metálico, reflectancia media, es isótropo, con dureza alta al pulido (Fig. 4).

Limonita
La limonita es un óxido de hierro presente sobre todo en la pasta de la toba, muestra hábito masivo, color marrón-rojizo en la muestra de mano y gris-oscuro en sección pulida, brillo opaco, reflectancia baja, moderada anisotropía, reflejos internos rojos y dureza media al pulido (Fig. 4).

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ASOCIACIONES MINERALES

Se observan asociaciones minerales entre: Hematita-Magnetita-Limonita.

SECUENCIA PARAGENETICA

Primera Fase: Magnetita- Hematita.
Segunda Fase: Limonita.

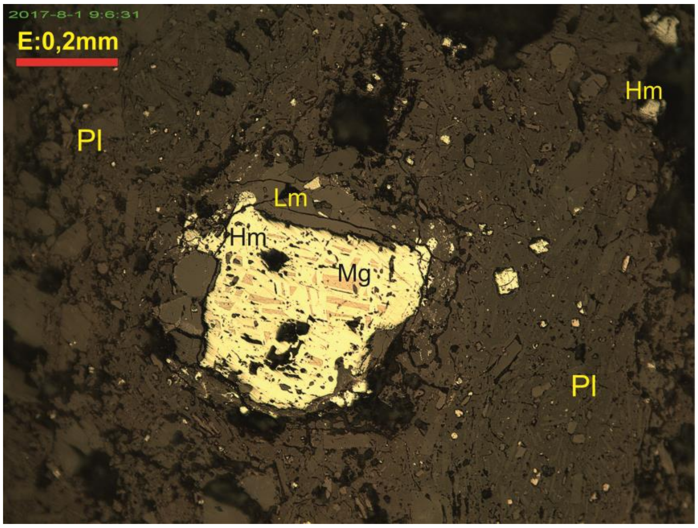

Fig. 4. Muestra 7808. Aumento 10X, Polarizadores ll. Toba Ignimbrítica, con plagioclasas (Pl) y micro-cristales de magnetita (Mg) reemplazados en gran parte por hematita (Hm) y limonita (Lm).

Analizado por: Ing. José Luis Argandoña C.
ENCARGADO DEL LABORATORIO

APPENDIX B

CONVENIO DE COOPERACIÓN INTERINSTITUCIONAL Y
CONTRATO DE CONSULTORIA DIREMAR - SERGEOMIN

SERGEOMIN
SERVICIO GEOLÓGICO MINERO

ANEXO D

BASE DE DATOS

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CONVENIO DE COOPERACIÓN INTERINSTITUCIONAL Y CONTRATO DE CONSULTORIA DIREMAR - SERGEOMIN

SERGEOMIN
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BASE DE DATOS GEOLÓGICOS

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SERVICIO GEOLOGICO MINERO

DIRECCION ESTRATEGICA DE REINVINDICACION MARITIMA, SILALA Y RECURSOS HIDRICOS INTERNACIONALES

MAPEO GEOLOGICO DEL AREA CIRCUNDANTE AL MANANTIAL DEL SILALA

BASE DE DATOS

N°	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S1	600773	7566342	4382	250/11NW		Ignimbrita	Se puede ver ignimbritas de grano fino, de una matrix ferruginosa.Nis-2	22/05/2017
S2	600813	7566226	4383	50/6SE	7702	Toba	Toba ignimbritica de composicion intermedia de grano medio donde se observa una intercalacion entre bandas lenticulares de color marron y bandas de tono negruzco, ambas meustras cristales de feldespatos blanquecinos, escazos cuarzo, piroxenos, pomez alargadas y oxidos de hierro diseminados, rodeados por una pasta ferruginosa y vitrea, con mayor presencia de hierro en las bandas negruzcas, la toba presenta alto nivel de soldadura, por lo que muestra elevada dureza y compactacion y tambien es llamada toba soldada.	22/05/2017
S3	600956	7566439	4411	250/15SE		Flujo de detritos	Clastos angulosos a subredondeados monoliticos, diametro de los clastos (1mm-30cm),matriz ferruginosa terrosa. Nfd2	22/05/2017
S4	600972	7566398	4399	250/20SE		Ignimbrita	Se puede ver ignimbritas de grano fino, de una matrix ferruginosa.Nis-2	22/05/2017
S5	600973	7566397	4395	250/10SE	7706	Ignimbrita	Toba ignimbritica de composicion intermedia, de una estructura bandeada de grano medio(>1 mm), donde se observa una intercalacion entre bandas lenticulares de color marron, muestran cristales de feldespatos blanquecinos y muy escazos cuarzos, piroxenos, pomez alargadas y abundantes oxidos de hierro diseminados rodeados por una pasta ferruginosa y vitrea, con mayor presencia de hierro en las bandas negruzcas, la toba presenta alto nivel de soldadura, por lo que muestra elevada dureza y compactacion y tambien es llamada toba soldada. Nis-2	22/05/2017
S6	600982	7566368	4378	245/8SE		Ignimbrita	Clastos angulosos a subredondeados monoliticos en matriz ferruginosa silicificada. Nis-1	22/05/2017
S7	600998	7566324	4376	245/20SE		Ignimbrita	Clastos angulosos a subredondeados monoliticos en matriz ferruginosa silicificada. Nis-1	22/05/2017
S8	601012	7566321	4386	240/8SE		Ignimbrita	Clastos angulosos a subredondeados monoliticos en matriz ferruginosa silicificada. Nis-1	22/05/2017
S9	601011	7566289	4399	240/6SE		Flujo de detritos	Clastos angulosos a subredondeados monoliticos, diametro de los clastos (1mm -10 cm),matriz ferruginosa terrosa. Nfd2	22/05/2017
S10	601030	7566237	4401	245/8SE		Flujo de detritos	Clastos angulosos a subredondeados monoliticos, diametro de los clastos (1mm -10 cm),matriz ferruginosa terrosa. Nfd2	22/05/2017
S11	601031	7566226	4398	243/10SE		Toba	Tamaño de grano medio,textura bandeada compuesta de hematita y magnetita en matriz ferruginosa, y un espesor de 5 cm aproximadamente.	22/05/2017
S12	600875	7566672	4356	220/42SE		Lava	Flujos de lavas de grano medio a grueso en sectores se observa horizontes con bandeamiento, los cristales se encuentran fagmentados muy raras biotitas idiomorfas. Nlsc	23/05/2017
S13	600508	7565835	4363	210/10SE		Flujo de detritos	Clastos angulosos a subredondeados monoliticos, diametro de los clastos (1mm-10cm),matriz ferruginosa terrosa. Nfd2	23/05/2017
S14	600533	7565836	4352	207/8SE		Ignimbrita	Tamaño de grano medio,textura bandeada compuesta de hematita en matriz ferruginosa. Nis-2	23/05/2017
S15	600540	7565820	4347	204/5SE		Toba	Tamaño de grano medio,textura bandeada compuesta de hematita y magnetita en matriz ferruginosa, espesor = 8 cm.	23/05/2017

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Nº	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S16	600540	7565819	4345	205/8SE		Toba	Tamaño de grano medio,textura bandeada compuesta de hematita y magnetita en matriz ferruginosa, espesor = 10 cm.	23/05/2017
S17	600547	7565806	4332	203/10SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm-2 cm).Nis-1	23/05/2017
S18	600568	7565773	4333	202/8SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm-2 cm).Nis-1	23/05/2017
S19	600587	7565776	4339	200/5SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm-2 cm).Nis-1	23/05/2017
S20	600592	7565774	4339	199/15SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm-2 cm).Nis-1	23/05/2017
S21	600616	7565776	4357	215/10SE		Flujo de detritos	Se puede ver ignimbritas de grano fino, de una matrix ferruginosa.Nis-2	23/05/2017
S22	600942	7566168	4395	230/8SE		Toba	Tamaño de grano medio,textura bandeada compuesta de hematita en matriz ferruginosa, y un espesor de10 cm aproximadamente.	23/05/2017
S23	600831	7566233	4376	215/5SE		Toba	Tamaño de grano medio,textura bandeada compuesta de hematita y magnetita en matriz ferruginosa, y un espesor de15 cm aproximadamente.	23/05/2017
S24	600822	7566241	4365	220/10SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm -4cm). Nis-1	23/05/2017
S25	600704	7566320	4398	235/8SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm -4cm). Nis-1	23/05/2017
S26	600647	7566317	4389	220/5SE		Ignimbrita	Clastos monoliticos,matriz en proceso de alteracion argilica supergenica, diametro (1mm -6cm). Nis-1	23/05/2017
S27	601181	7565996	4457	220/10SE	7801	Lava	Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, biotita y anfíboles muy oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra moderada dureza y compactación. Nlsc	23/05/2017
S28	604895	7567297	4541	240/15SE		Ignimbrita	Afloramiento de ignimbrita, de tamaño de grano medio,cuarzo lechoso y cristalino subredondeados,biotitas frescas y alteradas.Nls-3	23/05/2017
S29	600564	7566022	4369	195/10SE		Ignimbrita	Ignimbrita color gris claro leve tono rosaceo con fragmentos de cuarzo con bordes sub redondeados y engolfamientos, biotita en fragmentos rodeados de una pasta ferruginosa polilitica clastos con aureolas de recalentamiento soldamiento moderado. Ns2	26/05/2017
S30	600216	7565447	4326	210/6NW		Ignimbrita	Ignimbrita color gris claro leve tono rosaceo con fragmentos de cuarzo con bordes sub redondeados y engolfamientos, biotita en fragmentos rodeados de una pasta ferruginosa polilitica clastos con aureolas de recalentamiento soldamiento moderado textura vesicular en sectores gradacion normal en la base se tiene un horizonte de ceniza volcanica de 8 cm de espesor.Ns1	26/05/2017

Nº	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S31	600247	7565411	4303	215/9NW		Flujo de detritos	Contacto aglomerado volcanico y aluvial matrix soportado color marron rojizo con clastos en su matrix que varian de 10 cm a 40 cm, sub redondeados de grano medio a grueso debil soldamiento matrix con alto contenido defragmentos de, cuarzo, biotita bloques polilíticos mal clasificados, aluvial material suelto y con cubierta de vegetacion	26/05/2017
S32	604898	7567298	4543	60/5Nw	7802	Ignimbrita	Fragmento de una roca de origen volcánico (toba), de color marrón con tono rosáceo, tiene superficies de meteorización, de composición ácida, muestra estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, biotita muy oxidada, anfíboles, pómez alargadas de tono blanquecino y óxidos de hierro, rodeados por una pasta vítrea y ferruginosa, muestra moderada dureza y grado de soldadura. Nls-3	15/06/2017
S33	605450	7566080	4602	60/39NW	7803	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos orientados, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino. La lava muestra elevada dureza y compactación. Nlsg	15/06/2017
S34	605074	7567088	4547	45/64NW		Ignimbrita	Plagioclasas alteradas y frescas,predominancia de biotita, cuarzo lechoso y cristalino subredondeados, presencia de pomez en la matriz en forma alineada. Nls-3	15/06/2017
S35	601828	7565534	4426	344/9SW		Lava	Flujos de lavas textura porfidica biotitica grano medio a grueso en sectores se observa horizontes con bandeamiento, los cristales se encuentran fagmentados muy raras biotitas idiomorfas. Nlsc	15/06/2017
S36	601728	7565604	4437	314/12SW		Lava	Flujos de lavas textura porfidica biotitica grano medio a grueso en sectores se observa horizontes con bandeamiento, los cristales se encuentran fagmentados muy raras biotitas idiomorfas.Nlsc	15/06/2017
S37	601630	7565591	4474	239/62SE		Lava	Flujos de lavas textura porfidica biotitica grano medio a grueso en sectores se observa horizontes con bandeamiento, los cristales se encuentran fagmentados muy raras biotitas idiomorfas direccion de flujo sub vertical. Nlsc	15/06/2017
S38	601362	7565777	4518	316/22SW		Lava	Flujos de lavas textura porfidica biotitica grano medio a grueso en sectores con bandeamiento, los cristales se encuentran fagmentados muy raras biotitas idiomorfas superficialmente con una patina de oxidacion. Nlsc	15/06/2017
S39	604803	7567280	4542	258/23NW		Ignimbrita	Se observa toba en su mayor parte distorsionadas,de color violaceo claro, de un adiametro de 3 cm, de forma angulosa y grano medio, presentan cuarzos subangulosos en su matrix, poca presencia de biotita, el espesor aproximado de la colada de lava es de 1 m, de textura afanitica. Nls-3	15/06/2017
S40	604132	7566944	4496	255/7SE		Ignimbrita	Se observa toba de color violaceo claro, tamaño de grano medio,en su mayor parte distorsionadas, presentan cuarzos angulosos en su matrix, poca presencia de biotita, de textura afanitica.Nls-3	15/06/2017
S41	604018	7566910	4489	251/18SE		Ignimbrita	Se observa toba de color violaceo y marron, de diametro de los clastos de 0.3 cm, angulosos y de grano medio, en su mayor parte distorsionadas, presentan cuarzosangulosos en su matrix, poca presencia de biotita,, el espesor aproximado de la colada de lava es de 1.5 m, de textura afanitica. Nls-3	15/06/2017

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S42	603641	7566505	4446	153/24SW		Flujo de detritos	Se observa flujo de detritos con de color marron claro con clastos en su matriz que varian de 0.5cm a 25 cm, angulosos y de grano medio en su matrix con alto contenido de vidrio, cuarzo y biotita. Su espesor aproximado es de 0.6cm, de textura terrosa. Ndf2	15/06/2017
S43	608497	7567689	4583		7804	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlsg	16/06/2017
S44	609739	7568018	4596		7805	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con superficies de meteorización, de composición ácida, muestra estructura holocristalina y textura porfídica de grano medio (>3 mm), donde se observan grandes cristales de feldespatos blanquecinos, cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlct	16/06/2017
S45	605988	75653322	4653	28/62SE		Lava	Pseudo estratificacion (pseudo plegamiento) de lavas daciticas silicificadas, tamaño de grano medio, esporadicas biotitas. Nlsg	16/06/2017
S46	604393	7566010	4523	215/27NW		Lavas	Flujos de lavas andesiticas de color gris con tonos marrones con clastos que varian de 0.2 mm a 25 cm, subangulosos y de grano medio en su matrix ,con contenido de cuarzo, biotita y feldespatos. El espesor total de la colada de lava es de 1.9 m aproximadamente, de textura bandeada. Nlsg	16/06/2017
S47	604897	7564887	4606	284/11SW		Lava	Se observa flujos de lavas de contenido andesitico de color marron violaceo, con clastos en su matrix que vaian de 1cm a 1 m, angulosos y de grano medio en su matrix, que presentan bandeamiento, cuarzo biotita muy silificado. El espesor aproximado de la colada de lava es de 3 m, de textura bandeada. Nlsg	16/06/2017
S48	600959	7566047	4395	221/6SE		Ignimbrita	Ignimbrita color gris claro leve tono rosaceo polilitico clastos de 1 a 3 cm con fragmentos de cuarzo con bordes sub redondeados y engolfamientos, biotita en fragmentos rodeados de una pasta ferruginosa polilitica clastos con aureolas de recalentamiento soldamiento moderado, aglomerado polilitico matrix soportado. Nis-2	16/06/2017
S49	601377	7565285	4538	245/4SE		Lava	Color gris claro grano fino a medio textura porfidica biotitica muestra pseudo estratificacion muy raras biotitas idiomorfas. Nlsc	16/06/2017
S50	604787	7576158	4522		7708	Toba	Fragmento de una roca de origen piroclástico (toba ignimbrítica) de composición intermedia, muestra estructura bandeada y textura porfídica de grano medio (>1 mm), donde se observa una intercalación entre delgadas bandas lenticulares de color marrón-negruzco y bandas de tono gris claro, ambas muestran cristales de feldespatos blanquecinos, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta vítrea, con más presencia de hierro en las bandas oscuras. La toba presenta un grado de soldadura moderado a alto (ignimbrita), por lo que muestra elevada dureza y compactación, también es llamada toba soldada. Ntpg	17/06/2017
S51	601942	7564641	4606		7712	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con superficies de meteorización, composición ácida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, contiene agregados de calcita rellenando pequeñas cavidades de la roca, la cual muestra elevada dureza y compactación. Nlsc	17/06/2017

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S52	606624	7563670	4939	240/50NW		Lava	Pseudo estratificacion de lavas daciticas silicificadas, con clastos monoliticos subredondeados a redondeados en la matriz, tamaño de grano medio, esporadicas biotitas.Nlsg	17/06/2017
S53	606660	7563630	4951	235/75NW		Lava	Pseudo estratificacion de lavas daciticas silicificadas, con clastos monoliticos subredondeados a redondeados en la matriz, tamaño de grano medio, esporadicas biotitas. Nlsg	17/06/2017
S54	606688	7563466	4973	250/60NW		Lava	Dacita silicificada, con clastos monoliticos subredondeados a redondeados en la matriz, diametro de los clastos (1 mm - 8 cm), tamaño de grano medio, esporadicas biotitas, textura bandeada constituida por mineral de Fe. Nlsg	17/06/2017
S55	606752	7563334	4999	235/65NW		Lava	Dacitica silicificada, con clastos monoliticos subredondeados a redondeados en la matriz, diametro de los clastos (1 mm-8 cm), tamaño de grano medio, esporadicas biotitas, textura bandeada constituida por mineral de Fe. Nlsg	17/06/2017
S56	606911	7563173	5037	230/65NW		Lava	Flujo de lava dacitica de coloracion grisaceo de grano medio. Nlsg	17/06/2017
S59	606789	7561214	5649	35/50NW	7806	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos orientados, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlsg	17/06/2017
S60	606758	7562878	5041	240/70SE	7807	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos orientados, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlsg	17/06/2017
S61	601966	7564742	4560	262/80NW		Lava	Color gris blanquecino porfido feldespatico biotitico grano medio a grueso las biotitas son idiomorfas muestra pseudo estratificación. Nlsc	17/06/207
S62	601972	7564714	4574	288/8SW		Lava	Lava color gris claro grano fino a medio textura porfido feldespatico biotitico cuarzo fragmentado sub redondeado con engolfamientos, en sectores muestra direccion de flujo. Nlsc	17/06/2017
S63	602053	7564203	4721	316/61SW		Lava	Afloramiento lavas color gris oscuro grano medio a fino disposicion de cristales fragmentados textura porfidica silicificado.Nlsc	17/06/2017
S64	602044	7564108	4760	173/41SW		Lava	Afloramiento lava color gris claro con xenolitos con aureolas de recalentamiento textura porfido feldespatico biotitico grano medio a fino. Nlsc	17/06/2017
S65	601966	7564718	4573	85/23NW		Lava	Presenta flujos de lavas andesiticos de coloracion marron blanquesino, granos de medio a grueso en su matrix, cristales de biotita sub redondeados. Clastos < 10 cm. Nlsc	17/06/2017

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S66	601941	7564642	4609	135/37SW		Lava	Presenta flujos de lavas andesiticos de coloracion marron blanquesino, de granos de medio a grueso en su matrix, cristales de biotita sub redondeados. Nlsc	17/06/2017
S67	602053	7564206	4719	85/30NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris, de grano grueso en su matrix, cristales de biotita sub redondeados. Nlsc	17/06/2017
S68	602052	7564099	4766	178/66SW	7713	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, presenta superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan grandes cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlsc	17/06/2017
S69	607807	7567446	4604	31/61NW		Lava	Coladas de lava andesitica ,plagioclasas frescas y alteradas, biotitas frescas y alteradas.Nlsg	18/06/2017
S70	608466	7567135	4664	120/25NE		Lava	Coladas de lava andesitica, tamaño de grano medio, plagioclasas frescas, esporadicas biotitas. Nlsg	18/06/2017
S71	608487	7566245	4650	30/60SE		Lava	Roca dacitica de color gris con matriz silicificada,textura bandeada, tamaño de grano fino , posible vidrio volcanico como patina.Nlsg	18/06/2017
S72	605556	7566660	4558	331/8SW		Ignimbrita	Toba de color griz claro porfido feldespatico de grano, sub redondeados y aureolas de recalentamiento cristales fragmentados. Nls-3	18/06/207
S74	606154	7566472	4596	74/17SE		Lava	Lava color gris ocuro textura afanitica con fragmentos de cuarzo, biotita muestra direccion de flujo y bandeamiento. Nlsg	18/06/207
S75	606397	7566315	4625	160/9SW		Lava	Lava color gris ocuro textura afanitica con fragmentos de cuarzo, biotita muestra direccion de flujo y bandeamiento muy silicificado. Nlsg	18/06/207
S76	605180	7566103	4593	3/26NW		Lavas	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medioa fino en su matrix, con menor contenido de cristales de biotita angulosos. Nlsg	18/06/2017
S77	606156	7566475	4595	280/32NE		Lavas	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Con clastos < 12 cm. Nlsg	18/06/2017
S78	607188	7567230	4596		7808	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, de composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos orientados, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlsg	19/069/2017
S79	607192	7567230	4601	N-S/30E		Lava	Lava de color gris oscuro, con algunos fragmetos de cuarzo. Nlsg	19/06/2017

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S80	607216	7567216	4599	130/67SW		Lava	Lava de color gris oscuro, con algunos fragmetos de cuarzo. Nlsg	19/06/2017
S81	604876	7567156	4555	326/3SW		Ignimbrita	Toba con pseudo estratificacion color gris claro porfido feldespatico con fragmentos de biotita en algunos casos idiomorfos. Nls-3	19/06/2017
S82	604877	7566773	4568	311/4SW		Ignimbrita	Afloramiento de toba de color gris claro textura porfidica cion biotita idiomorfa en algunos sectores mas cuarzo fragmentado. Nls-3	19/06/2017
S83	605150	7566818	4561	305/3SW		Ignimbrita	Toba color gris blanquecino matrix ferruginosa muestra pseudo estratificación. Nls-3	19/06/2017
S84	606290	7568048	4594	285/5SW		Ignimbrita	Toba color gris blanquecino matrix ferruginosa muestra pseudo estratificación. Nls-3	19/06/2017
S85	606425	7567952	4588	321/77NE		Ignimbrita	Toba color gris blanquecino matrix ferruginosa muestra pseudo estratificación. Nls-3	19/06/2017
S86	606242	7568071	4596	348/12NE	7716	Toba	Fragmento de una roca de origen volcánico (toba), de color marrón con tono grisáceo, tiene superficies de meteorización, de composición ácida, muestra estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, cuarzo, biotita oxidad, litoclastos y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderada dureza y grado de soldadura. Nls-3	19/06/2018
S87	608847	7566066	4661	340/35SW		Lava	Flujo de lava , de color grisaceo rosado, de grano medio a grueso. Nlsg	21/06/2017
S88	609452	7565671	4647	150/70NE		Lava	Flujo de lava , de color grisaceo rosado, de grano medio a grueso. Nlsg	21/06/2017
S89	600871	7566783	4437	317/19SW	7717	Lava	Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación. Nlsc	21/06/2017
S90	603511	7567642	4500	175/12NE	7720	Lava	Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de meteorización, de composición intermedia, muestra estructura cavernosa o vesicular y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, escaso cuarzo, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra moderada dureza y compactación, y cavidades rellenas por cuarzo. Nlin1	21/06/2017

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S92	605051	7569399	4580		7721	Ignimbrita	Fragmento de una roca de origen volcánico (toba), de color marrón con tono grisáceo, tiene superficies de meteorización, de composición ácida, muestra estructura vitro-cristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, cuarzo, biotita oxidad, litoclastos y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderada dureza y grado de soldadura. Nls-3	21/06/2017
S93	609644	7564821	4652	E - W/68S		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medioa fino en su matrix, con menor contenido de cristales de biotita angulosos. Nlsg	22/06/2017
S94	610068	7564182	4677	195/70SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medioa fino en su matrix, con menor contenido de cristales de biotita angulosos. Nlsg	22/06/2017
S95	610088	7564531	4627	240/53SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medioa fino en su matrix, con menor contenido de cristales de biotita angulosos. Nlsg	22/06/2017
S96	600816	7566953	4485	335/70SW	7809	Lava	Fragmento de una roca de origen volcánico (lava), de color gris, presenta superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación. Nlsc	12/07/2017
S97	600661	7567938	4547		7810	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono negruzco, presenta superficies de meteorización y composición básica, muestra estructura holocristalina y textura porfídica de grano medio a fino (>1 mm), donde se observan cristales de feldespatos blanquecinos con orientación, minerales máficos muy oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación, así como numerosas cavidades o amígdalas vacías.Nlin1	12/07/2020
S98	600166	7569312	4671	280/Sub.Hz.	7811	Brecha basal	Muy localizado, monolitico clastos angulosos matrix ferruginosa de composicion similar a la lava posiblemene sea una auto brecha.	12/07/2017
S99	600666	7567935	4544	210/80NW		Lava	Coladas de lava dacítica porfiriicas de color gris oscura, con fenocristales de sanidina, hornblenda, Qz, Bio, con pseudoestratificación laminadas. Nlin1	12/07/2017
S100	600240	7565400	4292	229/4NW		Flujo de detritos	Flujo detritos matrix soportado color marron rojizo con clastos en su matrix que varian de 5 cm a 25 cm, sub redondeados de grano medio a grueso debil soldamiento matrix con alto contenido de fragmentos de, cuarzo, biotita. textura terrosa.	12/07/2017
S101	600563	7565784	4320	209/9SE		Ignimbrita	Ignimbrita color gris claro leve tono rosaceo con fragmentos de cuarzo con bordes sub redondeados y engolfamientos, biotita en fragmentos rodeados de una pasta ferruginosa polilitica clastos con aureolas de recalentamiento soldamiento moderado.	12/07/2017

Nº	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S103	603136	7569882	4610	193/4SE		Lavas	Color gris con estructura holocristalina y textura porfídica de grano medio, donde se observan cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. la roca, muestra elevada dureza y compactación. Nlin 1	13/07/2017
S104	599317	7568831	4759	30/30SE	7813	Brecha basal	Muy localizado, monolitico clastos angulosos matrix ferruginosa de composicion similar a la lava posiblemene sea una auto brecha.	13/07/2017
S105	599174	7571415	5019	270/74SW		Lava	Color gris con textura porfídica de grano medio, donde se observan cristales de feldespatos blanquecinos, escaso cuarzo, biotita,rodeados por una pasta de grano muy fino. la roca, muestra elevada dureza y compactación.Nlin1	14/07/2017
S106	602960	7568618	4561	188/7SE		Lava	Color gris con textura porfídica de grano medio, donde se observan cristales de feldespatos blanquecinos, escaso biotita,rodeados por una pasta de grano muy fino.Nlin1	14/07/2017
S107	603440	7565926	4422		7814	Toba	Fragmento de una roca de origen piroclástico (toba), de color gris con tono rosáceo, muestra superficies de meteorización, composición intermedia, con estructura masiva y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos blanquecinos, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra moderada dureza y compactación, y presenta costras delgadas de malaquita.	14/07/2017
S108	602468	7565749	4415	273/20SW		Flujo de detritos	Clastos angulosos a subredondeados monoliticos, diametro de los clastos (1mm-30cm),matriz ferruginosa terrosa. Nfd2	14/07/2017
S109	602431	7565759	4420	60/16SE		Flujo de detritos	Clastos angulosos a subredondeados monoliticos, diametro de los clastos (1mm-30cm),matriz ferruginosa terrosa. Nfd2	14/07/2017
S110	603483	7564079	4558	160/55SW	7816	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos blanquecinos, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino, contiene agregados de calcita rellenando pequeñas cavidades, la roca muestra elevada dureza y compactación, y contiene algunos litoclastos de rocas volcánicas. Nlsg	15/07/2017
S111	606447	7562228	5165	290/25SW	7817	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro con superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos blanquecinos, biotita y anfíboles muy oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra moderada dureza y compactación.Nlsg	15/07/2017
S112	606447	7562228	5165	290/25NW	7818	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y cavernosa, con textura porfídica de grano medio (>1 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra elevada dureza y compactación.Nlsg	15/07/2017

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BASE DE DATOS

DIREMAR

Nº	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S113	607734	7564099	4868	290/13SW		Lava	Lava dacitica porfiritica laminadas y en bloques del Cerro Silala Grande de color gris negruzco. Nlsg	16/07/2017
S114	611232	7567663	4626		7722	Toba	Fragmento de una roca de origen piroclástico (toba vitro-cristalina), de color gris-blanquecino con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos, cuarzo, biotita con orientación, litoclastos de rocas volcánicas y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra reducido grado de dureza y soldadura, por lo que es deleznable. Ntpg	16/07/2017
S115	607925	7564449	4820	278/5SW		Lava	Lava dacitica porfiriticas laminares y en bloques del Cerro Silala Grande de color gris negruzco.Nlsg	16/07/2017
S116	607734	7564099	4868	290/13SW		Lava	Colada de lava volcanica posible dacita de textura bandeada, fenocristales de cuarzo, plagioclasa, biotita y ortoclasa. Nlsg	16/07/2017
S117	607792	7564663	4802	145/55SW	7820	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, tiene superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita y anfíboles oxidados, piroxenos, óxidos de hierro diseminados y pequeños litoclastos de rocas volcánicas, rodeados por una pasta de grano fino, la roca muestra elevada dureza y compactación.Nlsg	16/07/2017
S118	607069	7564443	4770	100/20NE		Lava	De color gris claro en superficie fresca y gris con patinas marron rojizas en superficie alterada. el afloraiento presenta textura afanitica con clastos liticos de ignimbritas de formas subredondeadas, de 0.5 a 2.5 cm. de diametro en una matrix de vidrio volcanico con presencia aislada de cristales de plagioclasas biotitas y feldespatos. Nlsg	16/07/2017
S119	611225	7567577	4640		7723	Toba	Fragmento de una roca de origen piroclástico (toba vitro-cristalina), de color gris-blanquecino con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm), donde se observan cristales de feldespatos, cuarzo, biotita con orientación y óxidos de hierro diseminados, rodeados por una pasta vítrea, muestra moderado grado de dureza y soldadura.Ntpg	16/07/2017
S120	609442	7569033	4653	37/64SE	7726	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con superficies de meteorización, composición relativamente ácida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan grandes cristales de feldespatos blanquecinos, escaso cuarzo, biotita, anfíboles, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, contiene agregados de calcita rellenando pequeñas cavidades, la roca muestra elevada dureza y compactación. Nlct	16/07/2017
S121	610029	7568343	4652	90/75NE		Lava	Color gris claro textura profidica feldespatica el porcentage de biotita es de 1-2% en algunos casos idiomorfo, el cuarzo es fragmentado con engolfamientos. Nlct	16/07/2017
S122	601256	7572117	5181	266/67S	7821	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita y anfíboles oxidados, escaso cuarzo y piroxenos, y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra elevada dureza y compactación, en general se halla fresca. Nlcn	18/07/2017

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S123	601256	7572117	5181	266/67S	7822	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita y anfíboles oxidados, escaso cuarzo y óxidos de hierro diseminados, rodeados por una pasta de grano fino, la roca muestra moderada dureza y compactación, en general se halla meteorizada. Nlcn	18/07/2017
S125	606484	7567980	4581	240/22NW		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	18/07/2017
S126	602762	7574297	4604	251/31NW		Lava	Color gris oscuro, muestra estructura holocristalina y textura porfídica de grano medio a grueso, se observan abundantes cristales de feldespatos blanquecinos, biotita oxidada, rodeados por una pasta de grano muy fino. Nlcn	18/07/2017
S127	602419	7574426	4632	234/8NW		Lava	Color gris oscuro de composición intermedia, muestra estructura holocristalina y textura porfídica de grano grueso, donde se observan abundantes cristales de feldespatos blanquecinos, biotita oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. Nlcn	18/07/2017
S128	601860	7574652	4636	95/17NE		Lava	Color gris oscuro de textura porfídica feldespatica de grano grueso - medio, donde se observan abundantes cristales de feldespatos, superficialmente se observa una patina color café rojizo.	18/07/2017
S129	601481	7574425	4674	48/10SE		Brecha basal	Muy localizado, monolitico clastos angulosos matrix ferruginosa de composicion similar a la lava posiblemene sea una auto brecha.	18/07/2017
S130	601174	7573895	4738	48/9SE		Lava	Color gris oscuro de textura porfídica feldespatica de grano grueso - medio, donde se observan abundantes cristales de feldespatos, superficialmente se observa una patina color café rojizo	18/07/2017
S131	601912	7573842	4731	84/6SE		Lava	Color gris oscuro, muestra estructura holocristalina y textura porfídica de grano medio a grueso, se observan abundantes cristales de feldespatos blanquecinos, escasa biotita oxidada, rodeados por una pasta de grano muy fino. Nlcn	18/07/2017
S132	601757	7573261	4833	32/6SW	7727	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro y superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación. Nlcn	18/07/2017
S133	602531	7573450	4708	222/80SE		Lava	Color gris oscuro, muestra estructura holocristalina y textura porfídica de grano grueso, donde se observan grandes cristales de feldespatos blanquecinos, cuarzo, biotita, y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación. Nlcn	18/07/2017
S134	602604	7575147	4607		7732	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, presenta superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita y anfíboles oxidados y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra elevada dureza y compactación. Nlcn	18/07/2017

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S135	605330	7574972	4741	118/48NE	7729	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono rosáceo, presenta superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan cristales de feldespatos blanquecinos, muy escaso cuarzo, biotita oxidada y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la lava muestra moderada dureza y compactación, por lo que es ligeramente deleznable.Nlct	19/07/2017
S136	606578	7568225	4555		7824	Arcillita	Fragmento de una roca sedimentaria pelítica (probablemente una arcillita) y color marrón-grisáceo, presenta una estructura masiva y terrosa con indicios de estratificación y textura clástica de grano muy fino (<0,5 mm), donde se observan bandas formadas por abundantes limos y arcillas, junto a óxidos de hierro y probablemente polvo de vidrio volcánico, por lo que la roca es muy suave, con reducida compactación y es deleznable.	19/07/2017
S137	606903	7568405	4558	275/15SW		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S138	606472	7568766	4614	290/14SW		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S139	606215	7568969	4637	310/20SW		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S140	605826	7569255	4618	305/16SW		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S141	605460	7570190	4573	220/16NW		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S142	606379	7569804	4581	105/30NE		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S143	606469	7569775	4581	120/26NE		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S144	606610	7569749	4585	125/30NE		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S145	607112	7569352	4591	140/28NE		Ignimbrita	Roca de origen piroclástico (toba vitro-cristalina), de color gris-rosáceo con superficies de meteorización, de composición ácida, muestra estructura hipocristalina y textura porfídica de grano medio (>1 mm). Nls-3	19/07/2017
S146	604894	7574836	4685	60/45NW		Lava	Color gris oscuro, grano grueso, textura porfidica donde se observan grandes cristales de feldespatos blanquecinos, no se observan afloramiento bien definidos. Nlct	19/07/2017
S147	605332	7574970	4729	118/48NW		Lava	Flujo de lava, feldespatico color griz rozaceo debido a la presencia de oxidos de hierro diseminados, en algunos casos las biotitas presentan cristales idiomorfos y el cuarzo con engolfamentos. Nlct	19/07/2017

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S148	605391	7574041	4673	153/20NW		Lava	Flujo de lava, feldespatico color griz rozaceo debido a la presencia de oxidos de hierro diseminados, en algunos casos las biotitas presentan cristales idiomorfos y el cuarzo con engolfamentos.Nlct	19/07/2017
S149	609620	7561040	4881	261/12SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S150	609749	7561333	4885	253/10SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S151	608832	7561019	5033	13/30NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S152	608686	7560971	5090	275/43SW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S153	608560	7560971	5113	314/18NE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S154	612126	7562928	4582	140/45NE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S155	611768	7562919	4620	260/38NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S156	611481	7562814	4613	30/30NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S157	610800	7562642	4647	205/83NW	7825	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura cavernosa con cavidades vacías y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, biotita muy oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra moderada dureza y compactación y un aspecto escoriáceo por sus numerosas cavidades. Nlsg	06/08/2017
S158	612434	7561644	4648	240/39NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S159	611835	7562022	4642	245/70NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S160	612206	7562500	4618	290/60NE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017

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S161	609147	7560225	4989	260/12SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S162	608925	7560251	5026	282/12SW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	06/08/2017
S163	620510	7566218	4910	352/64NE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S164	620023	7566597	4864	8/86NW	7737	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes y grandes cristales de feldespatos, anfíboles, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación.Nlrj	07/08/2017
S165	619280	7564248	4776	220/17NW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presencia de turmalina con seudoestratificacion casi sub horizontal . Nlcc	07/08/2017
S166	619257	7568501	4918	210/60NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S167	620924	7566120	4921	218/56NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S168	620759	7566225	4934	330/80NE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S169	620545	7566244	4928	230/60NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S170	621867	7564722	4951	20/30NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S171	622291	7564992	5142	25/83NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S172	620821	7566719	4973	263/10SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita angulosos. Nlrj	07/08/2017
S173	618904	7564384	4763	278/18SW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	07/08/2017

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S174	618817	7564254	4768	132/5SE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	07/08/2017
S175	617482	7561112	4655	300/8NE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S176	617615	7560949	4657	177/20NE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S177	618822	7561429	4775	187/18SE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S178	618730	7560378	4635	175/15SW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S179	618713	7559993	4743	210/11NW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S180	618587	7559454	4793	105/40SW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S181	618584	7559481	4783	350/22SW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S182	618526	7559441	4799	200/11NW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S183	618333	7559089	4723	168/26NE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S184	618217	7558961	4723	295/63SW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S185	618034	7561259	4713	305/15SW		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S186	617174	7560894	4622	130/2SW		Toba	Toba color gris blanquecino con presencia de vidrio volcanico y fragmentos de biotita, cuarzo fracturado, se observan cristales de feldespatos y biotita con orientacion, pomez y liticos menor a 2 cm. Ntpg	08/08/2017

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BASE DE DATOS

N°	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S187	619703	756092	5107	102/60NE	7827	Lava	Fragmento de una roca de origen volcánico (lava), de color gris, muestra superficies de meteorización, composición relativamente ácida, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, cuarzo, biotita muy oxidada, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación. Nlcc	08/08/2017
S188	619421	7562642		100/56NE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S189	618360	7561365	4717	310/75NE		Lava	Coladas de lavas andesiticos de coloracion rojiso blanquecino, de grano medio en su matrix, con menor contenido de cristales de cuarzo angulosos y mayor contenido biotita,con pseudoestratificacion casi sub horizontal . Nlcc	08/08/2017
S190	612064	7558181	4728	240/10NE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S191	612332	7558220	4694	140/35SW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S192	612754	7557905	4682	215/75SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S193	612979	7558120	4671	210/70SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S194	613267	7557851	4662	190/60SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S195	613602	7557947	4637	140/85SW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S196	611802	7556921	4803	307/27SE		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S197	611298	7556999	4899	315/40SW		Lava	Presenta flujos de lavas de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S198	611597	7556827	4823	244/19NW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S199	612357	7557311	4752	278/50SW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017

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S200	608527	7575347	4839	105/23SW		Lava	Coladas de lavas de coloracion rojizo blanquecino, de grano grueso en su matrix, con mayor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presenta una pseudoestratificacion. Nlct	09/08/2017
S201	608386	7574825	4793	170/10SW		Lava	Coladas de lavas de coloracion rojizo blanquecino, de grano grueso en su matrix, con mayor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presenta una pseudoestratificacion. Nlct	09/08/2017
S202	596557	7583978	4504	278/12SW		Lava	Coladas de lavas andesiticos de coloracion rojizo blanquecino, de grano grueso en su matrix, con mayor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presenta una seudoestratificacion.	09/08/2017
S203	608386	7574825	4793	170/10SW		Lava	Coladas de lavas de coloracion rojizo blanquecino, de grano grueso en su matrix, con mayor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presenta una pseudoestratificacion. Nlct	09/08/2017
S204	612000	7563000	5189	175/40NE		Lava	Presenta flujos de lavas de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S205	609524	7556683	5145	325/60SW		Lava	Presenta flujos de lavas de coloracion gris blanquecino, de grano medio a grueso en su matrix, con menor contenido de cristales de cuarzo angulosos y menor contenido biotita angulosos. Nlsg	09/08/2017
S206	607927	7571754	4656	214/35NW		Lava	Coladas de lavas de coloracion rojizo blanquecino, de grano grueso en su matrix, con mayor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presenta una pseudoestratificacion. Nlct	09/08/2017
S207	607923	7571638	4670	348/33NW		Lava	Coladas de lavas de coloracion rojizo blanquecino, de grano grueso en su matrix, con mayor contenido de cristales de cuarzo angulosos y mayor contenido biotita, presenta una pseudoestratificacion. Nlct	09/08/2017
S208	608212	7572823	4656	272/5SE		Toba	Color gris-claro poliltica rosáceo con superficies de meteorización, con vidrio volcanico en sectores pomez con direccion de flujo. Ntpg	09/08/2017
S209	608546	7556911	5420	220/62NW	7830	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos blanquecinos, anfiboles, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación. Nlsg	09/08/2017
S210	596988	7583971	4504	35/9NW		Lava	Color gris-oscuro textura porfídica de grano medio-fino, donde se observan grandes cristales de feldespatos blanquecinos, cuarzo, biotita, en fragmentosdiseminados, rodeados por una pasta de grano muy fino. La lava muestra elevada dureza y compactación.	11/08/2017
S211	596557	7583978	4504	278/12SW		Lava	Presenta flujos de lavas andesiticos de coloracion gris blanquecino, de grano medio a fino en su matrix, con menor contenido de cristales de biotita angulosos.	11/08/2017
S212	612647	7576961	4693	314/3SW		Toba	Coladas de lava con pseudo estratificacion (estrato volcan).	13/08/2017
S213	614063	7578118	4885	75/60NW		Lava	Coladas de lava con pseudo estratificacion (estrato volcan).	13/08/2017

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MAPEO GEOLOGICO DEL AREA CIRCUNDANTE AL MANANTIAL DEL SILALA
BASE DE DATOS

DIREMAR

Nº	ESTE (UTM)	NORTE (UTM)	ALTURA (m.s.n.m.)	DIRECCIÓN DE FLUJO	CODIGO MUESTRA	LITOLOGIA	DESCRIPCION MACROSCOPICA	FECHA
S214	614027	7578154	4917	310/50SW		Lava	Coladas de lava con pseudo estratificacion (estrato volcan).	13/08/2017
S215	613978	7578222	4960	50/25NW		Lava	Coladas de lava con pseudo estratificacion (estrato volcan).	13/08/2017
S216	614081	7578187	4922	350/45SW		Lava	Coladas de lava con pseudo estratificacion (estrato volcan).	13/08/2017
S217	614113	7578135	4865	60/58SE		Lava	Coladas de lava con pseudo estratificacion (estrato volcan).	13/08/2017
S218	612702	7577120	4608	60/54NW		Toba	Toba volcánica de consistencia porosa, formada por la acumulación de cenizas volcánicos muy pequeños,menor concentración en cristales.su consistencia es media, de color va desde blanco - amarillento.	13/08/2017
S219	613149	7577836	4987	153/42NE		Lava	Coladas de lavas andesiticos de coloracion gris, de grano grueso en su matrix, cristales de biotita sub redondeados, presenta una pseudoestratificacion casi sub horizontal..	13/08/2017
S220	613774	7578211	5005	230/60SE		Lava	Lavas de textura porfiritica de color gris blanquesino con presencia de cristales de plagioclasas, feldespatos y turmalina. Se observan una pseudoesratificacion sub vertical de espesores entre 0.20 a 0.90 m.	13/08/2017
S221	613706	7578166	5053	290/50SW		Lava	Lavas de textura porfiritica de color gris blanquesino con presencia de cristales de plagioclasas, feldespatos y turmalina. Se observan una pseudoesratificacion sub vertical de espesores entre 0.20 a 0.90 m.	13/08/2017
S222	598256	7570240	5176	188/4NW		Lava	Color gris-oscuro estructura holocristalina y textura porfídica de grano medio-fino, donde se observan cristales de feldespatos elevada dureza y compactación. Nlin1	14/08/2017
S223	596049	7568972	5622	260/45SE		Lava	Color gris oscuro estructura holocristalina elevada dureza y compactacion textura bandeada con direccion de flujo. Nlin1 , Zona de Alteración.	14/08/2017
S224	598689	7570632	5039	145/25NE		Lava	Color gris oscuro estructura holocristalina elevada dureza y compactacion textura bandeada con direccion de flujo. Nlin1 , Zona de Alteración.	14/08/2017
S225	599394	7568611	4696	303/17SW		Lava	Color gris-oscuro estructura holocristalina y textura porfídica de grano medio-fino, donde se observan cristales de feldespatos elevada dureza y compactación. Nlin1	14/08/2017
S226	595872	7569264	5631	145/25NE	7743	Lava	Fragmento de una roca de origen volcánico (lava), de color gris oscuro, tiene superficies de meteorización, composición intermedia, muestra estructura bandeada o fluidal y textura porfídica de grano medio a fino (>1 mm), donde se observan abundantes cristales de feldespatos, anfíboles, biotita, piroxenos y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra elevada dureza y compactación. Nlin1	14/08/2017
S227	598532	7567548	4609	160/67SW	7833	Lava	Fragmento de una roca de origen volcánico (lava), de color gris con tono oscuro, tiene superficies de intensa meteorización, composición intermedia, muestra estructura holocristalina y textura porfídica de grano medio (>2 mm), donde se observan abundantes cristales de feldespatos, anfíboles, biotita, piroxenos, poco cuarzo y óxidos de hierro diseminados, rodeados por una pasta de grano muy fino, la roca muestra moderada dureza y compactación. Nlin2	14/08/2017

CONVENIO DE COOPERACIÓN INTERINSTITUCIONAL Y
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BASE DE DATOS ESTRUCTURALES

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DIRECCIÓN TÉCNICA DE PROSPECCIÓN Y EXPLORACIÓN
"ESTUDIO GEOLOGICO-ESTRUCTURAL DEL AREA CIRCUNDANTE DEL MANANTIAL DEL SILALA"

SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
E1	600516	7565580	4339	Diaclasa	97	89	10		D	1	0	SR	Plana	8	Seco	Ignimbritas		R2	21-may.	
J1	601277	7566098	4447	Diaclasa		85	285		C	1	2	SR	Plana	8	Seco	Andesitas		R4	21-may.	
J2	601277	7566098	4447	Diaclasa		74	205		D	1	2	SR	Plana	8	Seco	Andesitas		R4	21-may.	
J3	601277	7566098	4447	Diaclasa		87	324		D	1	3	SR	Plana	8	Seco	Andesitas		R4	21-may.	
L1	600453	7565473	4344	Diaclasa		62	185		C	1	0	SR	Escalonada	6	Seco	Ignimbritas	Oxidación	R2	21-may.	
L2	600453	7565473	4344	Diaclasa		48	104		C	1	11	Arcilla	Escalonada	6	Seco	Ignimbritas	Oxidación	R2	21-may.	
L3	600453	7565473	4344	Diaclasa		73	74		D	1	1	Arcilla	Escalonada	6	Seco	Ignimbritas	Oxidación	R2	21-may.	
L4	601154	7566061	4434	Diaclasa		87	186		D	3	0	SR	Plana	8	Seco	Andesitas		R4	21-may.	
L6	601154	7566061	4434	Diaclasa	152	80	70		D	1	0	SR	Plana	8	Seco	Andesitas		R4	21-may.	
L7	601154	7566061	4434	Diaclasa		67	281		D	1	0	SR	Plana	8	Seco	Andesitas		R4	21-may.	
M1	601159	7566005	4448	Diaclasa		71	6		D	1	10	Arcilla	Plana	2	Seco	Andesitas	Oxidación	R4	21-may.	
M4	601252	7566072	4440	Diaclasa		67	195		D	1	10	Arcilla	Curva-Escalonada	8	Seco	Andesitas	Oxidación	R4	21-may.	
M5	601280	7565984	4452	Diaclasa		78	235		C	4	5	Arcilla	Plana	4	Seco	Andesitas	Oxidación	R4	21-may.	
N2	600516	7565580	4339	Diaclasa	130	56	30		D	1	0	SR	Plana	6	Seco	Ignimbritas		R2	21-may.	
N3	600516	7565580	4339	Diaclasa	116	80	26		C	2	5	SR	Plana	8	Seco	Ignimbritas		R2	21-may.	
N1	600516	7565580	4339	Falla	120	60	20		D	1	3	SR	Plana	6	Seco	Ignimbritas		R2	21-may.	
M3	601242	7565990	4464	Falla Dextral		83	263		C	2	0	Arcilla	Plana	4	Seco	Andesitas	Oxidación	R4	21-may.	
L5	601154	7566061	4434	Pseudoestratificación		8	285		D						Seco	Andesitas		R4	21-may.	
L8	601444	7566094	4415	Pseudoestratificación		2	10		C						Seco	Ignimbritas		R2	21-may.	
M4	601252	7566072	4440	Pseudoestratificación		22	248		C						Seco	Andesitas		R4	21-may.	
L11	600390	7565536	4313	Diaclasa		84	65		C	4	2	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L12	600390	7565536	4313	Diaclasa		67	65		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L13	600390	7565536	4313	Diaclasa		83	54		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L14	600390	7565536	4313	Diaclasa		78	56		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L15	600390	7565536	4313	Diaclasa		80	75		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L16	600390	7565536	4313	Diaclasa		87	40		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L17	600390	7565536	4313	Diaclasa		9	318		C	2	4	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L18	600390	7565536	4313	Diaclasa		85	36		C	11	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L19	600405	7565561	4305	Diaclasa		80	59		D	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L20	600405	7565561	4305	Diaclasa		84	51		C	2	0	SR	Plana	11	Seco	Ignimbritas		R3	22-may.	
L21	600405	7565561	4305	Diaclasa		87	49		C	2	0	SR	Plana	3	Seco	Ignimbritas		R3	22-may.	
L22	600405	7565561	4305	Diaclasa		88	240		C	3	0	SR	Plana	7	Seco	Ignimbritas		R3	22-may.	
L23	600447	7565616	4311	Diaclasa		86	220		C	3	0	SR	Plana	7	Seco	Ignimbritas		R3	22-may.	
L24	600527	7565719	4316	Diaclasa		89	35		C	5	0	SR	Plana	7	Seco	Ignimbritas		R3	22-may.	
L25	600527	7565719	4316	Diaclasa		76	34		C	6	0	SR	Plana	7	Seco	Ignimbritas		R3	22-may.	
L26	600527	7565719	4316	Diaclasa		87	215		C	6	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L27	600527	7565719	4316	Diaclasa		12	225		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L28	600536	7565761	4327	Diaclasa		82	20		C	1	50	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L29	600536	7565761	4327	Diaclasa		89	357		D	1	2	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L30	600536	7565761	4327	Diaclasa		85	20		D	10	1	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L31	600536	7565761	4327	Diaclasa		82	16		D	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L32	600536	7565761	4327	Diaclasa		89	25		C	3	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L33	600536	7565761	4327	Diaclasa		15	255		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L34	600536	7565761	4327	Diaclasa		88	10		C	3	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L35	600552	7565810	4324	Diaclasa		88	35		D	10	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L36	600552	7565810	4324	Diaclasa		80	50		D	3	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L38	600625	7565892	4334	Diaclasa		74	30		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L39	600625	7565892	4334	Diaclasa		89	20		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L40	600625	7565892	4334	Diaclasa		83	16		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L41	600625	7565892	4334	Diaclasa		80	20		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L42	600625	7565892	4334	Diaclasa		85	30		C	3	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L43	600625	7565892	4334	Diaclasa		86	31		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L44	600625	7565892	4334	Diaclasa		80	18		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L45	600625	7565892	4334	Diaclasa		84	12		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L46	600636	7565943	7342	Diaclasa		84	25		C	6	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L47	600636	7565943	7342	Diaclasa		86	28		C	3	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L48	600636	7565943	7342	Diaclasa		85	350		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L49	600636	7565943	7342	Diaclasa		82	29		C	4	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L50	600636	7565943	7342	Diaclasa		80	25		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L51	600636	7565943	7342	Diaclasa		88	25		C	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L52	600636	7565943	7342	Diaclasa		88	110		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L53	600636	7565943	7342	Diaclasa		83	18		C	2	20	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L54	600636	7565943	7342	Diaclasa		68	29		C	2	10	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L55	600621	7566042	4338	Diaclasa		82	15		D	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L56	600621	7566042	4338	Diaclasa		81	26		D	2	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L57	600621	7566042	4338	Diaclasa		89	120		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L58	600621	7566042	4338	Diaclasa		86	50		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L59	600621	7566042	4338	Diaclasa		85	30		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L60	600604	7566082	4349	Diaclasa		82	33		C	3	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L61	600604	7566082	4349	Diaclasa		84	12		C	1	0	SR	Plana	9	Seco	Ignimbritas		R3	22-may.	
L62	600604	7566082	4349	Diaclasa		80	27		C	7	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L63	600604	7566082	4349	Diaclasa		70	20		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L64	600604	7566082	4349	Diaclasa		78	22		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L65	600604	7566082	4349	Diaclasa		80	28		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L66	600604	7566082	4349	Diaclasa		60	25		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L67	600604	7566082	4349	Diaclasa		79	30		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L68	600604	7566082	4349	Diaclasa		81	25		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L69	600765	7566220	4355	Diaclasa		89	212		C	5	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L70	600765	7566220	4355	Diaclasa		52	190		D	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L71	600765	7566220	4355	Diaclasa		71	182		D	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L72	600765	7566220	4355	Diaclasa		79	195		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L73	600765	7566220	4355	Diaclasa		80	190		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L74	600765	7566220	4355	Diaclasa		45	95		D	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L75	600870	7566278	4366	Diaclasa		88	65		C	5	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L76	600870	7566278	4366	Diaclasa		87	71		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L77	600870	7566278	4366	Diaclasa		89	70		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L78	600870	7566278	4366	Diaclasa		89	68		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L79	600870	7566278	4366	Diaclasa		90	70		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L80	600870	7566278	4366	Diaclasa		78	10		D	5	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L81	600870	7566278	4366	Diaclasa		88	8		D	5	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L82	600870	7566278	4366	Diaclasa		87	2		D	5	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L83	600870	7566278	4366	Diaclasa		85	5		D	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L84	600870	7566278	4366	Diaclasa		83	6		D	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L85	600870	7566278	4366	Diaclasa		80	85		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L86	600870	7566278	4366	Diaclasa		88	96		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L87	600870	7566278	4366	Diaclasa		89	92		C	5	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L88	600987	7566343	4369	Diaclasa		82	84		D	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L89	600987	7566343	4369	Diaclasa		80	85		D	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L9	600214	7565398	4309	Diaclasa		3	320		C	3	5	ostra de oxidaci	Plana	4	Seco	Ignimbritas		R3	22-may.	
L90	600987	7566343	4369	Diaclasa		85	87		D	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L91	600987	7566343	4369	Diaclasa		85	15		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L92	600987	7566343	4369	Diaclasa		82	11		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L93	601024	7566411	4386	Diaclasa		87	60		D	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L94	601024	7566411	4386	Diaclasa		80	54		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L95	601024	7566411	4386	Diaclasa		78	46		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
L96	601024	7566411	4386	Diaclasa		82	50		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	22-may.	
M11	600549	7565711	4324	Diaclasa	285	76	15		C	2	3	SR	Escalonada-Rugosa	6	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		80	25		C	2	1	SR	Plana-Rugosa	7	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		88	28		C	2	1	SR	Plana-Rugosa	7	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		85	30		C	2	1	SR	Plana-Rugosa	7	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		23	55		C	5	10	SR	Rugosa	10	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		82	38		C	5	10	SR	Rugosa	10	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		89	301		C	4	6	SR	Rugosa	12	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		78	268		C	4	6	SR	Rugosa	12	Seco	Ignimbritas	Oxidación	R2	22-may.	
M12	600591	7565818	4323	Diaclasa		72	280		C	4	6	SR	Rugosa	12	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Diaclasa		75	120		C	2	10	SR	Rugosa	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Diaclasa		80	95		C	2	10	SR	Rugosa	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Diaclasa		87	188		D	3	3	SR	Plana	6	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Diaclasa		67	216		D	1	0,5	SR	Rugosa	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Diaclasa		90	20		D	3	1	SR	Plana	2	Seco	Ignimbritas	Oxidación	R2	22-may.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M7	600293	7565437	4315	Diaclasa		72	150		C	3	1	SR	Escalonada	3	Seco	Ignimbritas	Oxidación	R2	22-may.	
M7	600293	7565437	4315	Diaclasa		10	148		C	2	3	SR	Curva-Escalonada	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M7	600293	7565437	4315	Diaclasa		10	146		D	3	1	SR	Plana	6	Seco	Ignimbritas	Oxidación	R2	22-may.	
M7	600293	7565437	4315	Diaclasa		75	226		D	2	2	SR	Plana	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M8	600366	7565516	4298	Diaclasa		70	240		D	3	2	SR	Rugosa	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M8	600366	7565516	4298	Diaclasa		82	260		C	3	1	SR	Plana	4	Seco	Ignimbritas	Oxidación	R2	22-may.	
M8	600366	7565516	4298	Diaclasa		86	264		C	3	1	SR	Plana	4	Seco	Ignimbritas	Oxidación	R2	22-may.	
M8	600366	7565516	4298	Diaclasa		82	92		C	1	1	SR	Plana	3	Seco	Ignimbritas	Oxidación	R2	22-may.	
L37	600625	7565892	4334	Falla		82	34		C	1	5	Milonita	Plana	9	Seco	Ignimbritas		R3	22-may.	
M13	600652	7565897	4330	Falla Inversa		21	95		C	1	2	SR	Rugosa	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Falla Inversa		12	120		D	1	0,2	Arcilla	Plana	3	Seco	Ignimbritas	Oxidación	R2	22-may.	Desplazamiento de 10 cm
M6	600255	7565356	4298	Falla Inversa	322	82	52		C	3	10	SR	Escalonada	6	Seco	Ignimbritas	Oxidación	R2	22-may.	
M8	600366	7565516	4298	Falla Inversa		81	60		C	5	3	SR	Rugosa	5	Seco	Ignimbritas	Oxidación	R2	22-may.	
M10	600531	7565686	4315	Falla Normal		80	41		C	5	2	SR	Rugosa	8	Seco	Ignimbritas	Oxidación	R2	22-may.	
M13	600652	7565897	4330	Falla Normal		78	192		C	2	2	SR	Curva	12	Seco	Ignimbritas	Oxidación	R2	22-may.	
M7	600293	7565437	4315	Falla Normal		79	248		C	1	1	SR	Escalonada	10	Seco	Ignimbritas	Oxidación	R2	22-may.	Desplazamiento de 25 cm
M8	600366	7565516	4298	Falla Normal		78	268		C	1	5	SR	Rugosa	10	Humedo	Ignimbritas	Oxidación	R2	22-may.	
M8	600366	7565516	4298	Falla Normal		84	86		C	1	1	SR	Escalonada-Rugosa	10	Seco	Ignimbritas	Oxidación	R2	22-may.	
M9	600417	7565548	4296	Falla Normal	156	77	66		C	5	12	SR	Rugosa	5	Seco	Ignimbritas	Oxidación	R2	22-may.	
J1	600671,31	7566304,5	4374	Diaclasa		79	379		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J10	600633,68	7566318,5	4374	Diaclasa		47	100		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J11	600653,94	7566311,5	4374	Diaclasa		68	270		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J12	600653,94	7566311,5	4374	Diaclasa		78	345		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J13	600653,94	7566311,5	4374	Diaclasa		70	356		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J14	600633,68	7566318,5	4374	Diaclasa		70	36		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J15	600690,3	7566297,4	4376	Diaclasa		81	50		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J16	600690,3	7566297,4	4376	Diaclasa		83	138		C	1	3	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J17	600713	7566299	4387	Diaclasa		88	40		C	4	1	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J18	600713	7566299	4387	Diaclasa		72	332		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J19	600713	7566299	4387	Diaclasa		80	342		C	2	3	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J2	600671,31	7566304,5	4374	Diaclasa		70	34		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J20	600615	7566334	4383	Diaclasa		25	53		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J21	600615	7566334	4383	Diaclasa		56	315		D	2	3	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J22	600611	7566335	4385	Diaclasa		80	335		C	3	5	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J23	600682	7566301	4386	Diaclasa		72	33		C	3	10	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J24	600747	7566977	4487	Diaclasa		34	55		D	1	0	SR	Plana	2	Seco	Andesitas	Oxidación	R4	23-may.	
J25	600742	7566975	4487	Diaclasa		57	310		C	1	5	SR	Plana	2	Seco	Andesitas	Oxidación	R4	23-may.	
J26	600742	7566975	4487	Diaclasa		60	210		C	1	0	SR	Plana	2	Seco	Andesitas	Oxidación	R4	23-may.	
J27	600739	7566987	4487	Diaclasa		78	115		C	1	0	SR	Plana-Ondulada	2	Seco	Andesitas	Oxidación	R4	23-may.	
J28	600681	7566969	4480	Diaclasa		63	237		D	1	0	SR	Plana-Rugosa	2	Seco	Andesitas	Oxidación	R4	23-may.	
J29	600656	7566957	4475	Diaclasa		82	315		D	1	0	SR	Plana	2	Seco	Andesitas	Oxidación	R4	23-may.	
J3	600671,31	7566304,5	4374	Diaclasa		12	125		C	2	1	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J4	600673,52	7566303,1	4374	Diaclasa		14	62		C	3	3	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J5	600673,52	7566303,1	4374	Diaclasa		86	126		D	1	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J6	600673,52	7566303,1	4374	Diaclasa		74	123		C	3	10	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J7	600660,67	7566307,2	4374	Diaclasa		84	305		C	1	10	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J8	600657,37	7566308,1	4374	Diaclasa		65	192		C	3	3	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
J9	600657,37	7566308,1	4374	Diaclasa		70	36		C	4	0	SR	Plana	6	Seco	Ignimbritas		R3	23-may.	
M-15	600775	7565936	4356	Diaclasa		89	340		C	5	1	SR	Escalonada-Rugosa	15	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Diaclasa	130	18	40		C	25	2	SR	Escalonada-Rugosa	8	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-16	600831	7565960	4353	Diaclasa		64	216		C	3	0,5	SR	Escalonada	16	Seco	Flujo de detritos	Oxidación	R3	23-may.	
M-17	600817	7566049	4361	Diaclasa		75	215		C	3	5	SR	Plana-Rugosa	10	Seco	Flujo de detritos	Oxidación	R3	23-may.	
M-18	600931	7566095	4357	Diaclasa		82	240		C	4	2	SR	Escalonada-Rugosa	8	Seco	Flujo de detritos	Oxidación	R3	23-may.	
M-18	600931	7566095	4357	Diaclasa		25	195		D	5	0,5	SR	Escalonada	16	Seco	Flujo de detritos	Oxidación	R3	23-may.	
M-20	601079	7566209	4367	Diaclasa		72	60		C	1	1	SR	Escalonada	2	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Diaclasa		74	150		C	2	0,5	SR	Escalonada	2	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Diaclasa		82	230		C	1	0,5	SR	Rugosa	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Diaclasa		70	222		D	5	0,8	SR	Escalonada	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Diaclasa		84	221		C	3	1	SR	Escalonada	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-21	601177	7566251	4379	Diaclasa		80	256		C	5	5	SR	Plana-Rugosa	8	Humedo	Ignimbritas	Oxidación	R2	23-may.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M-21	601177	7566251	4379	Diaclasa		59	95		C	2	3	SR	Plana-Rugosa	8	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-21	601177	7566251	4379	Diaclasa		24	25		C	1	4	SR	Plana-Rugosa	8	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-22	601263	7566256	4372	Diaclasa		85	15		C	2	20	SR	Escalonada	12	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-23	601325	7566266	4390	Diaclasa		81	280		C	1	3	SR	Escalonada	12	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-23	601325	7566266	4390	Diaclasa		85	115		C	1	2	SR	Escalonada	12	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-25	601280	7566271	4398	Diaclasa		76	216		D	1	1	SR	Escalonada	12	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-25	601280	7566271	4398	Diaclasa		80	45		C	3	0	SR	Plana	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-25	601280	7566271	4398	Diaclasa		61	52		C	4	0	SR	Plana	7	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-25	601280	7566271	4398	Diaclasa		72	49		C	2	0	SR	Plana	8	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-25	601280	7566271	4398	Diaclasa		40	190		D	5	0	Arcilla	Plana	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla		88	84		C	2	5	SR	Plana-Rugosa	12	Seco	Ignimbritas	Sales	R2	23-may.	
M-15	600775	7565936	4356	Falla de Rumbo		8	150		C	3	1	SR	Escalonada-Rugosa	15	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla Inversa		77	148		D	1	2	SR	Escalonada-Rugosa	10	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-14	600732	7565903	4349	Falla Normal		7	32		C	5	1	SR	Curva-Escalonada	8	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-14	600732	7565903	4349	Falla Normal		68	75		C	2	5	SR	Escalonada-Rugosa	18	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla Normal		84	122		C	4	2	SR	Plana	4	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla Normal		86	132		C	2	2,5	SR	Plana	4	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla Normal		80	120		C	2	2,5	SR	Plana	4	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla Normal		82	124		C	1	2,5	SR	Plana	4	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-15	600775	7565936	4356	Falla Normal		37	230		C	2	2	SR	Escalonada-Rugosa	10	Seco	Ignimbritas	Oxidación	R2	23-may.	
M-19	600969	7566140	4365	Falla Normal	302	85	212		C	5	5	SR	Escalonada	8	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Falla Normal		80	210		C	2	5	SR	Escalonada	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Falla Normal		88	218		C	1	3	SR	Escalonada	3	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Falla Normal		88	218		C	2	1	SR	Escalonada	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-20	601079	7566209	4367	Falla Normal		86	220		C	2	1	SR	Escalonada	6	Humedo	Ignimbritas	Oxidación	R2	23-may.	
M-17	600817	7566049	4361	Pseudoestratificación		34	190		C						Seco	Flujo de detritos		R2	23-may.	
E2	604954	7566169	4563	Diaclasa		70	85		D	2	3	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
E3	605447	7566138	4583	Diaclasa		81	100		C	6	1	SR	Escalonada	6	Seco	Dacitas		R4	15-jun.	
E4	605105	7566048	4618	Diaclasa	196	85	286		D	1	2	SR	Ondulada	12	Seco	Dacitas		R4	15-jun.	
L100	604904	7567284	4544	Diaclasa		74	334		D	2	2	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L101	604904	7567284	4544	Diaclasa		70	335		D	2	2	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L102	604904	7567284	4544	Diaclasa		80	220		C	2	3	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L103	604904	7567284	4544	Diaclasa		78	205		C	2	3	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L104	604904	7567284	4544	Diaclasa		80	323		D	2	1	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L105	605075	7567074	4545	Diaclasa		78	134		D	2	0	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L106	605075	7567074	4545	Diaclasa		70	160		D	2	2	SR	Plana	6	Seco	Ignimbritas		R3	15-jun.	
L107	605075	7567074	4545	Diaclasa		70	160		D	3	0	SR	Plana	6	Seco	Ignimbritas		R3	15-jun.	
L108	605474	7566741	4551	Diaclasa		88	95		C	7	8	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L109	605474	7566741	4551	Diaclasa		84	81		C	7	2	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L110	605474	7566741	4551	Diaclasa		80	86		C	7	3	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L111	605474	7566741	4551	Diaclasa		84	75		C	7	0	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L112	605474	7566741	4551	Diaclasa		88	82		C	7	0	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L113	605474	7566741	4551	Diaclasa		87	94		C	8	0	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L114	605474	7566741	4551	Diaclasa		81	86		C	4	0	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L115	605474	7566741	4551	Diaclasa		89	175		D	3	5	SR	Plana	6	Seco	Dacita-Andesita		R4	15-jun.	
L116	605474	7566741	4551	Diaclasa		85	160		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L117	605474	7566741	4551	Diaclasa		87	80		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L118	606617	7565833	4670	Diaclasa		74	105		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L119	606359	7565778	4670	Diaclasa		80	200		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L120	606973	7565924	4660	Diaclasa		84	25		C	15	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L121	606973	7565924	4660	Diaclasa		75	348		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L122	606973	7565924	4660	Diaclasa		79	35		C	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L123	606973	7565924	4660	Diaclasa		89	85		C	10	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L124	606498	7566411	4591	Diaclasa		74	230		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L125	606498	7566411	4591	Diaclasa		82	300		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L126	606226	7566454	4593	Diaclasa		75	235		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	15-jun.	
L97	604904	7567284	4544	Diaclasa		84	358		C	5	3	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L98	604904	7567284	4544	Diaclasa		78	355		D	3	8	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
L99	604904	7567284	4544	Diaclasa		72	320		C	2	2	SR	Plana	8	Seco	Ignimbritas		R3	15-jun.	
M1	604921	7566167	4571	Diaclasa		75	70		C	2	5	SR	Escalonada	14	Seco	Dacitas		R4	15-jun.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M10	606009	7564550	4756	Diaclasa		46	52		D	1	15	SR	Escalonada	12	Seco	Dacitas		R4	15-jun.	
M11	606003	7564525	4756	Diaclasa		59	201		D	7	10	SR	Escalonada	12	Seco	Dacitas		R4	15-jun.	
M11	606003	7564525	4756	Diaclasa	340	75	20		C	1	8	SR	Escalonada	14	Seco	Dacitas		R4	15-jun.	
M2	604925	7566162	4568	Diaclasa		84	95		D	1	1	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M3	604920	7566163	4570	Diaclasa		77	68		D	2	10	SR	Curva-Escalonada	12	Seco	Dacitas		R4	15-jun.	
M4	604938	7566164	4575	Diaclasa		43	212		D	1	< 1	SR	Escalonada	12	Seco	Dacitas		R4	15-jun.	
M4	604938	7566164	4575	Diaclasa		15	205		D	1	2	SR	Escalonada	14	Seco	Dacitas		R4	15-jun.	
M4	604938	7566164	4575	Diaclasa		80	245		D	4	10	SR	Escalonada	12	Seco	Dacitas		R4	15-jun.	
M4	604938	7566164	4575	Diaclasa		42	6		D	3	3	SR	Escalonada	12	Seco	Dacitas		R4	15-jun.	
M4	604938	7566164	4575	Diaclasa		82	106		D	1	< 1	SR	Plana	10	Seco	Dacitas		R4	15-jun.	
M5	604947	7566150	4584	Diaclasa		51	241		D	3	3	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M5	604947	7566150	4584	Diaclasa		60	92		C	1	5	SR	Ondulada	8	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		85	337		D	3	20	SR	Plana	4	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		72	260		D	3	20	SR	Plana	4	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		42	177		D	3	15	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		81	130		D	2	2	SR	Plana	4	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		65	172		D	2	2	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		62	40		D	3	< 1	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M6	605032	7566136	4537	Diaclasa		78	275		D	2	< 1	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M7	605113	7566077	4613	Diaclasa		72	345		C	1	5	SR	Escalonada	14	Seco	Ignimbritas		R2	15-jun.	
M8	605574	7564904	4643	Diaclasa		49	286		D	2	10	SR	Escalonada	10	Seco	Dacitas		R4	15-jun.	
M8	605574	7564904	4643	Diaclasa		34	204		C	2	10	SR	Escalonada	10	Seco	Dacitas		R4	15-jun.	
M8	605574	7564904	4643	Diaclasa		50	71		D	3	5	SR	Escalonada	16	Seco	Dacitas		R4	15-jun.	
M8	605574	7564904	4643	Diaclasa		49	335		D	2	< 1	SR	Plana	6	Seco	Dacitas		R4	15-jun.	
M8	605574	7564904	4643	Diaclasa	160	90	70		D	1		SR	Plana	10	Seco	Dacitas		R4	15-jun.	
M8	605574	7564904	4643	Diaclasa		54	135		D	1	< 1	SR	Ondulada	6	Seco	Dacitas		R4	15-jun.	
M9	605914	7564756	4713	Diaclasa		65	81		D	1	8	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M9	605914	7564756	4713	Diaclasa		83	15		D	1	8	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
M9	605914	7564756	4713	Diaclasa		42	162		C	1	1	SR	Escalonada	12	Seco	Dacitas		R4	15-jun.	
E1	604957	7566168	4568	Falla Normal		58	165		C	1	10	SR	Plana	8	Seco	Dacitas		R4	15-jun.	
E3	605447	7566138	4583	Pseudoestratificación		57	257		C						Seco	Dacitas		R4	15-jun.	
E4	605105	7566048	4618	Pseudoestratificación	210	90	120		C						Seco	Dacitas		R4	15-jun.	
E5	605991	7564543	4752	Pseudoestratificación		36	145		C						Seco	Dacitas		R4	15-jun.	
M1	604921	7566167	4571	Pseudoestratificación		34	160		C						Seco	Dacitas		R4	15-jun.	
E11	606784	7563481	4955	Diaclasa		76	250		C	4	4	SR	Plana	14	Seco	Dacitas		R4	16-jun.	
E11	606784	7563481	4955	Diaclasa		69	39		D	3	2	SR	Plana	10	Seco	Dacitas		R4	16-jun.	
E11	606784	7563481	4955	Diaclasa		77	35		C	2	25	SR	Ondulada	12	Seco	Dacitas		R4	16-jun.	
E12	606909	7563170	5029	Diaclasa		81	70		C	4	2	SR	Plana	14	Seco	Andesitas		R4	16-jun.	
E12	606909	7563170	5029	Diaclasa		78	294		C	4	4	SR	Escalonada	12	Seco	Andesitas		R4	16-jun.	
E12	606909	7563170	5029	Diaclasa		66	310		D	2	2	SR	Escalonada	2	Seco	Andesitas		R4	16-jun.	
E12	606909	7563170	5029	Diaclasa		76	279		D	3	0	SR	Plana	2	Seco	Andesitas		R4	16-jun.	
E13	606624	7562239	5253	Diaclasa		84	144		C	6	20	SR	Escalonada	12	Seco	Andesitas		R4	16-jun.	
E13	606624	7562239	5253	Diaclasa		82	122		D	5	15	SR	Escalonada	2	Seco	Andesitas		R4	16-jun.	
E9	606248	7565102	4703	Diaclasa	75	77	13		D	3	2	SR	Escalonada	8	Seco	Dacitas		R4	16-jun.	
J1	605837	7565474	4651	Diaclasa		82	25		D	3	2	SR	Rugosa	14	Seco	Dacitas		R4	16-jun.	
J1	605837	7565474	4651	Diaclasa		60	82		D	6	0	SR	Rugosa	8	Seco	Dacitas		R4	16-jun.	
J1	605837	7565484	4651	Diaclasa		70	233		C	5	< 1	SR	Rugosa	14	Seco	Dacitas		R4	16-jun.	
J1	605837	7565472	4651	Diaclasa		65	87		C	2	10	SR	Plana	4	Seco	Dacitas		R4	16-jun.	
J1	605837	7565471	4651	Diaclasa		71	72		D	3	3	SR	Ondulada	6	Seco	Dacitas		R4	16-jun.	
J2	606255	7565106	4704	Diaclasa		85	10		C	1	4	SR	Ondulada	6	Seco	Dacitas		R4	16-jun.	
J2	606255	7565106	4704	Diaclasa		82	50		D	1	0	SR	Plana	4	Seco	Dacitas		R4	16-jun.	
J4	606628	7562234	5258	Diaclasa		81	55		C	3	5	SR	Ondulada	8	Seco	Dacitas		R4	16-jun.	
J4	606628	7562232	5258	Diaclasa		83	215		C	3	15	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
J5	606627	7562224	5264	Diaclasa	54	84	144		C	6	5	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
J5	606627	7562224	5264	Diaclasa		65	255		D	6	3	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
J5	606627	7562224	5264	Diaclasa		65	105		C	3	7	SR	Ondulada	8	Seco	Dacitas		R4	16-jun.	
M14	606044	7565302	4652	Diaclasa		85	303		D	6	5	SR	Ondulada	4	Seco	Dacitas		R4	16-jun.	
M14	606044	7565302	4652	Diaclasa		70	145		D	5	5	SR	Ondulada	8	Seco	Dacitas		R4	16-jun.	
M14	606044	7565302	4652	Diaclasa		78	96		C	2	< 1	SR	Plana	10	Humedo	Dacitas		R4	16-jun.	
M14	606044	7565302	4652	Diaclasa		77	96		C	2	6	SR	Plana	14	Seco	Dacitas		R4	16-jun.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M14*	606152	7565203	4677	Diaclasa		77	106		C	2	4	SR	Plana	12	Seco	Dacitas		R4	16-jun.	
M15	606264	7565180	4686	Diaclasa		75	82		C	4	2	SR	Plana	14	Seco	Dacitas		R4	16-jun.	
M15	606264	7565180	4686	Diaclasa		77	130		D	2	4	SR	Escalonada	8	Seco	Dacitas		R4	16-jun.	
M15	606264	7565180	4686	Diaclasa		56	136		D	3	< 1	SR	Plana	12	Seco	Dacitas		R4	16-jun.	
M16	606219	7565173	4687	Diaclasa		72	169		C	4	2	SR	Plana	12	Seco	Dacitas		R4	16-jun.	
M16	606219	7565173	4687	Diaclasa		88	10		D	1	2	SR	Ondulada	12	Seco	Dacitas		R4	16-jun.	
M16	606219	7565173	4687	Diaclasa		76	94		C	3	< 1	SR	Ondulada	12	Seco	Dacitas		R4	16-jun.	
M16	606219	7565173	4687	Diaclasa		55	155		D	2	< 1	SR	Ondulada	10	Seco	Dacitas		R4	16-jun.	
M16	606219	7565173	4687	Diaclasa		70	94		D	2	< 1	SR	Ondulada	10	Seco	Dacitas		R4	16-jun.	
M17	606331	7564278	4831	Diaclasa		77	332		C	3	2	SR	Plana	2	Seco	Andesitas		R4	16-jun.	
M17	606331	7564278	4831	Diaclasa		84	326		D	5	1	SR	Plana	2	Seco	Andesitas		R4	16-jun.	
M18	606658	7563652	4945	Diaclasa		66	156		C	2		SR	Escalonada	18	Seco	Andesitas		R4	16-jun.	
M18	606658	7563652	4945	Diaclasa	145	78	235		C	2	10	SR	Escalonada	18	Seco	Dacitas		R4	16-jun.	
M18	606658	7563652	4945	Diaclasa	158	88	248		D	1	2	SR	Ondulada	6	Seco	Dacitas		R4	16-jun.	
M19	606718	7563593	4941	Diaclasa		74	258		C	2	10	SR	Rugosa	18	Seco	Dacitas		R4	16-jun.	
M19	606718	7563593	4941	Diaclasa		66	87		C	2	3	SR	Rugosa	12	Seco	Dacitas		R4	16-jun.	
M19	606718	7563593	4941	Diaclasa		71	235		C	3	5	SR	Rugosa	12	Seco	Dacitas		R4	16-jun.	
M19	606718	7563593	4941	Diaclasa		81	230		D	3	0	SR	Rugosa	8	Seco	Dacitas		R4	16-jun.	
M19	606718	7563593	4941	Diaclasa		65	332		C	1	6	SR	Escalonada	18	Seco	Dacitas		R4	16-jun.	
M20	606732	7563443	4970	Diaclasa		74	149		C	3	2	SR	Plana	4	Seco	Dacitas		R4	16-jun.	
M20	606732	7563443	4970	Diaclasa		74	55		D	2	0	SR	Rugosa	14	Seco	Dacitas		R4	16-jun.	
M20	606732	7563443	4970	Diaclasa		64	272		D	2	< 1	SR	Rugosa	14	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa		85	102		C	5	3	SR	Plana	8	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa	156	83	246		C	6	2	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa	155	87	245		C	3	10	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa		86	48		D	4	< 1	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa		10	75		C	1	20	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa		67	222		D	4	4	SR	Escalonada	14	Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Diaclasa	132	84	222		C	3	10	SR	Plana	2	Seco	Dacitas		R4	16-jun.	
E11	606784	7563481	4955	Pseudoestratificación		56	140		C						Seco	Dacitas		R3	16-jun.	
E12	606909	7563170	5029	Pseudoestratificación		48	160		C						Seco	Andesitas		R4	16-jun.	
E8	607383	7565158	4707	Pseudoestratificación		38	200		D						Seco	Dacitas		R3	16-jun.	
M14	606044	7565302	4652	Pseudoestratificación		45	204		C						Seco	Dacitas		R4	16-jun.	
M17	606331	7564278	4831	Pseudoestratificación		42	200		C						Seco	Andesitas		R4	16-jun.	
M18	606658	7563652	4945	Pseudoestratificación		42	30		C						Seco	Andesitas		R4	16-jun.	
M18	606658	7563652	4945	Pseudoestratificación		72	158		C						Seco	Andesitas		R4	16-jun.	
M18	606658	7563652	4945	Pseudoestratificación	222	62	132		C						Seco	Andesitas		R4	16-jun.	
M19	606718	7563593	4941	Pseudoestratificación		49	175		C						Seco	Dacitas		R4	16-jun.	
M19	606718	7563593	4941	Pseudoestratificación		53	30		C						Seco	Dacitas		R4	16-jun.	
M20	606732	7563443	4970	Pseudoestratificación		52	162		C						Seco	Dacitas		R4	16-jun.	
M21	606519	7562224	5263	Pseudoestratificación	330	16	240		C						Seco	Dacitas		R4	16-jun.	
J6	607704	7563369	4975	Diaclasa		68	5		C	6	7	SR	Plana	12	Seco	Dacita-Andesita		R4	17-jun.	
J6	607704	7563368	4975	Diaclasa		70	355		D	3	2	SR	Plana	14	Seco	Dacita-Andesita		R4	17-jun.	
J6	607704	7563365	4975	Diaclasa		78	230		C	2	5	SR	Plana	8	Seco	Dacita-Andesita		R4	17-jun.	
J7	607659	7563363	4987	Diaclasa		65	235		C	3	5	SR	Plana	8	Seco	Dacita-Andesita		R4	17-jun.	
L162	609569	7565775	4590	Diaclasa		88	110		D	5	0	SR	Plana	10	Seco	Dacita-Andesita		R3	17-jun.	
L163	609569	7565775	4590	Diaclasa		87	265		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R3	17-jun.	
L164	609569	7565775	4590	Diaclasa		82	271		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R3	17-jun.	
L165	609569	7565775	4590	Diaclasa		85	272		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L169	609569	7565775	4590	Diaclasa		65	280		D	1	0	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L170	609569	7565775	4590	Diaclasa		80	310		D	1	0	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L171	609569	7565775	4590	Diaclasa		60	295		C	4	3	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L172	609569	7565775	4590	Diaclasa		62	290		C	2	0	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L173	609569	7565775	4590	Diaclasa		59	275		C	1	0	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L174	609569	7565775	4590	Diaclasa		52	260		C	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L175	609569	7565775	4590	Diaclasa		60	263		C	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L178	609569	7565775	4590	Diaclasa		59	158		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L179	609569	7565775	4590	Diaclasa		48	245		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L180	609569	7565775	4590	Diaclasa		60	330		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L181	609569	7565775	4590	Diaclasa		82	263		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L182	609569	7565775	4590	Diaclasa		70	82		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L183	609569	7565775	4590	Diaclasa		68	70		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L184	609472	7565800	4610	Diaclasa		70	76		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L185	608778	7567209	4598	Diaclasa		80	145		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L186	608778	7567209	4598	Diaclasa		70	140		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L187	608778	7567209	4598	Diaclasa		45	255		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L188	608778	7567209	4598	Diaclasa		60	5		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L189	608778	7567209	4598	Diaclasa		87	147		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L190	608778	7567209	4598	Diaclasa		68	10		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L191	608778	7567209	4598	Diaclasa		49	85		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L192	608778	7567209	4598	Diaclasa		55	345		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L193	608778	7567209	4598	Diaclasa		68	93		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L194	608778	7567209	4598	Diaclasa		50	118		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L195	608778	7567209	4598	Diaclasa		50	85		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L196	608778	7567209	4598	Diaclasa		89	267		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L197	608778	7567209	4598	Diaclasa		51	304		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L198	608778	7567209	4598	Diaclasa		79	68		D	4	5	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L199	608778	7567209	4598	Diaclasa		80	277		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L200	608778	7567209	4598	Diaclasa		83	292		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L201	608745	7567431	4588	Diaclasa		88	130		D	5	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L202	608745	7567431	4588	Diaclasa		60	140		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L203	608745	7567431	4588	Diaclasa		80	320		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L204	608745	7567431	4588	Diaclasa		85	342		D	2	6	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L205	608745	7567431	4588	Diaclasa		84	312		C	3	4	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L206	608745	7567431	4588	Diaclasa		83	114		C	2	2	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L207	608745	7567431	4588	Diaclasa		85	123		D	1	3	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L208	607840	7567411	4618	Diaclasa		70	165		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L209	607840	7567411	4618	Diaclasa		79	320		D	2	20	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L210	607840	7567411	4618	Diaclasa		88	308		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L211	607840	7567411	4618	Diaclasa		45	36		D	3	5	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L212	607840	7567411	4618	Diaclasa		38	285		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L213	607840	7567411	4618	Diaclasa		56	250		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L214	607840	7567411	4618	Diaclasa		60	290		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L215	607840	7567411	4618	Diaclasa		65	278		D	2	5	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L216	605738	7566568	4566	Diaclasa		83	335		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L217	605738	7566568	4566	Diaclasa		80	151		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L219	605738	7566568	4566	Diaclasa		54	260		D	1	10	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L226	605738	7566568	4566	Diaclasa		61	260		D	2	1	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L232	605738	7566568	4566	Diaclasa		10	140		D	2	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L234	605545	7566680	4554	Diaclasa		85	280		D	3	30	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L235	605545	7566680	4554	Diaclasa		87	76		D	2	10	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L236	605545	7566680	4554	Diaclasa		83	294		D	2	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L237	605545	7566680	4554	Diaclasa		89	315		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L245	605545	7566680	4554	Diaclasa		7	190		D	1	2	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L246	605545	7566680	4554	Diaclasa		4	183		D	1	2	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L247	605545	7566680	4554	Diaclasa		89	5		D	2	3	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L248	605545	7566680	4554	Diaclasa		85	10		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L249	605545	7566680	4554	Diaclasa		60	75		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L250	605545	7566680	4554	Diaclasa		89	83		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L251	605545	7566680	4554	Diaclasa		65	350		D	2	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L252	605545	7566680	4554	Diaclasa		80	100		D	3	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L253	605545	7566680	4554	Diaclasa		78	290		D	2	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L254	605545	7566680	4554	Diaclasa		60	250		D	1	5	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L255	605545	7566680	4554	Diaclasa		85	339		D	4	2	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L257	605545	7566680	4554	Diaclasa		84	110		D	2	1	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L258	605545	7566680	4554	Diaclasa		87	108		D	4	4	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L259	605545	7566680	4554	Diaclasa		89	130		D	2	2	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
M22	607672	7563334	4991	Diaclasa	135	82	45		D	3	2	SR	Escalonada	4	Seco	Dacitas		R3	17-jun.	
M22	607672	7563334	4991	Diaclasa	110	85	20		D	2	< 1	SR	Escalonada	6	Seco	Dacitas		R3	17-jun.	
M23	607666	7563323	4992	Diaclasa	180	47	90		D	5	2	SR	Escalonada	12	Seco	Dacitas		R3	17-jun.	

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M23	607666	7563323	4992	Diaclasa	148	74	58		D	3	0	SR	Escalonada	10	Seco	Dacitas		R3	17-jun.	
M23	607666	7563323	4992	Diaclasa	138	52	228		D	5	< 1	SR	Plana	6	Seco	Dacitas		R3	17-jun.	
M23	607666	7563323	4992	Diaclasa	185	89	370		D	3	< 1	SR	Escalonada	6	Seco	Dacitas		R3	17-jun.	
M24	607696	7563348	4985	Diaclasa	190	88	100		D	2	0	SR	Plana	4	Seco	Dacitas		R3	17-jun.	
M24	607696	7563348	4985	Diaclasa	152	86	242		C	3	10	SR	Escalonada	14	Seco	Dacitas		R3	17-jun.	
M24	607696	7563348	4985	Diaclasa	295	52	205		C	2	0	SR	Plana	12	Seco	Dacitas		R3	17-jun.	
M24	607696	7563348	4985	Diaclasa	222	72	150		C	3	6	SR	Plana	6	Seco	Dacitas		R3	17-jun.	
M24	607696	7563348	4985	Diaclasa	20	87	110		D	2	7	SR	Plana	4	Seco	Dacitas		R3	17-jun.	
L159	609569	7565775	4590	Falla		82	115		D	1	5	SR	Plana	10	Seco	Dacita-Andesita		R3	17-jun.	
L160	609569	7565775	4590	Falla		72	93		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R3	17-jun.	
L161	609569	7565775	4590	Falla		82	120		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R3	17-jun.	
L166	609569	7565775	4590	Falla		68	135	200	D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L167	609569	7565775	4590	Falla		40	320	185	D	1	0	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L168	609569	7565775	4590	Falla		38	324	185	D	1	0	SR	Plana	10	Seco	Brecha de base		R3	17-jun.	
L177	609569	7565775	4590	Falla		56	340		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
L220	605738	7566568	4566	Falla		76	155	230	D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L221	605738	7566568	4566	Falla		89	210		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L222	605738	7566568	4566	Falla		88	190		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L223	605738	7566568	4566	Falla		81	315		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L224	605738	7566568	4566	Falla		87	245		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L225	605738	7566568	4566	Falla		80	260		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L227	605738	7566568	4566	Falla		89	266		D	1	10	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L228	605738	7566568	4566	Falla		88	97		D	1	10	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L229	605738	7566568	4566	Falla		82	335		D	1	10	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L230	605738	7566568	4566	Falla		87	290		D	1	5	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L231	605738	7566568	4566	Falla		65	300		D	1	2	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L233	605545	7566680	4554	Falla		80	20		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L238	605545	7566680	4554	Falla		80	290		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L239	605545	7566680	4554	Falla		77	308		D	1	3	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L240	605545	7566680	4554	Falla		78	280		D	1	8	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L241	605545	7566680	4554	Falla		86	260		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L242	605545	7566680	4554	Falla		88	320		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L243	605545	7566680	4554	Falla		88	316		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L244	605545	7566680	4554	Falla		89	310		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L218	605738	7566568	4566	Falla Inversa		87	140		D	1	0	SR	Plana	10	Seco	Ignimbritas		R3	17-jun.	
L256	605545	7566680	4554	Falla Inversa		86	325		D	1	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jun.	
L176	609569	7565775	4590	Falla Normal		48	160		D	1	2	SR	Plana	10	Seco	Dacita-Andesita		R4	17-jun.	
M22	607672	7563334	4991	Pseudoestratificación	38	33	128		C						Seco	Dacitas		R3	17-jun.	
M24	607696	7563348	4985	Pseudoestratificación	240	30	150		C						Seco	Dacitas		R3	17-jun.	
E17	610262	7564392	4623	Diaclasa		75	295		D	3	2	SR	Plana	12	Seco	Dacitas		R4	18-jun.	
E17	610262	7564392	4623	Diaclasa		70	335		D	1	10	SR	Plana	12	Seco	Dacitas		R4	18-jun.	
E18	610033	7564255	4666	Diaclasa	134	78	224		C	1	10	SR	Plana	12	Seco	Dacitas		R4	18-jun.	
E19	607120	7561061	5690	Diaclasa		26	155		C	4	20	SR	Plana	12	Seco	Dacitas		R4	18-jun.	
E19	607120	7561061	5690	Diaclasa		71	21		C	5	< 1	SR	Plana	10	Seco	Andesitas		R4	18-jun.	
E19	607120	7561061	5690	Diaclasa		79	85		D	1	1	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
E19	607120	7561061	5690	Diaclasa		84	238		C	2	3	SR	Escalonada	12	Seco	Andesitas		R4	18-jun.	
E20	607098	7561059	5691	Diaclasa		54	309		C	2	5	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
E20	607098	7561059	5691	Diaclasa		76	22		D	1	1	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
E20	607098	7561059	5691	Diaclasa		86	14		C	5	7	SR	Plana	14	Seco	Andesitas		R4	18-jun.	
E20	607098	7561059	5691	Diaclasa		71	18		C	3	8	SR	Plana	12	Seco	Andesitas		R4	18-jun.	
E21	606972	7561117	5671	Diaclasa		54	15		C	3	2	SR	Plana	10	Seco	Andesitas		R4	18-jun.	
E21	606972	7561117	5671	Diaclasa		42	200		D	2	1	SR	Plana	16	Seco	Andesitas		R4	18-jun.	
E21	606972	7561117	5671	Diaclasa		68	30		C	3	2	SR	Plana	14	Seco	Andesitas		R4	18-jun.	
E21	606972	7561117	5671	Diaclasa		85	305		D	5	3	SR	Plana	14	Seco	Andesitas		R4	18-jun.	
E22	607180	7561389	5499	Diaclasa		62	96		C	3	10	SR	Plana	8	Seco	Andesitas		R4	18-jun.	
E22	607180	7561389	5499	Diaclasa		57	159		C	1	2	SR	Plana	14	Seco	Andesitas		R4	18-jun.	
E22	607180	7561389	5499	Diaclasa		69	246		D	3	2	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
E22	607180	7561389	5499	Diaclasa		74	161		D	1	20	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Diaclasa		66	139		D	7	0	SR	Plana	2	Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Diaclasa		59	98		D	6	0	SR	Plana	2	Seco	Andesitas		R4	18-jun.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
E23	607161	7561490	5434	Diaclasa		69	332		C	2	2	SR	Plana	8	Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Diaclasa		84	31		D	2	1	SR	Plana	6	Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Diaclasa		72	326		C	2	5	SR	Plana	10	Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Diaclasa		83	42		D	2	4	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Diaclasa	198	68	108		D	3	0,1	SR	Escalonada	14	Seco	Andesitas		R4	18-jun.	
E24	607375	7561600	5359	Diaclasa		41	102		C	5	10	SR	Plana	12	Seco	Andesitas		R4	18-jun.	
E24	607375	7561600	5359	Diaclasa		72	174		D	3	0,5	SR	Ondulada	6	Seco	Andesitas		R4	18-jun.	
J10	607338	7561529	5410	Diaclasa		85	190		C	1	4	SR	Escalonada	14	Seco	Andesitas		R4	18-jun.	
J11	607336	7561538	5410	Diaclasa		76	25		D	1	1	SR	Ondulada	8	Seco	Andesitas		R4	18-jun.	
J12	607336	7561538	5410	Diaclasa		79	48		C	1	< 1	SR	Plana	4	Seco	Andesitas		R4	18-jun.	
J14	607330	7561553	5408	Diaclasa		75	201		C	1	< 1	SR	Plana	4	Seco	Andesitas	Oxidación	R4	18-jun.	
J15	607330	7561553	5408	Diaclasa		77	327		D	1	0	SR	Ondulada	8	Seco	Andesitas	Oxidación	R4	18-jun.	
J16	607384	7561589	5356	Diaclasa		80	200		C	2	0	SR	Escalonada	14	Seco	Andesitas	Oxidación	R4	18-jun.	
J17	607384	7561589	5356	Diaclasa		35	255		D	1	0	SR	Ondulada	8	Seco	Andesitas	Oxidación	R4	18-jun.	
L-260	602558	7565950	4454	Diaclasa		80	60		D	2	10	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L261	602558	7565950	4454	Diaclasa		80	295		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-262	602558	7565950	4454	Diaclasa		80	130		D	2	5	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-263	602558	7565950	4454	Diaclasa		62	225		C	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-264	602558	7565950	4454	Diaclasa		55	290		D	10	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-265	602558	7565950	4454	Diaclasa		60	288		D	8	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-266	602558	7565950	4454	Diaclasa		62	253		D	10	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-267	602558	7565950	4454	Diaclasa		80	293		D	4	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-268	602239	7566172	4451	Diaclasa		75	255		D	2	4	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-269	602239	7566172	4451	Diaclasa		80	260		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-270	602239	7566172	4451	Diaclasa		87	235		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-271	602239	7566172	4451	Diaclasa		89	257		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-272	602239	7566172	4451	Diaclasa		85	259		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-273	602239	7566172	4451	Diaclasa		83	267		D	3	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-274	601454	7565833	4459	Diaclasa		70	185		D	2	2	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-275	601454	7565833	4459	Diaclasa		84	182		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-276	601454	7565833	4459	Diaclasa		88	164		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-277	601454	7565833	4459	Diaclasa		64	187		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-278	601454	7565833	4459	Diaclasa		73	191		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-279	601454	7565833	4459	Diaclasa		70	185		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-280	601454	7565833	4459	Diaclasa		50	135		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-281	601594	7565581	4486	Diaclasa		88	45		D	4	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-282	601594	7565581	4486	Diaclasa		85	43		D	2	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-283	601594	7565581	4486	Diaclasa		88	47		D	1	5	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-284	601594	7565581	4486	Diaclasa		80	40		D	1	1	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-285	601594	7565581	4486	Diaclasa		88	43		D	2	10	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-286	601594	7565581	4486	Diaclasa		81	39		D	4	5	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-287	601594	7565581	4486	Diaclasa		83	41		D	3	3	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-290	601498	7565393	4560	Diaclasa		71	300		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-291	601498	7565393	4560	Diaclasa		78	270		D	1	5	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-292	601498	7565393	4560	Diaclasa		80	281		D	2	20	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-293	601498	7565393	4560	Diaclasa		85	330		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-294	601498	7565393	4560	Diaclasa		84	335		D	1	20	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-295	601578	7565105	4573	Diaclasa		60	252		D	8	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-296	601578	7565105	4573	Diaclasa		71	248		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-297	601578	7565105	4573	Diaclasa		65	265		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-298	601578	7565105	4573	Diaclasa		68	254		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-299	601578	7565105	4573	Diaclasa		60	249		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
L-300	601578	7565105	4573	Diaclasa		71	259		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
M26	609824	7563953	4701	Diaclasa	281	81	191		D	2	0	SR	Plana	8	Seco	Dacitas		R4	18-jun.	
M26	609824	7563953	4701	Diaclasa	78	71	168		D	6	5	SR	Plana	6	Seco	Dacitas		R4	18-jun.	
M26	609824	7563953	4701	Diaclasa	232	48	142		D	6	< 1	SR	Plana	8	Seco	Dacitas		R4	18-jun.	
M26	609824	7563953	4701	Diaclasa	275	90	185		D	5	45	SR	Plana	6	Seco	Dacitas		R4	18-jun.	
M27	609827	7563944	4694	Diaclasa	155	70	245		D	4	30	SR	Plana	8	Seco	Dacitas		R4	18-jun.	
M28	607758	7561686	5266	Diaclasa	268	55	178		C	1	25	SR	Plana	4	Seco	Dacitas	Argilica	R3	18-jun.	
M29	607422	7561341	5460	Diaclasa	228	89	318		D	1	0	SR	Plana	4	Seco	Dacitas	Argilica	R3	18-jun.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M30	607377	7561236	5513	Diaclasa	0	71	90		D	3	< 1	SR	Plana	2	Seco	Andesitas	Argilica	R3	18-jun.	
M30	607377	7561236	5513	Diaclasa	200	90	110		D	1	1,5	SR	Plana	2	Seco	Andesitas	Argilica	R3	18-jun.	
M30	607377	7561236	5513	Diaclasa		70	202		D	4	< 1	SR	Escalonada	4	Seco	Andesitas	Argilica	R3	18-jun.	
M30	607377	7561236	5513	Diaclasa	216	78	126		D	1	2	SR	Ondulada	8	Seco	Andesitas	Argilica	R3	18-jun.	
M31	607375	7561234	5521	Diaclasa	260	70	170		C	1	5	SR	Plana	4	Seco	Andesitas	Argilica	R3	18-jun.	
M32	607296	7561128	5589	Diaclasa		98	275		C	1	3	SR	Plana	4	Seco	Andesitas	Argilica	R3	18-jun.	
M33	606987	7561126	5667	Diaclasa	295	85	205		C	3	30	SR	Rugosa	14	Seco	Andesitas		R4	18-jun.	
M33	606987	7561126	5667	Diaclasa	290	71	70		D	1	2	SR	Rugosa	14	Seco	Andesitas		R4	18-jun.	
M34	607029	7561216	5597	Diaclasa		82	31		C	5	10	SR	Escalonada	10	Seco	Andesitas		R4	18-jun.	
M34	607029	7561216	5597	Diaclasa		78	34		C	4	5	SR	Escalonada	8	Seco	Andesitas		R4	18-jun.	
M34	607029	7561216	5597	Diaclasa		86	35		C	5	8	SR	Escalonada	10	Seco	Andesitas		R4	18-jun.	
M34	607029	7561216	5597	Diaclasa		79	41		C	6	5	SR	Plana	11	Seco	Andesitas		R4	18-jun.	
M35	607153	7561381	5496	Diaclasa		82	66		C	2	7	SR	Rugosa	8	Seco	Dacitas	Argilica	R3	18-jun.	
M35	607153	7561381	5496	Diaclasa		72	195		D	1	< 1	SR	Plana	2	Seco	Dacitas	Argilica	R3	18-jun.	
M36	607164	7561402	5484	Diaclasa	0	90	2		D	1	0	SR	Plana	4	Seco	Dacitas	Argilica	R3	18-jun.	
M37	607299	7561450	5446	Diaclasa		80	210		D	2	2	SR	Escalonada	4	Seco	Dacitas	Argilica	R3	18-jun.	
M37	607299	7561450	5446	Diaclasa		90	146		D	3	8	SR	Escalonada	8	Seco	Dacitas	Argilica	R3	18-jun.	
M37	607299	7561450	5446	Diaclasa		75	200		D	2	2	SR	Escalonada	4	Seco	Dacitas	Argilica	R3	18-jun.	
M37	607299	7561450	5446	Diaclasa		42	180		C	3	4	SR	Plana	4	Seco	Dacitas	Argilica	R3	18-jun.	
M38	607289	7561466	5463	Diaclasa		23	95		C	1	0	SR	Plana	4	Seco	Dacitas		R4	18-jun.	
M39	607318	7561480	5427	Diaclasa		70	245		D	2	1	SR	Escalonada	10	Seco	Dacitas		R4	18-jun.	
M39	607318	7561480	5427	Diaclasa		90	307		C	5	0	SR	Escalonada	8	Seco	Dacitas		R4	18-jun.	
M39	607318	7561480	5427	Diaclasa		84	180		D	4	10	SR	Plana	8	Seco	Dacitas		R4	18-jun.	
E16	610307	7564437	4614	Falla		86	345		C	1	5	SR	Plana	8	Seco	Dacitas		R4	18-jun.	Desplazamiento de 20 cm
E17	610262	7564392	4623	Falla		72	160		D	1	0	SR	Plana	12	Seco	Dacitas		R4	18-jun.	
E19	607120	7561061	5690	Falla		81	240		C	2	5	SR	Escalonada	12	Seco	Andesitas		R4	18-jun.	Desplazamiento de 15 cm
M26	609824	7563953	4701	Falla	96	67	186		C	1	1	SR	Plana	14	Seco	Dacitas		R4	18-jun.	
M26	609824	7563953	4701	Falla	80	62	170		D	6	5	SR	Plana	12	Seco	Dacitas		R4	18-jun.	
E23	607161	7561490	5434	Falla Inversa		76	167		C	1	2	SR	Ondulada	14	Seco	Andesitas		R4	18-jun.	Desplazamiento de 5 a 20 cm
E20	607098	7561059	5691	Falla Normal		68	177		C	3	20	SR	Plana	8	Seco	Andesitas		R4	18-jun.	
E20	607098	7561059	5691	Falla Normal		78	266		C	4	10	SR	Escalonada	12	Seco	Andesitas		R4	18-jun.	Desplazamiento de 15 cm.
E24	607375	7561600	5359	Falla Normal		63	82		C	1	5	SR	Plana-Ondulada	10	Seco	Andesitas		R4	18-jun.	Desplazamiento de 5 cm
L-288	601498	7565393	4560	Falla Normal		78	130		D	1	2	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	Desplazamiento 20 cm
L-289	601498	7565393	4560	Falla Normal		75	121		D	1	0	SR	Plana	10	Seco	Dacita-Andesita		R4	18-jun.	
M25	610424	7564477	4590	Falla Normal	165	89	255		C	1	0	SR	Plana	8	Seco	Dacitas		R4	18-jun.	
E21	606972	7561117	5671	Pseudoestratificación		20	315		C						Seco	Andesitas		R4	18-jun.	
E23	607161	7561490	5434	Pseudoestratificación		31	297		C						Seco	Andesitas		R4	18-jun.	
J13	607336	7561538	5410	Pseudoestratificación		36	50		C						Seco	Andesitas		R4	18-jun.	
J9	607010	7561116	5580	Pseudoestratificación	194	90			C						Seco	Dacitas		R3	18-jun.	
M26	609824	7563953	4701	Pseudoestratificación	138	45	48		C						Seco	Dacitas		R4	18-jun.	
M27	609827	7563944	4694	Pseudoestratificación	160	34	70		C						Seco	Dacitas		R4	18-jun.	
M39	607318	7561480	5427	Pseudoestratificación		17	96		C						Seco	Dacitas		R4	18-jun.	
M39	607318	7561480	5427	Pseudoestratificación		88	358		C						Seco	Dacitas		R4	18-jun.	
M40	607340	7561557	5393	Pseudoestratificación	110	72	20		C						Seco	Dacitas		R4	18-jun.	
E-28	609855	7567898	4601	Diaclasa	126	87	36		C	6	0,3	SR	Plana	6	Seco	Ignimbritas		R3	20-jun.	
J18	609859	7567911	4604	Diaclasa	315	79	45		C	4	2	SR	Rugosa	8	Seco	Dacitas		R4	20-jun.	
J19	609858	7567911	4604	Diaclasa	100	78	10		D	3	7	SR	Escalonada	14	Seco	Dacitas		R4	20-jun.	
J20	609859	7567914	4604	Diaclasa	5	62	95		D	2	1	SR	Ondulada	8	Seco	Dacitas		R4	20-jun.	
J21	609859	7567914	4604	Diaclasa		45	340		D	2	0	SR	Rugosa	8	Seco	Dacitas		R4	20-jun.	
J22	609860	7567911	4604	Diaclasa		11	44		C	4	1	SR	Escalonada	14	Seco	Dacitas		R4	20-jun.	
J23	609804	7567973	4613	Diaclasa	40	85	130		C	2	3	SR	Rugosa	8	Seco	Dacitas		R4	20-jun.	
J24	609804	7567973	4613	Diaclasa	95	80	185		D	2	10	SR	Escalonada	14	Seco	Dacitas		R4	20-jun.	
J25	611228	7567657	4640	Diaclasa		85	181		C	3	0,5	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J26	611228	7567657	4640	Diaclasa		85	290		C	2	5	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J27	611228	7567657	4640	Diaclasa		90	313		C	2	0	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J28	611228	7567659	4640	Diaclasa		16	80		C	2	0	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J29	611228	7567661	4640	Diaclasa		36	156		C	3	0,5	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J30	611228	7567662	4640	Diaclasa		16	283		C	2	1	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J31	611228	7567664	4640	Diaclasa		90	10		C	6	0,5	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J32	611368	7567712	4646	Diaclasa		90	328		C	3	0,5	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
J33	611368	7567721	4646	Diaclasa		82	10		C	2	0	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J34	611368	7567722	4646	Diaclasa		90	2		C	2	1	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
J35	611368	7567722	4646	Diaclasa		87	225		C	2	0,5	SR	Ondulada	8	Seco	Ignimbritas		R2	20-jun.	
L-301	601958	7564741	4564	Diaclasa		55	248		C	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-302	601958	7564741	4564	Diaclasa		68	256		C	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-303	601958	7564741	4564	Diaclasa		65	249		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-304	601958	7564741	4564	Diaclasa		74	238		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-305	601958	7564741	4564	Diaclasa		71	241		C	1	10	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-306	601958	7564741	4564	Diaclasa		50	245		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-307	601958	7564741	4564	Diaclasa		62	255		C	10	2	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-308	602012	7564461	4648	Diaclasa		80	135		D	8	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-309	602012	7564461	4648	Diaclasa		88	132		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-310	602012	7564461	4648	Diaclasa		85	142		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-311	602012	7564461	4648	Diaclasa		71	100		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-312	602012	7564461	4648	Diaclasa		72	280		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-313	602012	7564461	4648	Diaclasa		85	134		C	8	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-314	602012	7564461	4648	Diaclasa		87	140		C	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-315	602012	7564461	4648	Diaclasa		78	325		C	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-316	602012	7564461	4648	Diaclasa		86	315		C	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-317	602012	7564461	4648	Diaclasa		83	306		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-319	602054	7564305	4686	Diaclasa		64	260		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-320	602054	7564305	4686	Diaclasa		79	280		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-321	602054	7564305	4686	Diaclasa		68	246		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-322	602054	7564305	4686	Diaclasa		70	275		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-323	602054	7564305	4686	Diaclasa		72	250		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-324	602054	7564305	4686	Diaclasa		75	270		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-326	602054	7564305	4686	Diaclasa		84	125		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-327	602054	7564305	4686	Diaclasa		79	128		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-328	602054	7564305	4686	Diaclasa		75	141		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-329	602054	7564305	4686	Diaclasa		86	130		D	3	1	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-330	602331	7564072	4651	Diaclasa		88	100		D	2	2	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-331	602331	7564072	4651	Diaclasa		15	265		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-332	602331	7564072	4651	Diaclasa		79	97		D	2	3	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-333	602331	7564072	4651	Diaclasa		49	104		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-334	602331	7564072	4651	Diaclasa		88	103		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-335	602331	7564072	4651	Diaclasa		71	80		C	4	2	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-336	602331	7564072	4651	Diaclasa		70	73		C	3	3	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-337	602331	7564072	4651	Diaclasa		69	276		C	2	4	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-338	602331	7564072	4651	Diaclasa		60	210		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-339	602331	7564072	4651	Diaclasa		62	207		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-340	602331	7564072	4651	Diaclasa		64	209		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-341	602525	7564213	4597	Diaclasa		65	30		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-342	602525	7564213	4597	Diaclasa		70	35		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-343	602525	7564213	4597	Diaclasa		88	54		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-344	602525	7564213	4597	Diaclasa		86	48		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-345	603358	7565299	4454	Diaclasa		62	150		D	3	20	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-346	603358	7565299	4454	Diaclasa		60	260		D	2	10	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-347	603466	7565294	4468	Diaclasa		80	40		D	2	30	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-348	603466	7565294	4468	Diaclasa		77	50		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-349	603466	7565294	4468	Diaclasa		85	146		D	1	20	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-350	603466	7565294	4468	Diaclasa		79	200		D	2	10	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-351	603466	7565294	4468	Diaclasa		86	348		D	4	2	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-355	604340	7565975	4516	Diaclasa		85	15		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-357	604340	7565975	4516	Diaclasa		82	23		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-358	604340	7565975	4516	Diaclasa		85	20		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
M41	609855	7567898	4601	Diaclasa		57	2		D	1	10	SR	Plana	4	Seco	Dacitas		R5	20-jun.	
M42	609839	7567923	4603	Diaclasa		74	140		D	1	2	SR	Escalonada	12	Seco	Dacitas		R5	20-jun.	
M42	609839	7567923	4603	Diaclasa	65	78	335		C	3	3	SR	Escalonada	14	Seco	Dacitas		R5	20-jun.	
M42	609839	7567923	4603	Diaclasa	77	80	347		C	3	5	SR	Plana	14	Seco	Dacitas		R5	20-jun.	
M43	609825	7567934	4602	Diaclasa	84	85	276		C	2	2	SR	Ondulada	12	Seco	Dacitas		R5	20-jun.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M43	609825	7567934	4602	Diaclasa		73	178		D	3	3	SR	Plana	12	Seco	Dacitas		R5	20-jun.	
M43	609825	7567934	4602	Diaclasa	80	81	350		D	2	7	SR	Escalonada	18	Seco	Dacitas		R5	20-jun.	
M43	609825	7567934	4602	Diaclasa	65	82	335		C	1	5	SR	Escalonada	14	Seco	Dacitas		R5	20-jun.	
M44	611200	7567601	4643	Diaclasa		85	186		C	2	< 1	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	
M45	611200	7567601	4643	Diaclasa		75	32		D	1	0	SR	Escalonada	16	Seco	Ignimbritas		R3	20-jun.	
M46	611202	7567627	4641	Diaclasa	10	15	100		C	2		SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	
M47	611213	7567631	4630	Diaclasa		88	183		C	2		SR	Plana	6	Seco	Ignimbritas		R3	20-jun.	
M47	611213	7567631	4630	Diaclasa		87	300		C	3	0,5	SR	Plana	4	Seco	Ignimbritas		R3	20-jun.	
M48	611216	7569644	4645	Diaclasa	135	87	225		C	3		SR	Escalonada	4	Seco	Ignimbritas		R3	20-jun.	
M48	611216	7569644	4645	Diaclasa		88	235		D	2	< 1	SR	Escalonada	5	Seco	Ignimbritas		R3	20-jun.	
M48	611216	7569644	4645	Diaclasa		84	4		C	2	0	SR	Escalonada	4	Seco	Ignimbritas		R3	20-jun.	
M49	611227	7567644	4637	Diaclasa		89	304		C	2	4	SR	Escalonada	4	Seco	Ignimbritas		R3	20-jun.	
M49	611227	7567644	4637	Diaclasa		86	190		D	1	0,2	SR	Plana	4	Seco	Ignimbritas		R3	20-jun.	
M49	611227	7567644	4637	Diaclasa		87	195		C	1	0,2	SR	Plana	4	Seco	Ignimbritas		R3	20-jun.	
M49	611227	7567644	4637	Diaclasa		86	284		C	1	< 1	SR	Escalonada	6	Seco	Ignimbritas		R3	20-jun.	
M50	611351	7567700	4640	Diaclasa		88	2		C	3	2	SR	Plana	8	Seco	Ignimbritas		R3	20-jun.	
M50	611351	7567700	4640	Diaclasa		90	283		C	1		SR	Plana	8	Seco	Ignimbritas		R3	20-jun.	
M51	611363	7567703	4650	Diaclasa		83	35		C	1	0,5	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	
M51	611363	7567703	4650	Diaclasa		84	135		C	1	0,5	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	
M51	611363	7567703	4650	Diaclasa		83	96		C	3	2	SR	Plana	8	Seco	Ignimbritas		R3	20-jun.	
M51	611363	7567703	4650	Diaclasa		88	295		C	1	0,5	SR	Plana	1	Seco	Ignimbritas		R3	20-jun.	
M51	611363	7567703	4650	Diaclasa	275	81	5		D	1	0,5	SR	Plana	1	Seco	Ignimbritas		R3	20-jun.	
M51	611363	7567703	4650	Diaclasa		70	145		C	1	2	SR	Escalonada	1	Seco	Ignimbritas		R3	20-jun.	
E-25	609855	7567898	4601	Falla		6	50		C	1	0,5	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	Desplazamiento 10 cm
E-26	609855	7567898	4601	Falla		4	53		C	2	0,5	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	Desplazamiento 5 cm
E-27	609855	7567898	4601	Falla		5	57		C	1	0,5	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	Desplazamiento 10 cm
L-318	602012	7564461	4648	Falla		88	321	230	D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-325	602054	7564305	4686	Falla		74	160	80	D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-352	603466	7565294	4468	Falla		89	80	82	D	1	5	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-353	603466	7565294	4468	Falla		80	50		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-354	604340	7565975	4516	Falla		65	215		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
L-356	604340	7565975	4516	Falla		77	70	10	D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	20-jun.	
M41	609855	7567898	4601	Falla Inversa	16	67	344		C	1	3	SR	Escalonada	14	Seco	Dacitas		R5	20-jun.	
M47	611213	7567631	4630	Falla Inversa		15	20		C	1	0,3	SR	Plana	10	Seco	Ignimbritas		R3	20-jun.	
M48	611216	7569644	4645	Falla Inversa		18	28		C	1	< 1	SR	Plana	8	Seco	Ignimbritas		R3	20-jun.	
M41	609855	7567898	4601	Falla Normal	2	84	92		C	1	12	SR	Escalonada	14	Seco	Dacitas		R5	20-jun.	
M41	609855	7567898	4601	Falla Normal	68	71	139		C	1	4	SR	Escalonada	14	Seco	Dacitas		R5	20-jun.	
M43	609825	7567934	4602	Falla Normal	75	80	345		C	1	10	SR	Escalonada	18	Seco	Dacitas		R5	20-jun.	
M46	611202	7567627	4641	Falla Normal		90	182		C	1	< 1	SR	Escalonada	18	Seco	Ignimbritas		R3	20-jun.	
M41	609855	7567898	4601	Pseudoestratificación	130	65			C						Seco	Dacitas		R5	20-jun.	
M51	611363	7567703	4650	Pseudoestratificación		15	80		C						Seco	Ignimbritas		R2	20-jun.	
E29	601346	7566262	4395	Diaclasa		80	75		C	1	3	SR	Ondulada	6	Seco	Ignimbritas	Sales	R3	21-jun.	
E29	601346	7566262	4395	Diaclasa	264	82	354		C	1	3	SR	Ondulada	14	Seco	Ignimbritas		R3	21-jun.	
E30	601350	7566258	4384	Diaclasa		76	41		D	1	0	SR	Plana	18	Seco	Ignimbritas		R3	21-jun.	
E30	601350	7566258	4384	Diaclasa	118	82	28		C	3	0,5	SR	Escalonada	12	Seco	Ignimbritas	Sales	R3	21-jun.	
E31	601415	7566263	4390	Diaclasa		69	318		D	3	0	SR	Escalonada	18	Humedo	Ignimbritas		R3	21-jun.	
E31	601415	7566263	4390	Diaclasa	232	88	142		D	2	0	SR	Escalonada	14	Humedo	Ignimbritas		R3	21-jun.	
E33	601628	7566187	4396	Diaclasa	232	85	142		C	3	4	SR	Plana	14	Seco	Ignimbritas		R3	21-jun.	
E33	601628	7566187	4396	Diaclasa		84	21		D	1	0,2	SR	Escalonada	14	Seco	Ignimbritas		R3	21-jun.	
E33	601628	7566187	4396	Diaclasa	220	77	130		D	1	1,5	SR	Escalonada	12	Seco	Ignimbritas		R3	21-jun.	
E33	601628	7566187	4396	Diaclasa		83	14		D	2	0,2	SR	Curva	12	Seco	Ignimbritas		R3	21-jun.	
E33	601628	7566187	4396	Diaclasa		85	129		C	1	0,2	SR	Curva	12	Humedo	Ignimbritas	Sales	R3	21-jun.	
E33	601628	7566187	4396	Diaclasa		80	55		D	1	0,2	SR	Plana	12	Humedo	Ignimbritas	Sales	R3	21-jun.	
E33	601628	7566187	4396	Diaclasa	227	88	137		D	1	1	SR	Plana	13	Humedo	Ignimbritas	Sales	R3	21-jun.	
J36	601335	7566262	4385	Diaclasa	7	70	277		C	2	10	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J37	601335	7566270	4385	Diaclasa	8	76	98		C	2	12	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J38	601335	7566269	4385	Diaclasa	150	82	60		C	6	15	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J39	601363	7566268	4385	Diaclasa	305	53	215		C	4	30	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J40	601363	7566263	4385	Diaclasa	110	80	20		C	4	2	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J41	601360	7566265	4390	Diaclasa	355	20	265		C	3	2	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
J42	601396	7566278	4390	Diaclasa	67	77	337		C	2	3	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J43	601404	7566267	4391	Diaclasa	40	81	310		C	6	1	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J44	601404	7566260	4391	Diaclasa	230	87	140		C	5	3	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J45	601411	7566267	4391	Diaclasa	245	42	155		C	1	5	SR	Escalonada	14	Humedo	Flujo de detritos		R3	21-jun.	
J46	601432	7566270	4391	Diaclasa	61	85	300		C	3	5	SR	Escalonada	14	Humedo	Ignimbritas		R3	21-jun.	
J47	601455	7566259	4388	Diaclasa	5	85	95		C	3	3	SR	Escalonada	14	Humedo	Ignimbritas		R3	21-jun.	
J48	601492	7566268	4385	Diaclasa		45	215		C	1	3	SR	Escalonada	14	Humedo	Ignimbritas		R3	21-jun.	
J49	601492	7566268	4385	Diaclasa	70	81	340		C	5	10	SR	Escalonada	14	Humedo	Ignimbritas		R3	21-jun.	
J50	601723	7566116	4390	Diaclasa		82	137		C	1	0	SR	Ondulada	8	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J51	601723	7566116	4390	Diaclasa		86	66		C	1	0	SR	Ondulada	8	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J52	601723	7566111	4390	Diaclasa		83	154		C	3	1	SR	Ondulada	8	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J53	601723	7566111	4390	Diaclasa		78	41		C	4	0	SR	Ondulada	8	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J54	601723	7566110	4390	Diaclasa		68	325		C	2	0,5	SR	Ondulada	8	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J55	601723	7566110	4390	Diaclasa		74	255		C	1	0	SR	Escalonada	14	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J56	601682	7566148	4390	Diaclasa		90	220		C	3	0,5	SR	Escalonada	14	Humedo	Ignimbritas	Silicificación	R2	21-jun.	
J57	601686	7566153	4390	Diaclasa		68	115		C	6	0,5	SR	Escalonada	14	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J58	601686	7566153	4390	Diaclasa		87	216		C	2	0	SR	Escalonada	14	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J59	601642	7566176	4392	Diaclasa		88	214		C	2	0,5	SR	Escalonada	14	Seco	Ignimbritas	Silicificación	R2	21-jun.	
J60	601642	7566176	4391	Diaclasa		10	28		C	2	0,5	SR	Ondulada	8	Seco	Ignimbritas	Silicificación	R2	21-jun.	
L359	604001	7565210	4499	Diaclasa		65	52		D	3	0	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L360	604001	7565210	4499	Diaclasa		89	310		D	1	0	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L361	604001	7565210	4499	Diaclasa		79	304		D	2	4	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L362	604001	7565210	4499	Diaclasa		68	306		D	2	5	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L363	604833	7564857	4631	Diaclasa		70	320		D	2	8	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L364	604833	7564857	4631	Diaclasa		68	310		D	1	5	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L365	604833	7564857	4631	Diaclasa		83	280		D	1	3	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L366	604833	7564857	4631	Diaclasa		75	240		D	1	7	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L368	605320	7564510	4678	Diaclasa		75	150		D	2	5	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L369	605320	7564510	4678	Diaclasa		70	156		D	2	3	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L370	605320	7564510	4678	Diaclasa		62	147		D	1	0	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L371	605320	7564510	4678	Diaclasa		70	154		D	1	0	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L372	605320	7564510	4678	Diaclasa		88	135		D	2	0	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L373	605320	7564510	4678	Diaclasa		87	129		D	2	0	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L374	605809	7564213	4778	Diaclasa		88	265		D	2	4	SR	Rugosa	8	Seco	Dacitas		R5	21-jun.	
L375	605809	7564213	4778	Diaclasa		45	150		D	3	5	SR	Rugosa	8	Seco	Dacitas		R5	21-jun.	
L376	605809	7564213	4778	Diaclasa		51	156		D	3	0	SR	Rugosa	8	Seco	Dacitas		R5	21-jun.	
L377	605809	7564213	4778	Diaclasa		83	262		D	2	2	SR	Rugosa	8	Seco	Dacitas		R5	21-jun.	
L378	605809	7564213	4778	Diaclasa		87	205		D	1	0	SR	Rugosa	8	Seco	Dacitas		R5	21-jun.	
L379	605809	7564213	4778	Diaclasa		86	192		D	1	3	SR	Rugosa	8	Seco	Dacitas		R5	21-jun.	
L380	604350	7564124	4590	Diaclasa		82	95		D	2	3	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L381	604350	7564124	4590	Diaclasa		72	66		D	1	4	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L382	604350	7564124	4590	Diaclasa		60	70		D	3	6	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
L384	604350	7564124	4590	Diaclasa		79	105		D	2	3	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
M52	601320	7566267	4387	Diaclasa	105	84	15		C	1	1	SR	Plana	6	Seco	Flujo de detritos		R3	21-jun.	
M52	601320	7566267	4387	Diaclasa		85	15		C	1	2,5	SR	Ondulada	4	Seco	Flujo de detritos		R3	21-jun.	
M52	601320	7566267	4387	Diaclasa		70	281		D	1	0,1	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M53	601329	7566263	4384	Diaclasa		69	67		C	1	0	SR	Ondulada	17	Seco	Flujo de detritos		R3	21-jun.	
M54	601336	7566267	4373	Diaclasa	251	78	341		C	2	5	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M54	601336	7566267	4373	Diaclasa		78	5		C	1	2	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M55	601342	7566262	4395	Diaclasa	226	75	316		D	1	2	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M56	601339	7566261	4404	Diaclasa		82	320		C	1	0	SR	Ondulada	17	Seco	Flujo de detritos		R3	21-jun.	
M56	601339	7566261	4404	Diaclasa		60	335		C	1	0	SR	Ondulada	17	Seco	Flujo de detritos		R3	21-jun.	
M57	601337	7566255	4398	Diaclasa		82	175		C	1	2	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M57	601337	7566255	4398	Diaclasa		80	45		C	2		SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M58	601331	7566250	4400	Diaclasa		70	173		C	1	4	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M58	601331	7566250	4400	Diaclasa		80	290		C	1	2	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M59	601350	7566246	4399	Diaclasa		90	215		C	2	0,1	SR	Ondulada	18	Seco	Flujo de detritos		R3	21-jun.	
M59	601350	7566246	4399	Diaclasa		72	290		D	1	0,5	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M59	601350	7566246	4399	Diaclasa		84	5		D	1	0	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M60	601404	7566257	4398	Diaclasa		74	105		C	2	0,5	SR	Ondulada	18	Seco	Flujo de detritos		R3	21-jun.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M60	601404	7566257	4398	Diaclasa		80	100		D	1	0,7	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M61	601410	7566256	4393	Diaclasa		57	200		C	2	4	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M62	601418	7566259	4385	Diaclasa		78	315		C	1	4	SR	Escalonada	18	Seco	Ignimbritas		R2	21-jun.	
M62	601418	7566259	4385	Diaclasa		75	275		D	2	0	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	
M62	601418	7566259	4385	Diaclasa		80	318		D	1	0,3	SR	Escalonada	17	Seco	Ignimbritas		R2	21-jun.	
M63	601416	7566257	4408	Diaclasa	224	84	134		C	1	2	SR	Plana	15	Seco	Ignimbritas		R2	21-jun.	
M63	601416	7566257	4408	Diaclasa		63	166		C	2	2	Arcilla	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M63	601416	7566257	4408	Diaclasa		76	134		C	2	2	Arcilla	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M64	601424	7566261	4398	Diaclasa		73	314		C	1	0,2	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M64	601424	7566261	4398	Diaclasa		76	144		C	1	5	SR	Plana	18	Seco	Ignimbritas		R2	21-jun.	
M65	601440	7566251	4395	Diaclasa		66	170		C	1	5	SR	Ondulada	18	Seco	Ignimbritas		R2	21-jun.	
M65	601440	7566251	4395	Diaclasa	232	86	322		C	1	0,5	SR	Escalonada	17	Seco	Ignimbritas		R2	21-jun.	
M65	601440	7566251	4395	Diaclasa		87	176		C	1	2	SR	Plana	18	Seco	Ignimbritas		R2	21-jun.	
M65	601440	7566251	4395	Diaclasa		83	103		C	1	0,3	SR	Plana	18	Seco	Ignimbritas		R2	21-jun.	
M65	601440	7566251	4395	Diaclasa		83	172		D	1	0,2	Arenas	Plana	18	Seco	Ignimbritas		R2	21-jun.	
M66	601482	7566248	4391	Diaclasa		76	160		C	6	3	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M66	601482	7566248	4391	Diaclasa		74	223		D	1	1,5	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M66	601482	7566248	4391	Diaclasa		85	108		D	2	5	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M66	601482	7566248	4391	Diaclasa		82	105		C	3	0,5	SR	Plana	15	Seco	Ignimbritas		R2	21-jun.	
M67	601475	7566261	4415	Diaclasa		74	22		C	2	2	Arcilla	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M67	601475	7566261	4415	Diaclasa		82	44		D	1	3	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M67	601475	7566261	4415	Diaclasa		75	329		D	1	2	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M67	601475	7566261	4415	Diaclasa		84	125		C	3	3	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M68	601504	7566248	4389	Diaclasa		88	107		C	1	11	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M68	601504	7566248	4389	Diaclasa	123	78	33		C	1	0,3	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M69	601517	7566246	4385	Diaclasa		70	231		D	3	0,3	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M69	601517	7566246	4385	Diaclasa		83	257		C	1	5	Arcilla	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M70	601521	7566245	4388	Diaclasa		81	257		C	2	2	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M70	601521	7566245	4388	Diaclasa		80	169		C	2	2	SR	Ondulada	16	Seco	Ignimbritas		R2	21-jun.	
M70	601521	7566245	4388	Diaclasa		77	279		D	2	3	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M70	601521	7566245	4388	Diaclasa	130	85	40		D	3	7	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M70	601521	7566245	4388	Diaclasa		80	208		D	2	0,5	SR	Plana	18	Seco	Ignimbritas		R2	21-jun.	
M71	601544	7566231	4391	Diaclasa	185	78	95		C	1	0	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	
M72	601556	7566228	4390	Diaclasa		84	325		C	2	0,5	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	
M72	601556	7566228	4390	Diaclasa		84	212		C	2	0,1	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	
M72	601556	7566228	4390	Diaclasa		83	175		C	1	0	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	
M73	601564	7566220	4398	Diaclasa		82	175		C	1	0	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	
L383	604350	7564124	4590	Falla		59	73		D	1	2	SR	Plana	8	Seco	Dacitas		R5	21-jun.	
M52	601320	7566267	4387	Falla Inversa	195	85	285		C	1	25	SR	Ondulada	6	Seco	Flujo de detritos	Sales	R3	21-jun.	
M52	601320	7566267	4387	Falla Inversa		82	115	31	D	1	0	SR	Escalonada	18	Seco	Flujo de detritos		R3	21-jun.	
M54	601336	7566267	4373	Falla Inversa		84	52	310	C	1	0,4	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
E 32	601566	7566218	4492	Falla Normal		65	80		D	1	0,2	SR	Curva	12	Seco	Ignimbritas		R3	21-jun.	
E 32	601566	7566218	4492	Falla Normal		83	215		C	1	0,2	SR	Plana	12	Seco	Ignimbritas		R3	21-jun.	
M53	601329	7566263	4384	Falla Normal	105	84	15	73	C	1	3	SR	Ondulada	16	Seco	Flujo de detritos		R3	21-jun.	
M55	601342	7566262	4395	Falla Normal		68	330		C	1	1	SR	Escalonada	17	Seco	Flujo de detritos		R3	21-jun.	
M69	601517	7566246	4385	Falla Normal		82	263	338	C	1	0,2	SR	Plana	16	Seco	Ignimbritas		R2	21-jun.	
M71	601544	7566231	4391	Falla Normal		88	45		C	1	0,5	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	Desplazamiento de 30 cm
M71	601544	7566231	4391	Falla Normal		86	235		C	1	0,5	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	Desplazamiento de 20 cm
M72	601556	7566228	4390	Falla Normal		67	284		C	1	0	SR	Plana	14	Seco	Ignimbritas		R2	21-jun.	desplzamiento de 10 cm
M72	601556	7566228	4390	Falla Normal		89	215		C	1	0	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	Desplazamiento de 10 cm
M73	601564	7566220	4398	Falla Normal	165	82	255		C	3	0	SR	Plana	17	Seco	Ignimbritas		R2	21-jun.	
L367	604833	7564857	4631	Pseudoestratificación		9	15		C						Seco	Dacitas		R5	21-jun.	
M56	601339	7566261	4404	Pseudoestratificación	310	20	220		C						Seco	Flujo de detritos		R3	21-jun.	
e-595	610663	7568280	4647	Diaclasa	290	85	20		C	3	3	SR	Plana	18	Seco	Dacitas		R4	22-jun.	
e-595	610663	7568280	4647	Diaclasa	284	84	14		C	2	10	Arenas	Curva	18	Seco	Dacitas		R4	22-jun.	
e-595	610663	7568280	4647	Diaclasa		10	86		C	1	3	SR	Escalonada	18	Seco	Dacitas		R4	22-jun.	
e-595	610663	7568280	4647	Diaclasa		70	21		D	2	1	Arenas	Plana	6	Seco	Dacitas		R4	22-jun.	
e-595	610663	7568280	4647	Diaclasa		4	10		C	3	1	SR	Plana	6	Seco	Dacitas		R4	22-jun.	
e-595	610663	7568280	4647	Diaclasa		87	66		D	1	2	SR	Plana	12	Seco	Dacitas		R4	22-jun.	
e-596	610495	7568419	4653	Diaclasa		63	108		D	3	0,5	SR	Plana	12	Seco	Dacitas		R4	22-jun.	

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PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
e-596	610495	7568419	4653	Diaclasa	109	86	19		C	1	3	Arenas	Plana	12	Seco	Dacitas		R4	22-jun.	
e-596	610495	7568419	4653	Diaclasa		40	323		C	2	1,5	Arenas	Escalonada	10	Seco	Dacitas		R4	22-jun.	
e-596	610495	7568419	4653	Diaclasa		60	200		D	3	3	Arenas	Plana	10	Seco	Dacitas		R4	22-jun.	
e-597	610283	7568529	4649	Diaclasa		61	94		D	1	0,3	SR	Plana	10	Seco	Dacitas		R4	22-jun.	
e-597	610283	7568529	4649	Diaclasa		56	131		D	1	0,2	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
e-597	610283	7568529	4649	Diaclasa	296	63	206		C	2	5	Arenas	Plana	16	Seco	Dacitas		R4	22-jun.	
e-597	610283	7568529	4649	Diaclasa	85	65	355		C	1	10	Arenas	Plana	10	Seco	Dacitas		R4	22-jun.	
e-597	610283	7568529	4649	Diaclasa		40	3		C	1	5	Arenas	Plana	12	Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Diaclasa	125	70	35		D	2	0,3	SR	Plana	14	Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Diaclasa		75	282		D	1	0,5	SR	Curva	10	Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Diaclasa		35	73		D	2	1	Arenas	Plana	10	Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Diaclasa		83	98		D	1	0,5	SR	Plana	8	Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Diaclasa	185	76	95		D	2	2	Arenas	Escalonada	12	Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Diaclasa	328	72	58		D	2	0,5	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
J61	610268	7567991	4643	Diaclasa		82	50		C	3	0,8	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
J61	610268	7567991	4643	Diaclasa		73	212		C	5	3	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
J61	610268	7567994	4643	Diaclasa		79	18		C	2	7	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
J61	610268	7567995	4643	Diaclasa		71	320		C	2	30	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
J61	610268	7567995	4643	Diaclasa		51	78		C	6	0,3	SR	Plana	4	Seco	Dacitas		R4	22-jun.	
J62	609965	7567984	4638	Diaclasa		55	308		C	1	1,5	SR	Ondulada	8	Seco	Dacitas		R4	22-jun.	
J62	609965	7567984	4638	Diaclasa		78	275		C	1	3	SR	Ondulada	8	Seco	Dacitas		R4	22-jun.	
J62	609965	7567984	4638	Diaclasa		82	6		C	3	10	SR	Plana	4	Seco	Dacitas		R4	22-jun.	
J62	609965	7567984	4638	Diaclasa		37	4		C	2	0,5	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
J63	609763	7568186	4625	Diaclasa		53	314		C	4	0,5	SR	Ondulada	8	Seco	Dacitas		R4	22-jun.	
J63	609763	7568186	4625	Diaclasa		58	80		C	5	1	SR	Plana	4	Seco	Dacitas		R4	22-jun.	
J63	609763	7568187	4625	Diaclasa		46	342		C	5	0,5	SR	Ondulada	8	Seco	Dacitas		R4	22-jun.	
J63	609763	7568188	4626	Diaclasa		88	154		C	1	10	SR	Ondulada	8	Seco	Dacitas		R4	22-jun.	
J63	609763	7568191	4627	Diaclasa		83	194		C	4	15	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
L386	609500	7569555	4719	Diaclasa		50	150		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L387	609500	7569555	4719	Diaclasa		80	142		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L388	609500	7569555	4719	Diaclasa		64	165		D	2	4	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L389	609500	7569555	4719	Diaclasa		72	185		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L391	609500	7569555	4719	Diaclasa		80	50		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L392	609500	7569555	4719	Diaclasa		88	175		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L395	609500	7569555	4719	Diaclasa		60	25		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L398	609500	7569555	4719	Diaclasa		55	155		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L399	609500	7569555	4719	Diaclasa		82	25		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L400	609642	7570190	4779	Diaclasa		79	335		D	2	10	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L401	609642	7570190	4779	Diaclasa		88	190		D	3	3	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L403	609642	7570190	4779	Diaclasa		61	30		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L404	609642	7570190	4779	Diaclasa		72	315		D	3	10	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L405	609642	7570190	4779	Diaclasa		88	164		D	2	25	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L406	609642	7570190	4779	Diaclasa		89	182		D	2	25	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L407	609642	7570190	4779	Diaclasa		79	196		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L409	611165	7569978	7913	Diaclasa		84	189		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L410	611165	7569978	7913	Diaclasa		83	181		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L411	611165	7569978	7913	Diaclasa		82	210		D	2	3	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L412	611165	7569978	7913	Diaclasa		84	226		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L413	610746	7569444	4852	Diaclasa		80	115		D	6	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L414	610746	7569444	4852	Diaclasa		79	126		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L415	610746	7569444	4852	Diaclasa		84	112		D	7	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L416	610746	7569444	4852	Diaclasa		61	122		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L421	610746	7569444	4852	Diaclasa		60	132		D	2	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L422	610746	7569444	4852	Diaclasa		72	230		D	1	2	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L423	610746	7569444	4852	Diaclasa		81	124		D	3	0	SR	Escalonada	8	Seco	Dacita-Andesita		R4	22-jun.	
L424	610746	7569444	4852	Diaclasa		84	128		D	2	0	SR	Escalonada	8	Seco	Dacita-Andesita		R4	22-jun.	
L425	610746	7569444	4852	Diaclasa		80	126		D	2	2	SR	Escalonada	8	Seco	Dacita-Andesita		R4	22-jun.	
L426	610746	7569444	4852	Diaclasa		86	130		D	2	0	SR	Escalonada	8	Seco	Dacita-Andesita		R4	22-jun.	
L427	609909	7569155	7433	Diaclasa		78	292		D	4	5	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L428	609909	7569155	7433	Diaclasa		70	302		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	

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SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L429	609909	7569155	7433	Diaclasa		80	300		D	2	4	SR	Ondulada	8	Seco	Dacita-Andesita		R4	22-jun.	
L431	609909	7569155	7433	Diaclasa		80	305		D	1	15	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L432	609909	7569155	7433	Diaclasa		85	326		C	2	30	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L433	609511	7568759	4658	Diaclasa		70	156		D	1	10	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L435	609511	7568759	4658	Diaclasa		84	15		D	2	10	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L436	609595	7568583	4641	Diaclasa		61	5		C	5	20	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L437	609595	7568583	4641	Diaclasa		86	224		C	4	10	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
M74	610369	7568081	4642	Diaclasa		84	335		C	3	2	Arenas	Plana	16	Seco	Dacitas		R4	22-jun.	
M74	610369	7568081	4642	Diaclasa		52	278		C	1	0,5	SR	Plana	16	Seco	Dacitas		R4	22-jun.	
M75	610369	7568081	4642	Diaclasa		80	30		C	2	1	Arenas	Plana	16	Seco	Dacitas		R4	22-jun.	
M75	610361	7568086	4644	Diaclasa		65	122		C	3	2	Arcilla	Plana	16	Seco	Dacitas		R4	22-jun.	
M75	610361	7568086	4644	Diaclasa		81	45		C	1	0,8	SR	Plana	16	Seco	Dacitas		R4	22-jun.	
M76	610320	7568099	4649	Diaclasa		79	149		C	2	0,5	Arenas	Ondulada	14	Seco	Dacitas		R4	22-jun.	
M76	610320	7568099	4649	Diaclasa		79	87		D	5	10	Arenas	Escalonada	14	Seco	Dacitas		R4	22-jun.	
M77	601235	7568114	4645	Diaclasa		82	48		D	2	2	SR	Escalonada	17	Seco	Dacitas		R4	22-jun.	
M77	601235	7568114	4645	Diaclasa		82	337		C	7	0,5	SR	Plana	14	Seco	Dacitas		R4	22-jun.	
M77	601235	7568114	4645	Diaclasa		87	235		C	4	0,4	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
M78	610108	7568134	4639	Diaclasa		43	285		D	4	3	SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
M78	610108	7568134	4639	Diaclasa		72	8		D	3		SR	Escalonada	14	Seco	Dacitas		R4	22-jun.	
M78	610108	7568134	4639	Diaclasa		74	145		C	3	8	Arenas	Plana	16	Seco	Dacitas		R4	22-jun.	
M78	610108	7568134	4639	Diaclasa		74	15		C	4	5,5	SR	Escalonada	16	Seco	Dacitas		R4	22-jun.	
M79	609990	7568155	4335	Diaclasa		95	73		C	2	3	SR	Plana	18	Seco	Dacitas		R4	22-jun.	
M79	609990	7568155	4335	Diaclasa		165	63		D	2	0,4	SR	Plana	16	Seco	Dacitas		R4	22-jun.	
M80	609793	7568183	4631	Diaclasa		52	12		C	3	2	SR	Plana	16	Seco	Dacitas		R4	22-jun.	
M80	609793	7568183	4631	Diaclasa		83	260		C	4	3	SR	Plana	16	Seco	Dacitas		R4	22-jun.	
M80	609793	7568183	4631	Diaclasa		55	220		D	3	2	SR	Escalonada	16	Seco	Dacitas		R4	22-jun.	
M81	609500	7569555	4719	Diaclasa		76	340		C	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L390	609500	7569555	4719	Falla		80	5		D	1	80	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L393	609500	7569555	4719	Falla		80	185		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L394	609500	7569555	4719	Falla		85	187		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L397	609500	7569555	4719	Falla		59	40		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L402	609642	7570190	4779	Falla		80	10	20	D	1	15	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L417	610746	7569444	4852	Falla		89	118		D	2	4	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L418	610746	7569444	4852	Falla		42	128		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L420	610746	7569444	4852	Falla		10	212		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
L430	609909	7569155	7433	Falla		89	145		D	1	10	SR	Plana	8	Seco	Dacita-Andesita		R4	22-jun.	
e-595	610663	7568280	4647	Pseudoestratificación		45	320		C						Seco	Dacitas		R4	22-jun.	
e-595	610663	7568280	4647	Pseudoestratificación		41	320		C						Seco	Dacitas		R4	22-jun.	
e-596	610495	7568419	4653	Pseudoestratificación		82	131		C						Seco	Dacitas		R4	22-jun.	
e-597	610283	7568529	4649	Pseudoestratificación		56	68		C						Seco	Dacitas		R4	22-jun.	
e-599	609868	7568700	4669	Pseudoestratificación	245	78	335		C						Seco	Dacitas		R4	22-jun.	
J62	609965	7567984	4638	Pseudoestratificación		17	76		C						Seco	Dacitas		R4	22-jun.	
L396	609500	7569555	4719	Pseudoestratificación		75	100		C						Seco	Dacita-Andesita		R4	22-jun.	
L408	611165	7569978	7913	Pseudoestratificación		45	40		C						Seco	Dacita-Andesita		R4	22-jun.	
L419	610746	7569444	4852	Pseudoestratificación		38	133		C						Seco	Dacita-Andesita		R4	22-jun.	
L434	609511	7568759	4658	Pseudoestratificación		48	35		C						Seco	Dacita-Andesita		R4	22-jun.	
D-1	603213	7569830	4603	Diaclasa		88	310		C	3	7	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-1	603213	7569831	4603	Diaclasa		85	195		D	1	25	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-10	603015	7568631	4553	Diaclasa		63	230		C	3	2	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-11	602911	7568636	4566	Diaclasa		74	320		D	2	0,5	SR	Plana	6	Seco	Andesitas		R4	12-jul.	
D-11	602910	7568636	4566	Diaclasa		75	305		D	3	0,5	SR	Rugosa	12	Seco	Andesitas		R4	12-jul.	
D-11	602910	7568634	4567	Diaclasa		52	300		D	5	1	SR	Escalonada	14	Seco	Andesitas		R4	12-jul.	
D-12	603057	7568424	4545	Diaclasa		62	182		C	4	0,5	SR	Rugosa	12	Seco	Andesitas		R4	12-jul.	
D-12	603058	7568432	4544	Diaclasa		65	188		D	2	1	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
D-12	603057	7568435	4545	Diaclasa		80	172		C	2	1	SR	Escalonada	14	Seco	Andesitas		R4	12-jul.	
D-12	603065	7568436	4544	Diaclasa		80	330		C	3	0,2	SR	Rugosa	12	Seco	Andesitas		R4	12-jul.	
D-13	603142	7568336	4530	Diaclasa		89	160		D		0	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-13	603142	7568336	4530	Diaclasa		70	194		D		3,5	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-2	603191	7569852	4625	Diaclasa		86	330		D	1	2	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
D-3	603178	7569848	4612	Diaclasa		87	336		C	5	2	SR	Plana	4	Seco	Andesitas		R4	12-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
D-4	603116	7569259	4592	Diaclasa		86	183		C	3	1		Plana-Ondulada	6	Seco	Andesitas		R4	12-jul.	
D-4	603116	7569259	4592	Diaclasa		80	280		D	4	2		Plana	4	Seco	Andesitas		R4	12-jul.	
D-5	603075	7569195	4591	Diaclasa		66	15		D	1			Rugosa	8	Seco	Andesitas		R4	12-jul.	
D-5	603075	7569195	4591	Diaclasa		65	35		D	1	0	SR	Plana	5	Seco	Andesitas		R4	12-jul.	
D-6	603047	7569138	4588	Diaclasa		86	235		C	3	0	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
D-6	603047	7569138	4588	Diaclasa		86	220		C	1	0		Plana	4	Seco	Andesitas		R4	12-jul.	
D-8	603050	7568898	4560	Diaclasa		89	250		C	4	1,5	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-8	603050	7568898	4560	Diaclasa		85	300		C	2	5	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
D-9	603024	7568633	4554	Diaclasa		72	332		C	4	2	SR	Ondulada	8	Seco	Andesitas		R4	12-jul.	
D-9	603024	7568633	4554	Diaclasa		82	265		D	1	1	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
L438	602990	7566012	4458	Diaclasa		85	345		D	3	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L439	602990	7566012	4458	Diaclasa		80	340		D	4	2	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L440	602990	7566012	4458	Diaclasa		87	336		D	2	0	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L441	602990	7566012	4458	Diaclasa		82	210		D	1	0	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L443	602990	7566012	4458	Diaclasa		82	176		D	5	0	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L444	602990	7566012	4458	Diaclasa		80	193		D	1	0	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L445	602990	7566012	4458	Diaclasa		79	222		D	2	0	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L446	602990	7566012	4458	Diaclasa		74	328		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L447	602990	7566012	4458	Diaclasa		83	327		C	2	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L448	602990	7566012	4458	Diaclasa		86	348		C	6	3	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L449	602735	7566198	4462	Diaclasa		70	190		D	4	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L450	602735	7566198	4462	Diaclasa		61	344		D	2	0	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L452	602735	7566198	4462	Diaclasa		81	110		D	3	2	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L453	602735	7566198	4462	Diaclasa		88	40		C	2	8	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L454	602735	7566198	4462	Diaclasa		72	300		D	3	4	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L455	602735	7566198	4462	Diaclasa		80	342		D	2	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L456	602735	7566198	4462	Diaclasa		72	328		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L459	602683	7566266	4434	Diaclasa		75	323		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L461	602683	7566266	4434	Diaclasa		68	182		D	5	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L462	602683	7566266	4434	Diaclasa		62	193		D	4	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L463	602683	7566266	4434	Diaclasa		85	174		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L464	602683	7566266	4434	Diaclasa		68	228		D	3	1	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L465	602683	7566266	4434	Diaclasa		54	221		D	2	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L466	602683	7566266	4434	Diaclasa		85	254		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L467	602683	7566266	4434	Diaclasa		81	280		D	4	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L468	602683	7566266	4434	Diaclasa		69	264		D	2	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L469	602683	7566266	4434	Diaclasa		69	295		D	4	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L470	602683	7566266	4434	Diaclasa		87	330		D	2	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L471	602329	7566489	4472	Diaclasa		85	248		D	5	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L472	602329	7566489	4472	Diaclasa		60	273		D	2	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L473	602329	7566489	4472	Diaclasa		45	92		D	4	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L474	602329	7566489	4472	Diaclasa		73	115		D	5	4	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L475	602329	7566489	4472	Diaclasa		76	101		D	4	1	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L476	602329	7566489	4472	Diaclasa		82	114		D	3	1	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L477	602329	7566489	4472	Diaclasa		84	109		D	2	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L479	602329	7566489	4472	Diaclasa		80	70		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L480	602177	7566524	4472	Diaclasa		65	26		D	3	10	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	
L481	602177	7566524	4472	Diaclasa		82	39		D	2	1	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L482	602177	7566524	4472	Diaclasa		64	75		D	4	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L483	602177	7566524	4472	Diaclasa		75	136		D	2	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L484	602177	7566524	4472	Diaclasa		70	30		D	6	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L486	602177	7566524	4472	Diaclasa		68	150		D	2	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L487	602177	7566524	4472	Diaclasa		88	146		D	6	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L488	602177	7566524	4472	Diaclasa		85	174		D	3	4	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L489	602177	7566524	4472	Diaclasa		79	172		D	4	1	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L490	602177	7566524	4472	Diaclasa		61	3		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L491	602177	7566524	4472	Diaclasa		80	9		D	2	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L492	602177	7566524	4472	Diaclasa		79	10		D	5	3	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L493	602177	7566524	4472	Diaclasa		88	352		D	4	3	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L494	601903	7566630	4460	Diaclasa		72	145		D	3	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	

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SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L495	601903	7566630	4460	Diaclasa		83	151		D	5	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L496	601903	7566630	4460	Diaclasa		66	285		D	2	5	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L497	601903	7566630	4460	Diaclasa		87	310		D	3	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L498	601903	7566630	4460	Diaclasa		84	255		C	2	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L499	601903	7566630	4460	Diaclasa		82	150		C	4	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L500	601903	7566630	4460	Diaclasa		87	160		C	4	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L501	601903	7566630	4460	Diaclasa		88	154		D	3	0	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L502	601903	7566630	4460	Diaclasa		80	154		D	3	2	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L503	601903	7566630	4460	Diaclasa		87	132		D	2	3	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L504	601903	7566630	4460	Diaclasa		75	158		D	3	2	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L505	601903	7566630	4460	Diaclasa		80	210		D	2	4	SR	Plana	7	Seco	Dacitas		R4	12-jul.	
L506	601758	7566837	4470	Diaclasa		87	100		D	5	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L507	601758	7566837	4470	Diaclasa		89	96		D	4	1	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L508	601758	7566837	4470	Diaclasa		88	92		D	3	3	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L509	601758	7566837	4470	Diaclasa		88	104		D	2	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L510	601758	7566837	4470	Diaclasa		85	102		D	4	4	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L511	601277	7567359	4507	Diaclasa		70	220		D	5	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L512	601277	7567359	4507	Diaclasa		85	224		D	6	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L513	601277	7567359	4507	Diaclasa		87	258		D	5	15	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L514	601277	7567359	4507	Diaclasa		81	300		D	4	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L515	601277	7567359	4507	Diaclasa		88	120		D	6	6	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L516	601277	7567359	4507	Diaclasa		85	132		D	3	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L517	601011	7567147	4470	Diaclasa		5	175		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L533	601013	7567022	4471	Diaclasa		81	210		D	7	6	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L534	601013	7567022	4471	Diaclasa		73	182		D	6	8	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L535	601013	7567022	4471	Diaclasa		71	212		D	4	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L536	601013	7567022	4471	Diaclasa		89	234		D	3	4	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L537	601013	7567022	4471	Diaclasa		87	214		D	3	3	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L538	601013	7567022	4471	Diaclasa		85	218		D	4	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
M1	603367	7568020	4519	Diaclasa	230	68	320		D	5	2	SR	Escalonada	6	Seco	Andesitas		R4	12-jul.	
M1	603367	7568020	4519	Diaclasa	234	85	144		D	5	2	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
M2	603360	7568016	4516	Diaclasa	257	83	347		D	5	2	SR	Plana	2	Seco	Andesitas		R4	12-jul.	
M2	603360	7568016	4516	Diaclasa		85	175		C	4	3	SR	Rugosa	3	Seco	Andesitas		R4	12-jul.	
M2	603360	7568016	4516	Diaclasa	198	64	108		D	2	2	SR	Rugosa	3	Seco	Andesitas		R4	12-jul.	
M3	603367	7568017	4515	Diaclasa	186	49	276		D	3	1	SR	Plana	12	Seco	Andesitas		R4	12-jul.	
M3	603367	7568017	4515	Diaclasa	234	81	324		C	2	3	SR	Curva	12	Seco	Andesitas		R4	12-jul.	
M3	603367	7568017	4515	Diaclasa	231	75	321		C	4	3	SR	Curva	14	Seco	Andesitas		R4	12-jul.	
M4	603372	7568013	4518	Diaclasa	265	71	355		C	3	2	SR	Escalonada	14	Seco	Andesitas		R4	12-jul.	
M5	603505	7567754	4513	Diaclasa	239	74	149		C	2	4	Arenas	Curva	6	Seco	Andesitas		R4	12-jul.	
M5	603505	7567754	4513	Diaclasa	198	82	288		C	4	2	Arenas	Escalonada	12	Seco	Andesitas		R4	12-jul.	
M6	603508	7567748	4509	Diaclasa	260	73	170		C	2	1	SR	Curva	10	Humedo	Andesitas		R4	12-jul.	
M6	603508	7567748	4509	Diaclasa	242	83	152		D	3	2	SR	Plana	10	Seco	Andesitas		R4	12-jul.	
M7	603361	7567758	4512	Diaclasa	299	77	61		C	4	1	Arenas	Plana	8	Seco	Andesitas		R4	12-jul.	
M7	603361	7567758	4512	Diaclasa	307	66	217		C	3	1	Arenas	Plana	8	Seco	Andesitas		R4	12-jul.	
M7	603361	7567758	4512	Diaclasa	90	83	180		C	10	2	SR	Plana	6	Seco	Andesitas		R4	12-jul.	
M7	603361	7567758	4512	Diaclasa	324	60	234		C	4	1	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
M7	603361	7567758	4512	Diaclasa	265	58	355		C	2	0,5	SR	Plana	8	Seco	Andesitas		R4	12-jul.	
M8	602548	7568177	4540	Diaclasa	335	82	25		C	4	1	SR	Plana	16	Seco	Andesitas		R4	12-jul.	
M8	602548	7568177	4540	Diaclasa	347	59	13		C	2	2	SR	Plana	16	Seco	Andesitas		R4	12-jul.	
L460	602683	7566266	4434	Falla		64	116		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L528	601013	7567022	4471	Falla		87	300		D	1	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 10 cm
L529	601013	7567022	4471	Falla		86	318		D	1	10	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L531	601013	7567022	4471	Falla		89	337		D	1	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L532	601013	7567022	4471	Falla		82	343		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	
L539	601013	7567022	4471	Falla		78	319		D	1	3	SR	Rugosa	6	Seco	Dacitas		R4	12-jul.	
L540	601013	7567022	4471	Falla		66	110		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 5 cm
M6	603508	7567748	4509	Falla	265	67	355		C	1	2	SR	Plana	4	Seco	Andesitas		R4	12-jul.	
L457	602683	7566266	4434	Falla Inversa		87	130		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 5 cm
L458	602683	7566266	4434	Falla Inversa		60	115	78	D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 5 cm
L530	601013	7567022	4471	Falla Inversa		80	328		D	1	30	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 10 cm

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M4	603372	7568013	4518	Falla Inversa	248	55	338		C	1	4	SR	Escalonada	12	Seco	Andesitas		R4	12-jul.	
L518	601011	7567147	4470	Falla Normal		70	330		D	1	10	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 10 cm
L519	601011	7567147	4470	Falla Normal		87	304		D	1	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 10 cm
L520	601011	7567147	4470	Falla Normal		70	318		D	1	5	SR	Ondulada	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 20 cm
L521	601011	7567147	4470	Falla Normal		89	285		D	1	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 15 cm
L522	601011	7567147	4470	Falla Normal		87	286		D	1	2	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 15 cm
L523	601011	7567147	4470	Falla Normal		87	325		D	1	20	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 5 cm
L524	601011	7567147	4470	Falla Normal		90	325		D	1	30	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 10 cm
L525	601011	7567147	4470	Falla Normal		80	310	82	D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 5 cm
L526	601011	7567147	4470	Falla Normal		88	333		D	1	0	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 5 cm
L527	601011	7567147	4470	Falla Normal		88	334		D	1	5	SR	Plana	6	Seco	Dacitas		R4	12-jul.	Desplazamiento 40 cm
M6	603508	7567748	4509	Falla Normal	234	74	324		C	1	2	SR	Escalonada	14	Seco	Andesitas		R4	12-jul.	
D-1	603213	7569831	4603	Pseudoestratificación		48	166		C						Seco	Andesitas		R4	12-jul.	
D-10	603013	7568631	4553	Pseudoestratificación		54	165		C						Seco	Andesitas		R4	12-jul.	
D-13	603142	7568336	4530	Pseudoestratificación		43	250		C						Seco	Andesitas		R4	12-jul.	
D-7	603011	7569004	4566	Pseudoestratificación		36	84		C						Seco	Andesitas		R4	12-jul.	
L442	602990	7566012	4458	Pseudoestratificación		75	195		C						Seco	Dacitas		R4	12-jul.	
L451	602735	7566198	4462	Pseudoestratificación		68	156		C						Seco	Dacitas		R4	12-jul.	
L478	602329	7566489	4472	Pseudoestratificación		76	350		C						Seco	Dacitas		R4	12-jul.	
L485	602177	7566524	4472	Pseudoestratificación		58	96		C						Seco	Dacitas		R4	12-jul.	
L541	601013	7567022	4471	Pseudoestratificación		72	65		C						Seco	Dacitas		R4	12-jul.	
M1	603367	7568020	4519	Pseudoestratificación		24	128		C						Seco	Andesitas		R4	12-jul.	
M5	603505	7567754	4513	Pseudoestratificación	136	42	226		C						Seco	Andesitas		R4	12-jul.	
M7	603361	7567758	4512	Pseudoestratificación	45	63	135		C						Seco	Andesitas		R4	12-jul.	
D-14	601185	7567630	4529	Diaclasa		75	85		C	4	4	SR	Plana	14	Seco	Dacitas		R4	13-jul.	
D-14	601185	7567625	4529	Diaclasa		74	30		D	2	2	SR	Rugosa	12	Seco	Dacitas		R4	13-jul.	
D-14	601185	7567625	4529	Diaclasa	110	84	20		D	1	1	SR	Escalonada	14	Seco	Andesitas		R4	13-jul.	
D-16	599869	7570023	4823	Diaclasa	248	80	338		D	3	15	SR	Plana	14	Seco	Andesitas		R4	13-jul.	
D-16	599868	7570021	4822	Diaclasa	55	70	325		C	3	3	SR	Escalonada	14	Seco	Andesitas		R4	13-jul.	
D-16	599868	7570021	4822	Diaclasa	45	62	315		C	3	10	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
D-17	599319	7570444	4949	Diaclasa		83	4		C	5	2	SR	Escalonada	14	Seco	Andesitas		R4	13-jul.	
D-17	599318	7570444	4949	Diaclasa		81	302		C	1	3	SR	Escalonada	14	Seco	Andesitas		R4	13-jul.	
D-17	599316	7570444	4949	Diaclasa		55	135		C	1	2,5	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
D-17	599316	7570444	4949	Diaclasa		53	34		C	1	7	SR	Plana	4	Seco	Andesitas		R4	13-jul.	
D-17	599316	7570444	4949	Diaclasa		72	140		C	1	1	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
D-17	599316	7570444	4949	Diaclasa		55	175		D	1	1	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
D-18	599362	7570401	4944	Diaclasa		73	10		C	1	0,5	SR	Plana	4	Seco	Andesitas		R4	13-jul.	
D-18	599363	7570401	4944	Diaclasa		73	95		C	3	0,5	SR	Plana	4	Seco	Andesitas		R4	13-jul.	
D-18	599365	7570400	4944	Diaclasa		76	130		C	1	3	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
D-19	599368	7570396	4940	Diaclasa		90	235		C	3	1	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
D-19	599368	7570396	4940	Diaclasa		64	255		D	1	0,5	SR	Ondulada	9	Seco	Andesitas		R4	13-jul.	
D-20	599400	7570360	4931	Diaclasa		74	231		D	1	1	SR	Plana	4	Seco	Andesitas		R4	13-jul.	
D-20	599399	7570360	4931	Diaclasa		90	308		D	1	0,5	SR	Escalonada	14	Seco	Andesitas		R4	13-jul.	
D-20	599399	7570360	4931	Diaclasa		83	255		D	3	2	SR	Plana	4	Seco	Andesitas		R4	13-jul.	
L542	601021	7566959	4468	Diaclasa		70	156		C	7	2	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L543	601021	7566959	4468	Diaclasa		69	348		C	5	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L544	601021	7566959	4468	Diaclasa		62	352		C	3	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L545	601021	7566959	4468	Diaclasa		81	334		D	4	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L546	601021	7566959	4468	Diaclasa		72	340		D	6	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L547	601021	7566959	4468	Diaclasa		80	160		D	5	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L548	601021	7566959	4468	Diaclasa		85	168		D	5	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L549	601021	7566959	4468	Diaclasa		88	159		D	10	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L550	601021	7566959	4468	Diaclasa		87	172		D	6	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L551	601021	7566959	4468	Diaclasa		88	167		D	7	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L554	601021	7566959	4468	Diaclasa		80	145		D	4	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L555	601021	7566959	4468	Diaclasa		72	150		D	3	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L556	601021	7566959	4468	Diaclasa		71	156		D	4	5	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L557	601021	7566959	4468	Diaclasa		66	327		D	2	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L558	601021	7566959	4468	Diaclasa		80	120		D	5	2	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L560	600776	7566999	4484	Diaclasa		62	336		D	5	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	

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SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L561	600719	7566966	4483	Diaclasa		78	87		D	3	20	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L562	600719	7566966	4483	Diaclasa		86	345		D	2	10	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L563	600719	7566966	4483	Diaclasa		81	359		D	4	3	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L564	600719	7566966	4483	Diaclasa		68	345		D	5	5	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L565	600719	7566966	4483	Diaclasa		80	165		D	2	4	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L566	600719	7566966	4483	Diaclasa		86	135		D	2	8	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L567	600719	7566966	4483	Diaclasa		88	164		D	4	5	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L568	600719	7566966	4483	Diaclasa		80	160		D	5	2	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L569	600719	7566966	4483	Diaclasa		80	183		D	2	5	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L570	600719	7566966	4483	Diaclasa		72	185		D	2	6	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L571	600719	7566966	4483	Diaclasa		50	3		D	3	10	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L572	600719	7566966	4483	Diaclasa		82	154		D	4	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L573	600518	7567029	4484	Diaclasa		82	285		D	2	6	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L574	600518	7567029	4484	Diaclasa		84	35		D	3	4	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L575	600518	7567029	4484	Diaclasa		88	170		D	5	3	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L576	600518	7567029	4484	Diaclasa		72	136		D	4	8	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L577	600518	7567029	4484	Diaclasa		85	182		D	3	10	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L578	600518	7567029	4484	Diaclasa		87	246		D	2	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L579	600518	7567029	4484	Diaclasa		89	168		D	4	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L580	600518	7567029	4484	Diaclasa		85	224		D	2	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L582	600518	7567029	4484	Diaclasa		80	150		C	1	0	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L583	600518	7567029	4484	Diaclasa		87	284		C	3	2	SR	Rugosa	6	Seco	Dacitas		R4	13-jul.	
L584	600518	7567029	4484	Diaclasa		80	356		C	2	4	SR	Rugosa	8	Seco	Dacitas		R4	13-jul.	
L585	599287	7571329	5001	Diaclasa		74	120		D	2	2	SR	Rugosa	10	Seco	Dacitas		R5	13-jul.	
L586	599287	7571329	5001	Diaclasa		84	100		D	3	0	SR	Ondulada	10	Seco	Dacitas		R5	13-jul.	
L587	599287	7571329	5001	Diaclasa		80	105		D	3	0	SR	Ondulada	10	Seco	Dacitas		R5	13-jul.	
L588	599287	7571329	5001	Diaclasa		87	118		D	2	5	SR	Ondulada	10	Seco	Dacitas		R5	13-jul.	
L589	599287	7571329	5001	Diaclasa		75	95		D	5	10	SR	Ondulada	10	Seco	Dacitas		R5	13-jul.	
L590	599287	7571329	5001	Diaclasa		88	350		D	2	5	SR	Plana	10	Seco	Dacitas		R5	13-jul.	
L593	599169	7571519	5011	Diaclasa		87	80		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L594	599169	7571519	5011	Diaclasa		88	88		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L595	599169	7571519	5011	Diaclasa		70	272		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L596	599169	7571519	5011	Diaclasa		82	100		D	3	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L597	599169	7571519	5011	Diaclasa		84	268		D	6	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L598	599169	7571519	5011	Diaclasa		68	97		D	8	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L599	599169	7571519	5011	Diaclasa		70	105		D	8	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L600	599169	7571519	5011	Diaclasa		73	110		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L601	599169	7571519	5011	Diaclasa		72	120		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L602	599169	7571519	5011	Diaclasa		64	114		D	10	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L603	599169	7571519	5011	Diaclasa		58	93		D	8	2	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L604	599169	7571519	5011	Diaclasa		56	111		D	6	1	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L605	599169	7571519	5011	Diaclasa		70	110		D	7	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L606	599169	7571519	5011	Diaclasa		58	106		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L607	599169	7571519	5011	Diaclasa		74	116		D	6	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L608	599169	7571519	5011	Diaclasa		80	92		D	6	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L609	599169	7571519	5011	Diaclasa		78	115		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L610	599169	7571519	5011	Diaclasa		79	100		D	10	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L611	599169	7571519	5011	Diaclasa		79	114		D	8	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L612	599169	7571519	5011	Diaclasa		73	89		D	8	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L613	599169	7571519	5011	Diaclasa		61	99		D	6	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L614	599169	7571519	5011	Diaclasa		80	107		D	10	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L615	599169	7571519	5011	Diaclasa		80	120		D	5	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L616	599169	7571519	5011	Diaclasa		79	111		D	7	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L617	599169	7571519	5011	Diaclasa		60	93		D	6	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L618	599169	7571519	5011	Diaclasa		65	72		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L619	599169	7571519	5011	Diaclasa		60	77		D	4	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
M11	603537	7567651	4502	Diaclasa		71	215		C	3	2	SR	Plana	10	Humedo	Andesitas		R4	13-jul.	
M11	603537	7567651	4502	Diaclasa	263	75	353		C	2	0,5	SR	Ondulada	14	Seco	Andesitas		R4	13-jul.	
M11	603537	7567651	4502	Diaclasa	264	82	354		C	3	3	SR	Ondulada	8	Humedo	Andesitas		R4	13-jul.	
M12	603538	7567648	4501	Diaclasa	235	36	325		D	2	2	SR	Plana	10	Seco	Andesitas		R4	13-jul.	

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SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M13	603540	7567636	4500	Diaclasa	308	64	52		D	3	0,2	SR	Plana	6	Seco	Andesitas		R4	13-jul.	
M13	603540	7567636	4500	Diaclasa	336	56	246		C	2	2	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M14	603514	7567634	4510	Diaclasa	12	82	282		D	2	0,5	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M15	603269	7567744	4517	Diaclasa	291	87	201		C	4	2	SR	Plana	6	Seco	Andesitas		R4	13-jul.	
M15	603269	7567744	4517	Diaclasa	311	66	221		D	2	5	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M15	603269	7567744	4517	Diaclasa	317	73	227		D	3	3	Arenas	Plana	8	Seco	Andesitas		R4	13-jul.	
M16	603270	7567736	4509	Diaclasa	60	86	150		C	1	1	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M16	603270	7567736	4509	Diaclasa	31	71	301		C	2	1	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M17	603512	7567701	4507	Diaclasa	210	57	300		D	3	0,5	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M17	603512	7567701	4507	Diaclasa	199	70	289		D	4	0,5	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M17	603512	7567701	4507	Diaclasa	188	66	278		D	5	0,5	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M19	603563	7567527	4494	Diaclasa	216	65	306		C	3	3	SR	Curva	10	Humedo	Andesitas		R4	13-jul.	
M19	603563	7567527	4494	Diaclasa	194	69	104		C	3	0,5	SR	Ondulada	2	Humedo	Andesitas		R4	13-jul.	
M19	603563	7567527	4494	Diaclasa	201	83	291		C	2	2	SR	Ondulada	6	Humedo	Andesitas		R4	13-jul.	
M20	603618	7567365	4494	Diaclasa	284	82	194		D	2	1	SR	Ondulada	6	Humedo	Andesitas		R4	13-jul.	
M22	603690	7567208	4481	Diaclasa		62	95		D	2	0,5	SR	Plana	14	Seco	Ignimbritas		R3	13-jul.	
M22	603690	7567208	4481	Diaclasa		78	275		C	1	6	Arenas	Rugosa	16	Seco	Ignimbritas		R3	13-jul.	
M23	603690	7567183	4475	Diaclasa		80	242		D	2	5	SR	Rugosa	12	Humedo	Ignimbritas		R3	13-jul.	
M24	603691	7567171	4478	Diaclasa	165	78	75		C	1	8	SR	Ondulada	12	Seco	Ignimbritas		R3	13-jul.	
M24	603691	7567171	4478	Diaclasa		80	242		C	2	2	Arenas	Curva	16	Seco	Ignimbritas		R3	13-jul.	
M24	603691	7567171	4478	Diaclasa	281	85	191		C	1	20	SR	Curva	6	Seco	Ignimbritas		R3	13-jul.	
M24	603691	7567171	4478	Diaclasa		22	292		C	1	0,2	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M25	603688	7567153	4480	Diaclasa		55	58		C	1	10	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M25	603688	7567153	4480	Diaclasa		75	160		C	1	12	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M26	603686	7567141	4467	Diaclasa		74	15		C	1	12	Arenas	Plana	14	Seco	Ignimbritas		R3	13-jul.	
M26	603686	7567141	4467	Diaclasa	52	82	322		C	1	15	Arenas	Ondulada	14	Seco	Ignimbritas		R3	13-jul.	
M28	603679	7567108	4470	Diaclasa		78	82		C	1	4	Arenas	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M28	603679	7567108	4470	Diaclasa		85	32		C	2	5	Arenas	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M29	603545	7567034	4472	Diaclasa	174	63	84		C	1	10	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M29	603545	7567034	4472	Diaclasa	274	72	184		C	2	4	SR	Escalonada	12	Seco	Andesitas		R4	13-jul.	
M29	603545	7567034	4472	Diaclasa		83	252		D	3	2	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M29	603545	7567034	4472	Diaclasa		70	195		C	2	5	SR	Ondulada	14	Seco	Andesitas		R4	13-jul.	
M31	603406	7566993	4496	Diaclasa	325	63	235		C	5	3	SR	Ondulada	12	Seco	Andesitas		R4	13-jul.	
M31	603406	7566993	4496	Diaclasa		70	345		C	1	0,5	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M31	603406	7566993	4496	Diaclasa	320	66	230		C	5	1	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M31	603406	7566993	4496	Diaclasa	319	68	41		C	3	2	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M32	603397	7566986	4488	Diaclasa	325	55	35		D	1	3	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M32	603397	7566986	4488	Diaclasa	320	70	230		D	4	1	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M33	603525	7566735	4474	Diaclasa	320	78	230		D	2	0,5	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M33	603525	7566735	4474	Diaclasa	3	79	273		C	4	0,5	Arenas	Plana	10	Seco	Andesitas		R4	13-jul.	
M33	603525	7566735	4474	Diaclasa	338	72	248		D	1	1	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M34	603215	7566686	4479	Diaclasa		77	130		C	3	2	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M34	603215	7566686	4479	Diaclasa		86	236		D	3	0,5	SR	Plana	6	Seco	Andesitas		R4	13-jul.	
M34	603215	7566686	4479	Diaclasa		76	71		D	6	1	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M34	603215	7566686	4479	Diaclasa	259	81	349		C	2	3	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M34	603215	7566686	4479	Diaclasa	284	81	194		D	3	2	Arenas	Plana	6	Seco	Andesitas		R4	13-jul.	
M35	603210	7566683	4480	Diaclasa	72	79	162		C	2	3	SR	Plana	3	Seco	Andesitas		R4	13-jul.	
M35	603210	7566683	4480	Diaclasa	39	82	309		C	3	0,5	Arenas	Curva	10	Seco	Andesitas		R4	13-jul.	
M35	603210	7566683	4480	Diaclasa	305	76	55		D	3	5	Arenas	Plana	10	Seco	Andesitas		R4	13-jul.	
M36	603468	7566330	4459	Diaclasa		85	195		D	2	0,5	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M36	603468	7566330	4459	Diaclasa	293	83	67		D	3	1	SR	Plana	10	Seco	Andesitas		R4	13-jul.	
M36	603468	7566330	4459	Diaclasa	337	68	23		D	2	0,5	SR	Plana	8	Seco	Andesitas		R4	13-jul.	
M36	603468	7566330	4459	Diaclasa	46	80	136		C	3	0,1	SR	Plana	6	Seco	Andesitas		R4	13-jul.	
M36	603468	7566330	4459	Diaclasa	293	67	67		C	3	2	SR	Curva	8	Seco	Andesitas		R4	13-jul.	
M37	602713	7565805	4406	Diaclasa		85	232		C	2	4	SR	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M37	602713	7565805	4406	Diaclasa		88	156		C	3	2	SR	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M37	602713	7565805	4406	Diaclasa		78	155		C	2	5	SR	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M38	602699	7565807	4406	Diaclasa		78	302		C	3	1	Arenas	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M38	602699	7565807	4406	Diaclasa		78	289		C	2	0,3	Arenas	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M38	602699	7565807	4406	Diaclasa		80	240		C	1	1	SR	Plana	10	Seco	Ignimbritas		R3	13-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M39	602690	7565808	4409	Diaclasa		85	259		C	2	2	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M39	602690	7565808	4409	Diaclasa		81	235		C	1	2	SR	Escalonada	14	Seco	Ignimbritas		R3	13-jul.	
M39	602690	7565808	4409	Diaclasa		84	295		C	1	0,2	SR	Plana	10	Seco	Ignimbritas		R3	13-jul.	
M39	602690	7565808	4409	Diaclasa		87	82		C	3	1	SR	Escalonada	10	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		81	50		D	3	10		Plana	16	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		73	205		C	2	0,5		Plana	12	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		79	220		C	3	1		Plana	12	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		81	240		D	2	3		Plana	10	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		85	246		C	1	2		Plana	12	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		87	38		C	2	3		Plana	10	Seco	Ignimbritas		R3	13-jul.	
M40	602632	7565805	4413	Diaclasa		87	45		D	1	12		Plana	10	Seco	Ignimbritas		R3	13-jul.	
M9	603540	7567694	4501	Diaclasa	349	62	259		C	1	1	SR	Plana	12	Seco	Andesitas		R4	13-jul.	
M9	603540	7567694	4501	Diaclasa	320	70	230		D	4	3	SR	Ondulada	8	Seco	Andesitas		R4	13-jul.	
M9	603540	7567694	4501	Diaclasa	272	63	182		D	2	0,2	SR	Escalonada	8	Seco	Andesitas		R4	13-jul.	
M9	603540	7567694	4501	Diaclasa		63	67		D	2	2	SR	Curva	8	Seco	Andesitas		R4	13-jul.	
N10	598398	7571597	5213	Diaclasa		80	172		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N11	598398	7571597	5213	Diaclasa		83	174		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N12	598398	7571597	5213	Diaclasa		79	181		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N13	598398	7571597	5213	Diaclasa		80	179		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N6	598398	7571597	5213	Diaclasa		86	230		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N7	598398	7571597	5213	Diaclasa		81	205		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N8	598398	7571597	5213	Diaclasa		89	196		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N9	598398	7571597	5213	Diaclasa		80	160		C	3	2	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
L552	601021	7566959	4468	Falla		85	310		D	1	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
L553	601021	7566959	4468	Falla		72	348		D	1	0	SR	Plana	8	Seco	Dacitas		R4	13-jul.	
M16	603270	7567736	4509	Falla	347	85	257		C	1	2	SR	Escalonada	14	Seco	Andesitas		R4	13-jul.	
M18	603527	7567704	4503	Falla	176	82	266		C	1	6	Gravas	Ondulada	14	Seco	Andesitas		R4	13-jul.	
N1	598398	7571597	5213	Falla de Rumbo		89	185	5	C	5	1	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N2	598398	7571597	5213	Falla de Rumbo		82	245	4	C	5	1	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N3	598398	7571597	5213	Falla de Rumbo		85	265	2	C	5	1	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N4	598398	7571597	5213	Falla de Rumbo		89	275	3	C	5	1	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
N5	598398	7571597	5213	Falla de Rumbo		86	235		C	5	1	SR	Plana	2	Seco	Dacita-Andesita		R4	13-jul.	
L591	599169	7571519	5011	Falla Dextral		5	120		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
L592	599169	7571519	5011	Falla Dextral		3	109		D	1	0	SR	Plana	8	Seco	Dacita-Andesita		R4	13-jul.	
M27	603684	7567131	4474	Falla Dextral		79	256		C	2	2	SR	Curva	10	Seco	Ignimbritas		R3	13-jul.	
M10	603542	7567682	4502	Falla Inversa		31	209		C	1	2	SR	Curva	6	Seco	Andesitas		R4	13-jul.	desplazmaiento 10 cm
M14	603514	7567634	4510	Falla Inversa	66	42	336		D	3	1	SR	Escalonada	12	Seco	Andesitas		R4	13-jul.	
M22	603690	7567208	4481	Falla Inversa		77	144		C	1	1	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M27	603684	7567131	4474	Falla Inversa		84	47		C	1	2	Arenas	Plana	14	Seco	Ignimbritas		R3	13-jul.	
M12	603538	7567648	4501	Falla Normal	173	62	83		C	1	7	SR	Escalonada	10	Seco	Andesitas		R4	13-jul.	
M13	603540	7567636	4500	Falla Normal	340	70	20		C	9	7	SR	Escalonada	12	Seco	Andesitas		R4	13-jul.	Desplazamiento 8 cm
M14	603514	7567634	4510	Falla Normal	10	69	280		D	1	2	SR	Ondulada	12	Seco	Andesitas		R4	13-jul.	
M17	603512	7567701	4507	Falla Normal	196	70	106		C	1	2	Arenas	Escalonada	10	Seco	Andesitas		R4	13-jul.	
M19	603563	7567527	4494	Falla Normal	211	72	301		C	1	2	SR	Escalonada	10	Seco	Andesitas		R4	13-jul.	
M20	603618	7567365	4494	Falla Normal	258	88	348		C	1	12	SR	Escalonada	6	Humedo	Andesitas		R4	13-jul.	
M20	603618	7567365	4494	Falla Normal	290	87	200		C	4	2	SR	Ondulada	8	Humedo	Andesitas		R4	13-jul.	
M21	603620	7567363	4494	Falla Normal	270	88	180		C	1	2	SR	Plana	8	Humedo	Andesitas		R4	13-jul.	
M22	603690	7567208	4481	Falla Normal		65	131		C	1	1	SR	Plana	14	Seco	Ignimbritas		R3	13-jul.	
M28	603679	7567108	4470	Falla Normal	240	85	150		C	3	4	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M28	603679	7567108	4470	Falla Normal		88	146		C	2	2	Arenas	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M28	603679	7567108	4470	Falla Normal		81	152		C	2	10	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
M30	603543	7567025	4494	Falla Normal		81	216		C	1	2	SR	Ondulada	14	Seco	Andesitas		R4	13-jul.	
M32	603397	7566986	4488	Falla Normal	319	49	41		C	3	4	SR	Ondulada	10	Seco	Andesitas		R4	13-jul.	
M23	603690	7567183	4475	Falla Sinestral		86	46		C	1	20	SR	Rugosa	12	Humedo	Ignimbritas		R3	13-jul.	
M25	603688	7567153	4480	Falla Sinestral	290	90	200		C	1	12	SR	Plana	12	Seco	Ignimbritas		R3	13-jul.	
D-15	601162	7567993	4553	Pseudoestratificación		53	260		C						Seco	Andesitas		R4	13-jul.	
D-16	599869	7570025	4823	Pseudoestratificación		8	210		C						Seco	Andesitas		R4	13-jul.	
D-17	599319	7570444	4949	Pseudoestratificación		11	220		C						Seco	Andesitas		R4	13-jul.	
L559	600776	7566999	4484	Pseudoestratificación		60	185		C						Seco	Dacitas		R4	13-jul.	
L581	600518	7567029	4484	Pseudoestratificación		65	84		C						Seco	Dacitas		R4	13-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L620	599169	7571519	5011	Pseudoestratificación		65	150		C						Seco	Dacita-Andesita		R4	13-jul.	
M10	603542	7567682	4502	Pseudoestratificación		6	303		C						Seco	Andesitas		R4	13-jul.	
M11	603537	7567651	4502	Pseudoestratificación		33	240		C						Seco	Andesitas		R4	13-jul.	
M14	603514	7567634	4510	Pseudoestratificación	125	12	35		C						Seco	Andesitas		R4	13-jul.	
M16	603270	7567736	4509	Pseudoestratificación	70	21	340		C						Seco	Andesitas		R4	13-jul.	
M17	603512	7567701	4507	Pseudoestratificación	326	42	236		C						Seco	Andesitas		R4	13-jul.	
M29	603545	7567034	4472	Pseudoestratificación		31	21		C						Seco	Andesitas		R4	13-jul.	
M35	603210	7566683	4480	Pseudoestratificación	340	35	250		C						Seco	Andesitas		R4	13-jul.	
M39	602690	7565808	4409	Pseudoestratificación		4	10		C						Seco	Ignimbritas		R2	13-jul.	
M9	603540	7567694	4501	Pseudoestratificación	285	5	195		C						Seco	Andesitas		R4	13-jul.	
D-21	599826	7569253	4720	Diaclasa		76	328		D	3	0	SR	Rugosa	12	Seco	Flujo de detritos		R2	14-jul.	
D-21	599826	7569253	4720	Diaclasa		75	230		D	1	0	SR	Rugosa	12	Seco	Flujo de detritos		R2	14-jul.	
D-21	599826	7569253	4720	Diaclasa		68	263		C	3	0,2	SR	Escalonada	14	Seco	Flujo de detritos		R2	14-jul.	
D-22	599760	7569278	4720	Diaclasa		21	70		C	1	1	SR	Escalonada	14	Seco	Flujo de detritos		R2	14-jul.	
D-22	599760	7569278	4720	Diaclasa		79	88		C	1	0,5	SR	Escalonada	14	Seco	Flujo de detritos		R2	14-jul.	
D-23	599549	7569420	4805	Diaclasa		75	355		C	6	5	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-24	599488	7569477	4842	Diaclasa		52	268		C	1	2,5	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-24	599492	7569477	4843	Diaclasa		87	315		C	2	3	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-24	599492	7569477	4843	Diaclasa		88	105		C	1	0,5	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-24	599492	7569477	4843	Diaclasa		72	188		C	1	2	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-24	599492	7569477	4843	Diaclasa		75	118		C	2	1,5	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-24	599492	7569477	4843	Diaclasa		64	105		C	5	1,5	SR	Ondulada	8	Seco	Brecha de base		R3	14-jul.	
D-25	599350	7569580	4843	Diaclasa		75	280		C	1	1	SR	Rugosa-Ondulada	10	Seco	Brecha de base		R3	14-jul.	
D-25	599350	7569580	4843	Diaclasa		86	124		C	1	0,5	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-25	599350	7569580	4843	Diaclasa		72	343		C	3	3	SR	Rugosa-Ondulada	10	Seco	Brecha de base		R3	14-jul.	
D-25	599350	7569580	4843	Diaclasa		66	175		C	2	1	SR	Rugosa-Ondulada	10	Seco	Brecha de base		R3	14-jul.	
D-26	599220	7569632	4887	Diaclasa		76	332		C	5	15	SR	Rugosa	12	Seco	Brecha de base		R3	14-jul.	
D-26	599220	7569632	4887	Diaclasa		60	270		D	1	2,5	SR	Escalonada-Rugosa	14	Seco	Brecha de base		R3	14-jul.	
D-26	599220	7569632	4887	Diaclasa		58	145		D	1	3	SR	Rugosa	12	Seco	Brecha de base		R3	14-jul.	
D-26	599220	7569632	4887	Diaclasa		74	356		D	1	3	SR	Rugosa	10	Seco	Brecha de base		R3	14-jul.	
D-26	599215	7569633	4887	Diaclasa		74	222		C	3	7	SR	Ondulada	8	Seco	Brecha de base		R3	14-jul.	
D-26	599214	7569633	4887	Diaclasa		65	135		C	1	6	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-26	599214	7569633	4887	Diaclasa		75	295		D	1	5	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-27	599210	7569644	4905	Diaclasa		72	330		D	1	4	SR	Ondulada	12	Seco	Brecha de base		R3	14-jul.	
D-27	599210	7569644	4905	Diaclasa		75	135		D	1	2	SR	Escalonada	14	Seco	Brecha de base		R3	14-jul.	
D-27	599065	7569612	4958	Diaclasa		84	34		C	1	0	SR	Ondulada	6	Seco	Brecha de base		R3	14-jul.	
D-28	598793	7569364	4965	Diaclasa		82	185		C	1	2	SR	Plana	4	Seco	Andesitas		R4	14-jul.	
D-28	598793	7569364	4965	Diaclasa		58	216		C	3	0,2	SR	Plana	4	Seco	Andesitas		R4	14-jul.	
D-28	598793	7569364	4965	Diaclasa		45	175		C	3	1	SR	Plana	6	Seco	Andesitas		R4	14-jul.	
D-28	598793	7569364	4965	Diaclasa		78	4		C	1	0,5	SR	Plana	4	Seco	Andesitas		R4	14-jul.	
L623	596017	7568943	5626	Diaclasa		73	235		D	3	0	SR	Plana	2	Seco	Andesitas		R4	14-jul.	
L624	596017	7568943	5626	Diaclasa		78	340		D	3	0	SR	Plana	2	Seco	Andesitas		R4	14-jul.	
L625	596017	7568943	5626	Diaclasa		74	92		D	3	10	SR	Plana	6	Seco	Andesitas		R4	14-jul.	
L627	596017	7568943	5626	Diaclasa		86	35		D	2	0,5	SR	Plana	2	Seco	Andesitas		R4	14-jul.	
L629	596017	7568943	5626	Diaclasa		64	185		D	6	0,5	SR	Curva	12	Seco	Andesitas		R4	14-jul.	
L630	596017	7568943	5626	Diaclasa		30	156		D	6	0	SR	Ondulada	8	Seco	Andesitas		R4	14-jul.	
L631	596017	7568943	5626	Diaclasa		62	170		D	3	2	SR	Plana	2	Seco	Andesitas		R4	14-jul.	
L632	596050	7569100	5626	Diaclasa		60	138		D	3	4	SR	Plana	6	Seco	Andesitas		R4	14-jul.	
L633	596050	7569100	5626	Diaclasa		84	175		D	8	2	SR	Plana	10	Seco	Andesitas		R4	14-jul.	
L634	596050	7569100	5626	Diaclasa		82	188		D	4	10	SR	Plana	6	Seco	Andesitas		R4	14-jul.	
L635	596050	7569100	5626	Diaclasa		67	115		D	4	10	SR	Plana	6	Seco	Andesitas		R4	14-jul.	
L636	596050	7569100	5626	Diaclasa		75	256		C	3	0	SR	Plana	12	Seco	Andesitas		R4	14-jul.	
L638	596661	7569157	5355	Diaclasa	8	84	98		D	5	3	SR	Curva	6	Seco	Andesitas		R4	14-jul.	
L639	596661	7569157	5355	Diaclasa	32	80	122		D	4	1	SR	Ondulada	6	Seco	Andesitas		R4	14-jul.	
L641	596661	7569157	5355	Diaclasa	334	66	244		D	3	3	SR	Escalonada	8	Seco	Andesitas		R4	14-jul.	
L642	597209	7568746	5302	Diaclasa	24	86	114		D	1	10	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
L643	597209	7568746	5302	Diaclasa	10	87	100		D	3	4	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
L644	597209	7568746	5302	Diaclasa	27	55	297		D	6	8	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
L645	597209	7568746	5302	Diaclasa	30	51	300		D	6	5	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
L647	597209	7568746	5302	Diaclasa	68	80	338		D	6	5	SR	Plana	8	Seco	Dacitas		R4	14-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L649	597209	7568746	5302	Diaclasa	10	75	100		D	4	5	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
L650	597209	7568746	5302	Diaclasa	14	76	284		D	3	20	Bloques	Plana	8	Seco	Dacitas		R4	14-jul.	
L651	597541	7568605	5104	Diaclasa		87	100		D	4	0,5	SR	Ondulada	6	Seco	Dacitas		R4	14-jul.	
L652	597541	7568605	5104	Diaclasa		80	65		C	3	1	Arenas	Ondulada	4	Seco	Dacitas		R4	14-jul.	
L653	597541	7568605	5104	Diaclasa		86	65		D	4	0,2	SR	Plana	6	Seco	Dacitas		R4	14-jul.	
L654	597541	7568605	5104	Diaclasa		84	75		D	2	1	Arenas	Ondulada	6	Seco	Dacitas		R4	14-jul.	
L655	597541	7568605	5104	Diaclasa		88	250		C	3	0,5	SR	Ondulada	6	Seco	Dacitas		R4	14-jul.	
L657	597541	7568605	5104	Diaclasa		87	75		D	2	0,5	SR	Plana	6	Seco	Dacitas		R4	14-jul.	
L658	597541	7568605	5104	Diaclasa		84	264		C	5	0	SR	Plana	6	Seco	Dacitas		R4	14-jul.	
M42	598782	7567931	4752	Diaclasa		57	282		D	1	5	SR	Plana	10	Seco	Dacitas		R4	14-jul.	
M42	598782	7567931	4752	Diaclasa		74	188		D	2	2	SR	Curva	12	Seco	Dacitas		R4	14-jul.	
M42	598782	7567931	4752	Diaclasa		74	12		D	1	2	SR	Plana	12	Seco	Dacitas		R4	14-jul.	
M42	598782	7567931	4752	Diaclasa		76	290		D	1	22	SR	Plana	10	Seco	Dacitas		R4	14-jul.	
M43	598773	7567919	4723	Diaclasa		85	169		D	2	0	SR	Ondulada	8	Seco	Dacitas		R4	14-jul.	
M43	598773	7567919	4723	Diaclasa		80	9		C	2	0	SR	Ondulada	12	Seco	Dacitas		R4	14-jul.	
M43	598773	7567919	4723	Diaclasa		82	44		C	2	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M43	598773	7567919	4723	Diaclasa		81	325		C	1	10	SR	Plana	2	Seco	Dacitas		R4	14-jul.	
M44	598778	7567919	4742	Diaclasa		80	142		C	1	12	SR	Plana	12	Seco	Dacitas		R4	14-jul.	
M44	598778	7567919	4742	Diaclasa		79	5		C	1	5	SR	Escalonada	14	Seco	Dacitas		R4	14-jul.	
M45	598775	7567925	4743	Diaclasa		75	15		D	2	3	SR	Escalonada	14	Seco	Dacitas		R4	14-jul.	
M45	598775	7567925	4743	Diaclasa		89	205		C	1	8	SR	Escalonada	12	Seco	Dacitas		R4	14-jul.	
M47	598775	7567929	4738	Diaclasa		85	175		C	1	4	SR	Escalonada	10	Seco	Dacitas		R4	14-jul.	
M47	598775	7567929	4738	Diaclasa		260	74		D	2	2	SR	Plana	12	Seco	Dacitas		R4	14-jul.	
M47	598775	7567929	4738	Diaclasa		60	102		D	2	2	SR	Escalonada	12	Seco	Dacitas		R4	14-jul.	
M47	598775	7567929	4738	Diaclasa		77	30		C	1	0	SR	Plana	10	Seco	Dacitas		R4	14-jul.	
M48	598761	7567944	4746	Diaclasa		80	352		C	1	2	SR	Plana	10	Seco	Dacitas		R4	14-jul.	
M48	598761	7567944	4746	Diaclasa		82	32		C	1	4	SR	Plana	10	Seco	Dacitas		R4	14-jul.	
M49	598747	7567972	4751	Diaclasa		86	4		C	6	30	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
M50	598741	7567990	4755	Diaclasa		72	178		C	8	5	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
M51	598665	7568029	4782	Diaclasa		54	174		C	3	2	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
M55	597950	7568610	4996	Diaclasa	215	76	125		D	1	5	Arenas	Plana	10	Seco	Dacitas		R4	14-jul.	
M56	597961	7568613	5008	Diaclasa		70	115		D	3	4	SR	Plana	12	Seco	Dacitas		R4	14-jul.	
M56	597961	7568613	5008	Diaclasa		78	318		C	2	0,5	SR	Plana	6	Seco	Dacitas		R4	14-jul.	
M56	597961	7568613	5008	Diaclasa		52	321		C	1	0,5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M56	597961	7568613	5008	Diaclasa		52	282		C	3	1	SR	Plana	10	Seco	Dacitas		R4	14-jul.	
M57	598004	7568580	5003	Diaclasa		47	314		C	8	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M57	598004	7568580	5003	Diaclasa		35	307		C	8	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M57	598004	7568580	5003	Diaclasa		41	308		C	8	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M59	598024	7568583	4989	Diaclasa		78	338		C	8	8	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M59	598024	7568583	4989	Diaclasa		63	330		C	8	0,5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M63	598104	7568511	4970	Diaclasa		78	140		C	2	0,1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M63	598104	7568511	4970	Diaclasa		82	142		C	1	0,3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N21	601194	7574121	4698	Diaclasa		86	320		C	4	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N22	601194	7574121	4698	Diaclasa		80	230		C	4	5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N23	601194	7574121	4698	Diaclasa		87	200		C	4	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N24	601194	7574121	4698	Diaclasa		79	115		C	4	7	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N25	601194	7574121	4698	Diaclasa		88	50		C	4	20	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N26	601194	7574121	4698	Diaclasa		80	352		C	4	2	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N27	601194	7574121	4698	Diaclasa		77	245		C	4	10	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N31	602224	7574476	4645	Diaclasa		88	330		C	3	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N32	602224	7574476	4645	Diaclasa		85	290		C	3	0,5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N33	602224	7574476	4645	Diaclasa		79	312		C	3	2	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N34	602224	7574476	4645	Diaclasa		87	320		C	3	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N35	602224	7574476	4645	Diaclasa		88	300		C	3	2	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N36	602224	7574476	4645	Diaclasa		79	295		C	3	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N37	602224	7574476	4645	Diaclasa		88	329		C	3	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N38	602224	7574476	4645	Diaclasa		80	277		C	3	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N39	602224	7574476	4645	Diaclasa		81	314		C	3	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N40	602224	7574476	4645	Diaclasa		89	285		C	3	5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N41	602224	7574476	4645	Diaclasa		79	288		C	3	2	SR	Plana	4	Seco	Dacitas		R4	14-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
N42	602224	7574476	4645	Diaclasa		80	304		C	3	4	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N43	602224	7574476	4645	Diaclasa		85	316		C	3	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N44	602224	7574476	4645	Diaclasa		80	330		C	3	1	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N45	602224	7574476	4645	Diaclasa		80	321		C	3	0,5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N46	602224	7574476	4645	Diaclasa		73	342		C	3	0,5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N47	602224	7574476	4645	Diaclasa		89	326		C	3	10	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
L621	596017	7568943	5626	Falla	82	74	172		C	1	4	SR	Ondulada	6	Seco	Andesitas		R4	14-jul.	
L622	596017	7568943	5626	Falla	88	75	178		C	1	0	SR	Plana	6	Seco	Andesitas		R4	14-jul.	
M49	598747	7567972	4751	Falla		78	353		C	2	12	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
M61	598094	7568530	4963	Falla		80	128		C	2	30	Gravas	Plana	6	Seco	Dacitas		R4	14-jul.	
N15	601194	7574121	4698	Falla		83	85		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N16	601194	7574121	4698	Falla		79	93		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N18	601194	7574121	4698	Falla		87	285		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N48	602224	7574476	4645	Falla		84	314		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N49	602224	7574476	4645	Falla		85	310		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N17	601194	7574121	4698	Falla Dextral		87	20		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
L637	596661	7569157	5355	Falla Inversa	21	76	291		C	1	4	SR	Plana	8	Seco	Andesitas		R4	14-jul.	
L640	596661	7569157	5355	Falla Inversa	340	45	250		C	1	2	SR	Plana	6	Seco	Andesitas		R4	14-jul.	Desplazamiento 10cm
L646	597209	7568746	5302	Falla Inversa	55	71	325		C	1	0	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
L648	597209	7568746	5302	Falla Inversa	38	71	308		C	1	4	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
M42	598782	7567931	4752	Falla Inversa		77	15		C	1	1	SR	Plana	2	Seco	Dacitas		R4	14-jul.	
M44	598778	7567919	4742	Falla Inversa		82	292		C	1	5	SR	Plana	6	Seco	Dacitas		R4	14-jul.	
M46	598775	7567928	4737	Falla Inversa		68	146		C	1	4	SR	Ondulada	14	Seco	Dacitas		R4	14-jul.	
M48	598761	7567944	4746	Falla Inversa		73	152		C	1	25	SR	Escalonada	10	Seco	Dacitas		R4	14-jul.	
M58	598019	7568579	4994	Falla Inversa		55	331		C	10	5	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M58	598019	7568579	4994	Falla Inversa		57	337		C	10	6	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M63	598104	7568511	4970	Falla Inversa		38	125		C	1	0	SR	Curva	6	Seco	Dacitas		R4	14-jul.	
L628	596017	7568943	5626	Falla Normal		75	194		D	1	1	SR	Escalonada	6	Seco	Andesitas		R4	14-jul.	Desplazamiento 4cm
L656	597541	7568605	5104	Falla Normal		70	64		C	1	2	SR	Ondulada	6	Seco	Dacitas		R4	14-jul.	Desplazamiento 15 cm
M42	598782	7567931	4752	Falla Normal		82	11		C	2	2	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M42	598782	7567931	4752	Falla Normal		79	11		C	2	3	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M44	598778	7567919	4742	Falla Normal		77	325		C	1	5	SR	Ondulada	8	Seco	Dacitas		R4	14-jul.	
M51	598665	7568029	4782	Falla Normal		71	170		C	1	10	SR	Plana	8	Seco	Dacitas		R4	14-jul.	
M51	598665	7568029	4782	Falla Normal		80	182		C	1	15	Arenas	Plana	8	Seco	Dacitas		R4	14-jul.	
M55	597950	7568610	4996	Falla Normal		84	130		C	1	12	SR	Ondulada	6	Seco	Dacitas		R4	14-jul.	
M60	598026	7568583	4986	Falla Normal		84	130		C	2	4	Arenas	Plana	4	Seco	Dacitas		R4	14-jul.	
M60	598026	7568583	4986	Falla Normal		86	128		C	1	10	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M62	598097	7568515	4971	Falla Normal		76	308		C	1	12	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
M62	598097	7568515	4971	Falla Normal		78	279		C	1	12	Gravas	Escalonada	6	Seco	Dacitas		R4	14-jul.	
M63	598104	7568511	4970	Falla Normal		78	290		C	1	2	SR	Plana	6	Seco	Dacitas		R4	14-jul.	
N14	601194	7574121	4698	Falla Normal		80	75		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N19	601194	7574121	4698	Falla Normal		70	110		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N20	601194	7574121	4698	Falla Normal		78	305		C	1	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N28	601194	7574121	4698	Foliacion		3	160		C	10	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N29	601194	7574121	4698	Foliacion		10	170		C	10	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N30	601194	7574121	4698	Foliacion		10	157		C	10	0	SR	Plana	4	Seco	Dacitas		R4	14-jul.	
N50	602224	7574476	4645	Foliacion		12	159		C	10	0	SR	Plana	5	Seco	Dacitas		R4	14-jul.	
L626	596017	7568943	5626	Pseudoestratificación		31	77		C						Seco	Andesitas		R4	14-jul.	
M48	598761	7567944	4746	Pseudoestratificación		10	280		C						Seco	Dacitas		R4	14-jul.	
M55	597950	7568610	4996	Pseudoestratificación		33	190		C						Seco	Dacitas		R4	14-jul.	
M64	596891	7570413	5370	Diaclasa		70	35		C	2	3	SR	Rugosa	12	Seco	Andesitas		R4	15-jul.	
M64	596891	7570413	5370	Diaclasa		71	120		C	1	2	SR	Escalonada	12	Seco	Andesitas		R4	15-jul.	
M64	596891	7570413	5370	Diaclasa		78	48		D	2	1	SR		12	Seco	Andesitas		R4	15-jul.	
M64	596891	7570413	5370	Diaclasa		75	20		C	2	1	SR	Ondulada	10	Seco	Andesitas		R4	15-jul.	
M64	596891	7570413	5370	Diaclasa		78	156		C	3	1	SR	Rugosa	14	Seco	Andesitas		R4	15-jul.	
M64	596891	7570413	5370	Diaclasa		89	62		C	1	1	SR	Escalonada	12	Seco	Andesitas		R4	15-jul.	
M66	596707	7570259	5404	Diaclasa		82	150		C	4	5	SR	Plana	8	Seco	Andesitas		R4	15-jul.	
M66	596707	7570259	5404	Diaclasa		88	40		C	1	3	SR	Plana	12	Seco	Andesitas		R4	15-jul.	
M66	596707	7570259	5404	Diaclasa		68	338		C	1	2	SR	Ondulada	12	Seco	Andesitas		R4	15-jul.	
M67	595921	7569400	5582	Diaclasa		48	10		D	1	0	SR	Escalonada	12	Seco	Dacitas		R4	15-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M67	595921	7569400	5582	Diaclasa		55	305		D	1	5	SR	Plana	8	Seco	Dacitas		R4	15-jul.	
M67	595921	7569400	5582	Diaclasa		78	255		C	1	0	SR	Plana	10	Seco	Dacitas		R4	15-jul.	
M68	595870	7569262	5628	Diaclasa		52	35		D	1	0,5	SR	Ondulada-Escalonada	14	Seco	Andesitas		R4	15-jul.	
M68	595870	7569262	5628	Diaclasa		76	7		D	2	1	SR	Plana	14	Seco	Andesitas		R4	15-jul.	
M68	595870	7569262	5628	Diaclasa		63	298		D	1	3	SR	Escalonada	10	Seco	Andesitas		R4	15-jul.	
M69	596041	7569110	5622	Diaclasa		80	195		D	3	5	SR	Escalonada	14	Seco	Andesitas		R4	15-jul.	
M69	596041	7569110	5622	Diaclasa		88	334		D	1	4	SR	Plana	8	Seco	Andesitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		82	115		C	4	10	SR	Escalonada-Rugosa	14	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		67	115		C	3	6	SR	Escalonada	14	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		85	213		C	2	3	SR	Rugosa	12	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		88	145		C	1	10	SR	Plana	4	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		78	265		C	3	2	SR	Plana	4	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		52	86		C	3	2	SR	Escalonada	14	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		61	73		C	2	4	SR	Ondulada	12	Seco	Dacitas		R4	15-jul.	
M70	597023	7569707	5312	Diaclasa		90	105		C	2	0	SR	Plana	8	Seco	Dacitas		R4	15-jul.	
M71	597582	7569888	5306	Diaclasa		88	45		C	1	10	SR	Escalonada-Rugosa	14	Seco	Andesitas		R4	15-jul.	
M71	597582	7569888	5306	Diaclasa		86	153		C	2	3	SR	Plana	12	Seco	Andesitas		R4	15-jul.	
M71	597582	7569888	5306	Diaclasa		75	155		C	5	6	SR	Plana	10	Seco	Andesitas		R4	15-jul.	
M72	597759	7569712	5214	Diaclasa		80	2		D	1	10	SR	Ondulada-Escalonada	14	Seco	Brecha de base		R3	15-jul.	
M72	597759	7569712	5214	Diaclasa		68	178		D	2	3	SR	Plana	8	Seco	Brecha de base		R3	15-jul.	
M72	597759	7569712	5214	Diaclasa		58	283		D	1	8	SR	Escalonada	14	Seco	Andesitas		R4	15-jul.	
M72	597759	7569712	5214	Diaclasa		85	185		C	3	2	SR	Escalonada	14	Seco	Andesitas		R4	15-jul.	
M73	597799	7569599	5149	Diaclasa		78	9		D	1	0	SR	Rugosa	10	Seco	Brecha de base		R3	15-jul.	
M73	597799	7569599	5149	Diaclasa		83	195		C	1	7	SR	Rugosa	12	Seco	Brecha de base		R3	15-jul.	
M73	597799	7569599	5149	Diaclasa		37	212		D	1	0	SR	Rugosa	8	Seco	Brecha de base		R3	15-jul.	
M65	596880	7570414	5381	Falla Inversa		70	280		C	1	2	SR	Plana	10	Seco	Andesitas		R4	15-jul.	Rechazo de 40 cm
M66	596707	7570259	5404	Falla Normal		84	323		C	1	7	SR	Plana	10	Seco	Andesitas		R4	15-jul.	Rechazo de 18 cm
M64	596891	7570413	5370	Pseudoestratificación		22	255		C						Seco	Andesitas		R4	15-jul.	
M66	596707	7570259	5404	Pseudoestratificación		18	344		C						Seco	Andesitas		R4	15-jul.	
M67	595921	7569400	5582	Pseudoestratificación		32	175		C						Seco	Dacitas		R4	15-jul.	
M68	595870	7569262	5628	Pseudoestratificación		41	151		C						Seco	Andesitas		R4	15-jul.	
M69	596041	7569110	5622	Pseudoestratificación		70	150		C						Seco	Andesitas		R4	15-jul.	
M71	597582	7569888	5306	Pseudoestratificación		42	0		C						Seco	Andesitas		R4	15-jul.	
M72	597759	7569712	5214	Pseudoestratificación		18	292		C						Seco	Andesitas		R4	15-jul.	
D-29	604290	7573650	4607	Diaclasa		45	282		C	1	3	SR	Rugosa-Ondulada	12	Seco	Dacitas		R4	16-jul.	
D-29	604290	7573650	4607	Diaclasa		50	168		C	2	3,5	SR	Plana-Rugosa	10	Seco	Dacitas		R4	16-jul.	
D-29	604290	7573650	4607	Diaclasa		70	190		C		0	SR	Plana-Rugosa	10	Seco	Dacitas		R4	16-jul.	
D-30	604418	7573585	4610	Diaclasa		66	340		D	2	5	SR	Plana-Rugosa	8	Seco	Dacitas		R4	16-jul.	
D-30	604418	7573585	4610	Diaclasa		70	305		D	1	0	SR	Rugosa-Ondulada	12	Seco	Dacitas		R4	16-jul.	
D-30	604418	7573585	4610	Diaclasa		76	290		D		0	SR	Plana-Rugosa	8	Seco	Dacitas		R4	16-jul.	
D-30	604418	7573585	4610	Diaclasa		76	276		C	2	4	SR	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-30	604418	7573585	4610	Diaclasa		74	295		C	1	5	Arenas	Plana	4	Seco	Dacitas		R4	16-jul.	
D-31	604454	7573598	4603	Diaclasa		71	345		C	4	0,5	SR	Plana-Rugosa	12	Seco	Dacitas		R4	16-jul.	
D-31	604454	7573598	4603	Diaclasa		74	45		D	2	1,5	SR	Rugosa	12	Seco	Dacitas		R4	16-jul.	
D-32	604621	7573820	4640	Diaclasa		83	330		C	2	0	SR	Plana-Ondulada	6	Seco	Dacitas		R4	16-jul.	
D-32	604621	7573820	4640	Diaclasa		74	180		C	2	0,5	SR	Rugosa	12	Seco	Dacitas		R4	16-jul.	
D-32	604621	7573820	4640	Diaclasa		85	105		C	2	0	SR	Rugosa	8	Seco	Dacitas		R4	16-jul.	
D-33	604664	7573889	4666	Diaclasa		65	38		D	5	0	SR	Plana	4	Seco	Dacitas		R4	16-jul.	
D-33	604664	7573889	4666	Diaclasa		12	245		D	1	2	Arenas	Plana	4	Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Diaclasa		86	244		C	5	1,5	Arenas	Plana	4	Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Diaclasa		71	315		C	1	1,5	SR	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Diaclasa		52	335		D	1	0,5	SR	Plana	4	Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Diaclasa		80	65		C	3	1,5	SR	Plana	4	Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Diaclasa		72	175		C	2	0	SR	Rugosa	8	Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Diaclasa		86	85		C	2	0,2	SR	Plana-Rugosa	8	Seco	Dacitas		R4	16-jul.	
D-35	604812	7573871	4676	Diaclasa		80	295		D	2	3	SR	Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-35	604812	7573871	4676	Diaclasa		78	270		C	1	1	Arenas	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-35	604812	7573871	4676	Diaclasa		80	283		C	2	1	Arenas	Escalonada	14	Seco	Dacitas		R4	16-jul.	
D-35	604812	7573871	4676	Diaclasa		54	287		D	2	1	SR	Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-35	604812	7573871	4676	Diaclasa		66	318		C	2	1,5	SR	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
D-35	604812	7573871	4676	Diaclasa		80	10		C	2	5	Arenas	Escalonada-Rugosa	14	Seco	Dacitas		R4	16-jul.	
D-35	604812	7573871	4676	Diaclasa		68	130		D	1	0,5	SR	Rugosa-Ondulada	12	Seco	Dacitas		R4	16-jul.	
D-36	605080	7573852	4666	Diaclasa		75	222		D	2	0	SR	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-36	605080	7573852	4666	Diaclasa		46	28		C	1	1	SR	Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		82	240		D	3	1,5	SR	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		58	240		C	1	1	SR	Plana	4	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		68	245		D	1	1	SR	Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		47	205		D	1	0	SR	Plana	4	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		80	85		D	2	3,5	SR	Escalonada-Rugosa	14	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		70	315		C	1	2	Arenas	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-37	605254	7574060	4624	Diaclasa		89	273		C	1	0	SR	Plana-Rugosa	10	Seco	Dacitas		R4	16-jul.	
D-38	605118	7574222	4662	Diaclasa		78	268		C	1	1	Arenas	Plana	4	Seco	Dacitas		R4	16-jul.	
D-38	605118	7574222	4662	Diaclasa		82	82		D	3	0,2	SR	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-38	605118	7574222	4662	Diaclasa		85	5		C	2	1,5	Arenas	Plana	4	Seco	Dacitas		R4	16-jul.	
D-38	605118	7574222	4662	Diaclasa		75	185		D	2	0,5	Arenas	Plana-Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-38	605118	7574222	4662	Diaclasa		74	26		C	4	0		Plana	4	Seco	Dacitas		R4	16-jul.	
D-39	604767	7574100	4630	Diaclasa		86	140		C	1	10	Arenas	Plana	4	Seco	Dacitas		R4	16-jul.	
D-39	604767	7574100	4630	Diaclasa		65	132		C	2	2,5	SR	Plana	4	Seco	Dacitas		R4	16-jul.	
D-39	604767	7574100	4630	Diaclasa		87	304		C	2	0	SR	Ondulada	8	Seco	Dacitas		R4	16-jul.	
D-39	604767	7574100	4630	Diaclasa		56	221		C	2	1	SR	Rugosa-Ondulada	14	Seco	Dacitas		R4	16-jul.	
D-39	604767	7574100	4630	Diaclasa		80	92		C	2	1	SR	Plana-Rugosa	12	Seco	Dacitas		R4	16-jul.	
L663	602713	7574969	4620	Diaclasa		83	240		D	4	2	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L664	602713	7574969	4620	Diaclasa		78	220		D	7	2	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L665	602713	7574969	4620	Diaclasa		80	200		D	6	1	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L666	602713	7574969	4620	Diaclasa		82	196		D	7	2	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L667	602713	7574969	4620	Diaclasa		81	328		D	4	0	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L668	602713	7574969	4620	Diaclasa		80	335		D	4	4	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L669	602713	7574969	4620	Diaclasa		84	230		D	8	3	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L670	602713	7574969	4620	Diaclasa		81	326		D	6	1	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L671	602713	7574969	4620	Diaclasa		88	306		D	5	0	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L672	602713	7574969	4620	Diaclasa		87	309		D	2	4	Arenas	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L673	602713	7574969	4620	Diaclasa		83	313		D	2	4	Arenas	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L674	602713	7574969	4620	Diaclasa		87	25		D	3	2	Arenas	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L675	602713	7574969	4620	Diaclasa		86	336		D	2	0	Arenas	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L676	602713	7574969	4620	Diaclasa		85	308		D	4	0	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L677	602713	7574969	4620	Diaclasa		78	31		D	3	1	SR	Rugosa	8	Seco	Dacitas		R4	16-jul.	
L678	602713	7574969	4620	Diaclasa		80	16		D	2	3	SR	Rugosa	8	Seco	Dacitas		R4	16-jul.	
L679	602713	7574969	4620	Diaclasa		77	328		C	3	4	Arenas	Rugosa	8	Seco	Dacitas		R4	16-jul.	
L680	602713	7574969	4620	Diaclasa		79	282		D	4	3	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L681	602713	7574969	4620	Diaclasa		85	11		C	2	10	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L682	602713	7574969	4620	Diaclasa		88	357		C	2	12	SR	Rugosa	8	Seco	Dacitas		R4	16-jul.	
L683	602713	7574969	4620	Diaclasa		65	3		D	2	6	SR	Rugosa	8	Seco	Dacitas		R4	16-jul.	
L686	597989	7573644	4930	Diaclasa		88	279		D	3	4	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L687	597989	7573644	4930	Diaclasa		87	284		D	2	2	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L688	597989	7573644	4930	Diaclasa		88	296		D	1	2	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L689	597469	7573465	4946	Diaclasa		80	205		D	2	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L690	597469	7573465	4946	Diaclasa		84	213		D	3	2	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L691	597469	7573465	4946	Diaclasa		87	208		D	2	1	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L692	597469	7573465	4946	Diaclasa		89	294		D	4	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L693	597469	7573465	4946	Diaclasa		82	296		C	6	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L694	597469	7573465	4946	Diaclasa		88	311		C	8	2	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L695	597469	7573465	4946	Diaclasa		80	34		D	2	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L696	597469	7573465	4946	Diaclasa		71	76		D	2	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L697	597469	7573465	4946	Diaclasa		84	207		C	3	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L698	597469	7573465	4946	Diaclasa		68	145		C	3	15	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L699	597469	7573465	4946	Diaclasa		78	38		D	2	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L700	597182	7573517	4502	Diaclasa		86	15		C	10	5	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L701	597182	7573517	4502	Diaclasa		90	12		C	10	6	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L702	597182	7573517	4502	Diaclasa		80	6		C	10	8	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L703	597182	7573517	4502	Diaclasa		90	358		D	10	10	SR	Plana	4	Seco	Dacitas		R3	16-jul.	

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SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L704	597182	7573517	4502	Diaclasa		86	16		D	8	0	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L705	597182	7573517	4502	Diaclasa		82	18		D	6	2	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L706	597182	7573517	4502	Diaclasa		89	5		D	7	4	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L707	597182	7573517	4502	Diaclasa		80	3		D	6	20	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L708	597182	7573517	4502	Diaclasa		85	13		D	5	10	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L709	597182	7573517	4502	Diaclasa		89	7		D	4	25	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L710	597182	7573517	4502	Diaclasa		88	8		D	8	5	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
L711	597182	7573517	4502	Diaclasa		89	9		D	10	12	SR	Plana	4	Seco	Dacitas		R3	16-jul.	
M74	604352	7573651	4605	Diaclasa		86	265		D	6	4	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Diaclasa		78	186		C	3	4	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Diaclasa		82	340		C	1	2	SR	Plana	12	Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Diaclasa		89	186		D	4	1	SR	Plana	12	Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Diaclasa		78	183		D	3	4	SR	Escalonada	12	Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Diaclasa		82	186		D	4	1	SR	Plana	12	Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Diaclasa		22	168		D	1	4	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa		78	175		C	3	8	Arenas	Escalonada	16	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa		55	45		C	3	7	Arenas	Ondulada	16	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa		82	105		D	2	2	SR	Ondulada	14	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa		78	317		D	3	2	SR	Plana	16	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa		66	211		C	4	5	Arenas	Plana	16	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa	190	88	100		D	2	2	SR	Ondulada	14	Seco	Dacitas		R4	16-jul.	
M75	604383	7573625	4604	Diaclasa		76	138		D	2	2	SR	Plana	14	Seco	Dacitas		R4	16-jul.	
M76	604617	7573956	4653	Diaclasa		84	62		D	1	8	Arenas	Escalonada	16	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Diaclasa		76	250		C	3	4	SR	Plana	14	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Diaclasa		81	5		D	3	10	SR	Escalonada	16	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Diaclasa		81	290		D	2	6	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Diaclasa	104	79	14		C	2	12	SR	Escalonada	12	Seco	Dacitas		R4	16-jul.	
M79	604709	7573950	4669	Diaclasa		75	72		C	6	0,5	SR	Plana	10	Seco	Dacitas		R4	16-jul.	
M79	604709	7573950	4669	Diaclasa		86	97		C	6	6	SR	Ondulada	14	Seco	Dacitas		R4	16-jul.	
M79	604709	7573950	4669	Diaclasa		83	30		C	6	5	SR	Ondulada	14	Seco	Dacitas		R4	16-jul.	
M79	604709	7573950	4669	Diaclasa		60	72		D	1	3	SR	Plana	14	Seco	Dacitas		R4	16-jul.	
M79	604709	7573950	4669	Diaclasa		80	250		C	3	8	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M79	604709	7573950	4669	Diaclasa		85	248		C	3	5	SR	Plana	14	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		71	35		D	6	5	SR	Ondulada	16	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		84	82		C	4	2	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		64	312		D	3	6	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		77	235		C	3	1	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		84	124		D	2	4	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		55	284		D	1	0	SR	Plana	14	Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Diaclasa		70	90		D	2	3	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
L659	602713	7574969	4620	Falla		87	125		C	1	0	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L660	602713	7574969	4620	Falla		80	340		C	1	2	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L662	602713	7574969	4620	Falla		41	344		C	1	0	SR	Rugosa	10	Seco	Dacitas		R4	16-jul.	
L684	597989	7573644	4930	Falla		87	223		D	1	0,5	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
L685	597989	7573644	4930	Falla		86	100		D	1	2	SR	Plana	8	Seco	Dacitas		R4	16-jul.	
M77	604641	7573962	4661	Falla Inversa		78	113		C	1	27	Arenas	Escalonada	10	Seco	Dacitas		R4	16-jul.	
M77	604641	7573962	4661	Falla Inversa		76	82		D	2	4	SR	Ondulada	10	Seco	Dacitas		R4	16-jul.	
M77	604641	7573962	4661	Falla Normal	194	70	284		C	1	10	SR	Curva	14	Seco	Dacitas		R4	16-jul.	
M77	604641	7573962	4661	Falla Normal		72	98		C	4	4	Arenas	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Falla Normal	200	79	290		C	3	5	SR	Escalonada	14	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Falla Normal		80	320		C	1	8	SR	Escalonada	12	Seco	Dacitas		R4	16-jul.	
M78	604647	7573948	4671	Falla Normal		77	204		C	2	3	SR	Plana	14	Seco	Dacitas		R4	16-jul.	
D-29	604290	7573650	4607	Pseudoestratificación		60	154		C						Seco	Dacitas		R4	16-jul.	
D-30	604418	7573585	4610	Pseudoestratificación		40	5		C						Seco	Dacitas		R4	16-jul.	
D-31	604454	7573598	4603	Pseudoestratificación		50	251		C						Seco	Dacitas		R4	16-jul.	
D-33	604664	7573889	4666	Pseudoestratificación		55	140		C						Seco	Dacitas		R4	16-jul.	
D-34	604738	7572914	4685	Pseudoestratificación		55	124		C						Seco	Dacitas		R4	16-jul.	
D-36	605080	7573852	4666	Pseudoestratificación		75	131		C						Seco	Dacitas		R4	16-jul.	
L661	602713	7574969	4620	Pseudoestratificación		25	130		C						Seco	Dacitas		R4	16-jul.	
M74	604352	7573651	4605	Pseudoestratificación		85	82		C						Seco	Dacitas		R4	16-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M75	604383	7573625	4604	Pseudoestratificación		87	125		C						Seco	Dacitas		R4	16-jul.	
M76	604617	7573956	4653	Pseudoestratificación		44	146		C						Seco	Dacitas		R4	16-jul.	
M80	604819	7573863	4680	Pseudoestratificación		52	120		C						Seco	Dacitas		R4	16-jul.	
D-40	606589	7570113	4585	Diaclasa		85	235		C	2	1,5	Arenas	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-40	606589	7570113	4585	Diaclasa		58	175		D	1	3,5	Arenas	Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-40	606589	7570113	4585	Diaclasa		90	175		C	1	2	Arenas	Rugosa-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-40	606589	7570113	4585	Diaclasa		70	70		C	3	3,5	Arenas	Plana-Rugosa	8	Seco	Ignimbritas		R3	17-jul.	
D-41	606472	7569776	4593	Diaclasa		65	296		C	2	3	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	17-jul.	
D-41	606472	7569776	4593	Diaclasa		82	110		D	2	0,5	SR	Plana-Ondulada	10	Seco	Ignimbritas		R3	17-jul.	
D-41	606472	7569776	4593	Diaclasa		45	225		C	2	2	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-41	606472	7569776	4593	Diaclasa		70	285		D	2	1,5	SR	Plana-Rugosa	8	Seco	Ignimbritas		R3	17-jul.	
D-42	606473	7569770	4593	Diaclasa		81	55		D	1	3,5	SR	Rugosa	10	Seco	Ignimbritas		R3	17-jul.	
D-43	605804	7568412	4611	Diaclasa		45	165		D	1	0	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	17-jul.	
D-43	605804	7568412	4611	Diaclasa		80	195		D	1	0	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-43	605804	7568412	4611	Diaclasa		89	90		D	2	2	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-43	605804	7568412	4611	Diaclasa		66	225		D	1	0	SR	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-44	606263	7568057	4604	Diaclasa		70	240		D	2	1,5	SR	Ondulada	10	Seco	Ignimbritas		R3	17-jul.	
D-44	606263	7568057	4604	Diaclasa		89	280		D	2	2	SR	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-45	606268	7568055	4604	Diaclasa		64	251		D	2	0,5	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-45	606268	7568055	4604	Diaclasa		60	277		C	2	2,5	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-45	606268	7568055	4604	Diaclasa		88	60		C	1	0	SR	Plana	4	Seco	Ignimbritas		R3	17-jul.	
D-45	606268	7568055	4604	Diaclasa		44	290		C	2	1	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		75	245		C	3	9	Arenas	Plana-Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		73	288		C	2	0,5	SR	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		76	105		C	1	0,2	SR	Rugosa-Ondulada	10	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		82	280		C	2	2	Arenas	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		40	267		C	1	1	SR	Rugosa-Ondulada	12	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		75	130		C	4	1,5	SR	Plana-Ondulada	12	Seco	Ignimbritas		R3	17-jul.	
D-46	606397	7567973	4591	Diaclasa		85	100		C	3	1	SR	Plana	4	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		85	325		D	1	3	Arenas	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		58	135		D	2	1	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		62	328		D	1	2	SR	Plana-Rugosa	8	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		48	270		D	2	0	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		31	322		C	2	2	Arenas	Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		58	95		D	1	0,5	SR	Rugosa	10	Seco	Ignimbritas		R3	17-jul.	
D-47	603850	7569465	4542	Diaclasa		74	290		C	2	2	Arenas	Rugosa-Ondulada	12	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Diaclasa		75	252		D	1	2,5	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Diaclasa		73	50		D	2	0	SR	Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Diaclasa		61	300		D	1	4	SR	Rugosa	10	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Diaclasa		85	104		C	1	6	Arenas	Plana-Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Diaclasa		68	335		D	2	5	Arenas	Rugosa	12	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Diaclasa		76	33		C	4	5	Arenas	Plana-Ondulada	10	Seco	Ignimbritas		R3	17-jul.	
L712	602844	7573598	4627	Diaclasa		81	280		D	4	1	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L713	602844	7573598	4627	Diaclasa		64	282		D	3	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L714	602844	7573598	4627	Diaclasa		70	256		D	5	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L716	602844	7573598	4627	Diaclasa		80	320		D	4	2	Arenas	Plana	8	Seco	Dacitas		R4	17-jul.	
L717	602844	7573598	4627	Diaclasa		80	60		C	2	10	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L719	602844	7573598	4627	Diaclasa		87	225		C	2	5	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L720	602844	7573598	4627	Diaclasa		74	85		D	4	2	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L721	602844	7573598	4627	Diaclasa		89	272		D	3	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L726	602844	7573598	4627	Diaclasa		85	110		C	4	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L727	602844	7573598	4627	Diaclasa		89	100		C	5	1	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L728	602844	7573598	4627	Diaclasa		87	107		C	4	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L729	602844	7573598	4627	Diaclasa		88	111		C	3	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L730	602844	7573598	4627	Diaclasa		86	114		C	3	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L731	602844	7573598	4627	Diaclasa		60	100		D	2	2	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L732	602844	7573598	4627	Diaclasa		62	109		D	1	3	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L734	602844	7573598	4627	Diaclasa		68	124		C	4	0	SR	Curva	6	Seco	Dacitas		R4	17-jul.	
L735	602844	7573598	4627	Diaclasa		65	94		D	3	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L736	602844	7573598	4627	Diaclasa		83	97		D	2	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	

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SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L737	602844	7573598	4627	Diaclasa		80	90		D	4	2	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L739	602620	7573423	4670	Diaclasa		88	146		C	4	8	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L741	602620	7573423	4670	Diaclasa		83	75		D	3	0	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L742	602620	7573423	4670	Diaclasa		60	150		C	4	2	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L743	602620	7573423	4670	Diaclasa		79	166		C	3	10	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L744	602620	7573423	4670	Diaclasa		87	260		C	2	0	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L745	602620	7573423	4670	Diaclasa		89	126		D	4	5	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L746	602620	7573423	4670	Diaclasa		70	80		D	3	6	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L747	602620	7573423	4670	Diaclasa		87	84		D	2	6	SR	Rugosa	8	Seco	Dacitas		R4	17-jul.	
L748	602620	7573423	4670	Diaclasa		81	72		D	4	0	SR	Rugosa	8	Seco	Dacitas		R4	17-jul.	
L749	602620	7573423	4670	Diaclasa		60	136		C	3	0	SR	Rugosa	8	Seco	Dacitas		R4	17-jul.	
L750	602620	7573423	4670	Diaclasa		88	165		C	3	10	SR	Ondulada	8	Seco	Dacitas		R4	17-jul.	
L751	602620	7573423	4670	Diaclasa		81	320		D	2	0	SR	Ondulada	8	Seco	Dacitas		R4	17-jul.	
L752	602620	7573423	4670	Diaclasa		85	318		C	3	25	Bloques	Ondulada	8	Seco	Dacitas		R4	17-jul.	
L753	602620	7573423	4670	Diaclasa		85	345		C	2	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L754	602620	7573423	4670	Diaclasa		87	5		C	1	40	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L755	602620	7573423	4670	Diaclasa		84	350		D	2	2	SR	Ondulada	8	Seco	Dacitas		R4	17-jul.	
L756	602620	7573423	4670	Diaclasa		87	326		D	4	6	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L757	602620	7573423	4670	Diaclasa		89	310		D	3	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L758	604025	7569543	4579	Diaclasa		70	105		D	4	2	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L759	604025	7569543	4579	Diaclasa		57	99		D	5	4	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L760	604025	7569543	4579	Diaclasa		82	115		D	3	3	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L761	604025	7569543	4579	Diaclasa		70	126		D	1	2	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L762	604025	7569543	4579	Diaclasa		73	120		D	3	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L763	604025	7569543	4579	Diaclasa		85	123		D	3	1	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L764	604025	7569543	4579	Diaclasa		80	103		D	5	4	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L765	604727	7569747	4572	Diaclasa		60	104		D	3	1	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L766	604727	7569747	4572	Diaclasa		88	45		D	3	1	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L767	604727	7569747	4572	Diaclasa		50	97		D	2	3	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L768	604727	7569747	4572	Diaclasa		78	100		D	6	2	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L769	604727	7569747	4572	Diaclasa		83	104		D	3	1	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L770	604727	7569747	4572	Diaclasa		87	355		D	4	2	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L771	604727	7569747	4572	Diaclasa		85	138		D	2	1	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L772	604727	7569747	4572	Diaclasa		65	326		D	2	2	Arenas	Plana	6	Seco	Dacitas		R4	17-jul.	
L773	605502	7570166	4573	Diaclasa		84	96		D	6	2	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L776	605502	7570166	4573	Diaclasa		62	260		D	3	3	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L779	605502	7570166	4573	Diaclasa		87	135		C	6	2	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L781	605502	7570166	4573	Diaclasa		70	30		D	3	5	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L782	605502	7570166	4573	Diaclasa		75	27		D	3	2	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L783	605502	7570166	4573	Diaclasa		81	350		D	4	0	SR	Plana	8	Seco	Ignimbritas		R3	17-jul.	
M81	605488	7570174	4575	Diaclasa		61	220		D	5	0	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M81	605488	7570174	4575	Diaclasa		87	85		D	4	0,2	SR	Plana	8	Seco	Ignimbritas		R2	17-jul.	
M81	605488	7570174	4575	Diaclasa		39	326		C	1	0,2	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Diaclasa		65	214		D	4	1	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Diaclasa		32	32		C	2	1	SR	Escalonada	11	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Diaclasa		40	230		D	4	0	SR	Plana	10	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Diaclasa		89	295		C	1	1	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Diaclasa		64	330		D	1	0,5	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Diaclasa		65	290		D	1	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M83	605471	7570143	4596	Diaclasa		68	165		D	3	2	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M83	605471	7570143	4596	Diaclasa		84	310		D	4	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Diaclasa		72	302		D	3	0,5	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Diaclasa		63	14		C	1	2	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Diaclasa		76	134		D	2	3	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Diaclasa		50	287		D	2	3	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Diaclasa		69	232		D	3	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Diaclasa		74	295		D	1	2	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		70	54		C	3	2	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		76	256		C	3	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		66	242		C	4	3	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	

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SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M85	606997	7570082	4589	Diaclasa		62	74		C	3	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		81	11		D	3	2	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		82	48		D	2	0	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		75	96		D	1	1	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M85	606997	7570082	4589	Diaclasa		72	27		D	4	3	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Diaclasa		45	148		D	3	0	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Diaclasa		76	95		C	14	1	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Diaclasa		72	91		C	12	1	Arenas	Ondulada	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Diaclasa		78	195		D	3	2	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Diaclasa		80	105		C	3	3	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Diaclasa		72	100		C	8	2	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		75	328		C	3	2	Arenas	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		75	345		C	2	1	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		66	47		D	1	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		82			C	5	10	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		73	261		C	1	1	Arenas	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		83	5		D	6	2	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M87	603713	7569506	4585	Diaclasa		85	70		C	4	2	SR	Escalonada	16	Seco	Ignimbritas		R2	17-jul.	
M88	603745	7569612	4585	Diaclasa		68	118		D	2	10	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M88	603745	7569612	4585	Diaclasa		64	170		C	3	8	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M88	603745	7569612	4585	Diaclasa		76	181		C	2	2	Arenas	Ondulada	14	Seco	Ignimbritas		R2	17-jul.	
M88	603745	7569612	4585	Diaclasa		67	26		C	1	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M89	604114	7569452	4596	Diaclasa		75	345		C	1	2	Arenas	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M89	604114	7569452	4596	Diaclasa		60	310		C	1	2	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M89	604114	7569452	4596	Diaclasa		76	300		C	1	4	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M89	604114	7569452	4596	Diaclasa		60	110		D	3	2	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M89	604114	7569452	4596	Diaclasa		42	340		D	1	3	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M89	604114	7569452	4596	Diaclasa		87	160		D	2	5	Arenas	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		86	325		C	1	0,2	Arenas	Curva	14	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		72	52		D	1	0,5	SR	Plana	16	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		75	251		D	2	2	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		80	269		C	3	0	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		71	260		C	3	10	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		78	25		D	3	4	Arenas	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		74	35		C	5	7	Arenas	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Diaclasa		80	293		C	1	3	Arenas	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M91	605271	7569381	4580	Diaclasa		80	110		C	3	2	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M91	605271	7569381	4580	Diaclasa		75	285		C	3	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M91	605271	7569381	4580	Diaclasa		83	282		D	2	1	SR	Escalonada	14	Seco	Ignimbritas		R2	17-jul.	
M91	605271	7569381	4580	Diaclasa		35	263		D	5	0,5	SR	Ondulada	14	Seco	Ignimbritas		R2	17-jul.	
M91	605271	7569381	4580	Diaclasa		76	310		C	2	0	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
L718	602844	7573598	4627	Falla		80	155		C	1	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L740	602620	7573423	4670	Falla		80	330		D	1	0	SR	Rugosa	6	Seco	Dacitas		R4	17-jul.	
L774	605502	7570166	4573	Falla		87	120		D	1	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
L780	605502	7570166	4573	Falla		75	156		D	1	4	SR	Plana	6	Seco	Dacitas		R4	17-jul.	
M81	605488	7570174	4575	Falla		60	128		C	1	0,2	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Falla		85	120		C	2	2	SR	Plana	10	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Falla		84	120		C	2	1	SR	Plana	10	Seco	Ignimbritas		R2	17-jul.	
M84	605998	7569870	4591	Falla		77	278		C		0			14	Seco	Ignimbritas		R2	17-jul.	
D-45	606268	7568055	4604	Falla Dextral		72	325		C	1	1,5	SR	Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-41	606472	7569776	4593	Falla Inversa		49	282		C	1	1		Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-42	606473	7569770	4593	Falla Inversa		75	302		C	1	0,5	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	17-jul.	
D-48	604587	7569403	4573	Falla Inversa		86	136		C	1	0	Arenas	Plana	12	Seco	Ignimbritas		R3	17-jul.	
M81	605488	7570174	4575	Falla Inversa	315	76	225		C	4	20	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M81	605488	7570174	4575	Falla Inversa		65	210		C	1	5	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Falla Inversa		65	231		C	3	0,2	SR	Plana	2	Seco	Ignimbritas		R2	17-jul.	
M88	603745	7569612	4585	Falla Inversa		64	98		C	3	0,5	SR	Escalonada	16	Seco	Ignimbritas		R2	17-jul.	
M88	603745	7569612	4585	Falla Inversa		58	96		C	3	0,5	SR	Plana	16	Seco	Ignimbritas		R2	17-jul.	
D-42	606473	7569770	4593	Falla Normal		57	163		C	1	5	SR	Plana	4	Seco	Ignimbritas		R3	17-jul.	
D-44	606263	7568057	4604	Falla Normal		79	245		C	1	4	SR	Plana	6	Seco	Ignimbritas		R3	17-jul.	

DIRECCIÓN TÉCNICA DE PROSPECCIÓN Y EXPLORACIÓN
"ESTUDIO GEOLOGICO-ESTRUCTURAL DEL AREA CIRCUNDANTE DEL MANANTIAL DEL SILALA"

SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L722	602844	7573598	4627	Falla Normal		82	305		C	1	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L723	602844	7573598	4627	Falla Normal		80	300		C	1	0	SR	Plana	8	Seco	Dacitas		R4	17-jul.	
L724	602844	7573598	4627	Falla Normal		80	110		C	1	3	SR	Plana	4	Seco	Dacitas		R4	17-jul.	Desplazamiento 10cm
L725	602844	7573598	4627	Falla Normal		83	122	75	C	1	20	Bloques	Plana	4	Seco	Dacitas		R4	17-jul.	
L733	602844	7573598	4627	Falla Normal		78	255		D	1	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	Desplazamiento 12cm
L738	602620	7573423	4670	Falla Normal		72	80		C	1	2	SR	Plana	6	Seco	Dacitas		R4	17-jul.	Desplazamiento 10cm
L775	605502	7570166	4573	Falla Normal		80	130		D	1	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	Desplazamiento 15 cm
L777	605502	7570166	4573	Falla Normal		65	132		D	1	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	Desplazamiento 15 cm
L778	605502	7570166	4573	Falla Normal		68	115		C	1	0	SR	Plana	6	Seco	Dacitas		R4	17-jul.	Desplazamiento 10 cm
M81	605488	7570174	4575	Falla Normal		67	140		C	3	1	Arenas	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Falla Normal		85	285		C	1	4	SR	Plana	12	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Falla Normal		75	125		C	1	10	Arenas	Plana	10	Seco	Ignimbritas		R2	17-jul.	
M82	605505	7570166	4578	Falla Normal		71	291		C	1	0	SR	Plana	10	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Falla Normal		76	102		C	1	2,5	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Falla Normal		64	114		C	1	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Falla Normal		65	125		C	2	1	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Falla Normal		78	110		C	5	4	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M86	605050	7569400	4576	Falla Normal		81	285		C	5	3	SR	Plana	14	Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Falla Normal		83	310		C	2	3	Arenas	Curva	14	Seco	Ignimbritas		R2	17-jul.	
L715	602844	7573598	4627	Pseudoestratificación		86	345		C						Seco	Dacitas		R4	17-jul.	
M86	605050	7569400	4576	Pseudoestratificación		26	200		C						Seco	Ignimbritas		R2	17-jul.	
M90	604565	7569415	4568	Pseudoestratificación		83	2		C						Seco	Ignimbritas		R2	17-jul.	
L784	596900	7573093	5084	Diaclasa	327	77	237		D	8	0	SR	Escalonada	8	Seco	Brecha de base		R2	18-jul.	
L785	596900	7573093	5084	Diaclasa	323	68	233		D	8	0	SR	Escalonada	8	Seco	Brecha de base		R2	18-jul.	
L793	596900	7573093	5084	Diaclasa		64	95		D	4	0	SR	Escalonada	10	Seco	Brecha de base		R2	18-jul.	
L810	596900	7573093	5084	Diaclasa		83	20		C	10	5	SR	Plana	10	Seco	Brecha de base		R3	18-jul.	
M92	597439	7573433	4942	Diaclasa		32	180		D	1	0,3	SR	Plana-Rugosa	10	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		89	230		D	5	2	SR	Plana	12	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		82	339		D	2	0	SR	Rugosa	10	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		85	117		C	1	1	Arenas	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		74	239		D	2	0,2	SR	Plana	4	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		36	224		D	3	1	SR	Plana	8	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		84	284		D	1	1	SR	Rugosa	14	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Diaclasa		56	300		C	2	0,2	SR	Plana	4	Seco	Andesitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		67	182		D	2	0,5	SR	Escalonada-Rugosa	12	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		87	87		C	1	1,5	Arenas	Rugosa	14	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		78	17		D	2	1	SR	Escalonada	12	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		49	90		D	1	0,5	SR	Ondulada	12	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		70	105		C	2	3	SR	Escalonada	12	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		86	295		C	1	14	SR	Escalonada	14	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		78	5		D	3	5	Arenas	Escalonada-Rugosa	14	Seco	Dacitas		R4	18-jul.	
M93	597364	7573240	5016	Diaclasa		60	275		D	1	4	SR	Plana	14	Seco	Dacitas		R4	18-jul.	
M95	597368	7573171	5028	Diaclasa		53	93		C	1	0,5	SR	Plana	12	Seco	Brecha de base		R3	18-jul.	
M96	597309	7573186	5146	Diaclasa		90	195		C	3	0,2	SR	Plana-Ondulada	8	Seco	Andesitas		R4	18-jul.	
M96	597309	7573186	5146	Diaclasa		87	204		C	2	0	SR	Plana	10	Seco	Andesitas		R4	18-jul.	
M96	597309	7573186	5146	Diaclasa		75	48		C	4	0	SR	Plana	10	Seco	Andesitas		R4	18-jul.	
M96	597309	7573186	5146	Diaclasa		90	210		C	3	0	SR	Plana-Ondulada	8	Seco	Andesitas		R4	18-jul.	
M96	597309	7573186	5146	Diaclasa		85	315		D	2	0	SR	Plana-Ondulada	8	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		80	253		C	1	3	SR	Plana-Ondulada	14	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		75	214		C	3	1	SR	Ondulada-Escalonada	14	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		77	75		C	1	6	SR	Ondulada	12	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		70	28		D	4	0	SR	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		82	342		C	1	1	SR	Plana-Ondulada	8	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		73	265		C	2	0,5	SR	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		76	261		C	4	0	SR	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		82	10		C	1	1	SR	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M97	597102	7572917	5143	Diaclasa		78	285		C	3	1	SR	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		87	130		D	1	1	SR	Rugosa-Ondulada	12	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		70	267		D	3	0	SR	Plana	6	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		88	0		C	4	0,5	Calcita	Plana	10	Seco	Andesitas		R4	18-jul.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M98	597073	7572838	5176	Diaclasa		76	170		C	5	2	SR	Escalonada	12	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		82	121		C	1	1	SR	Plana	4	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		75	345		C	2	2	SR	Escalonada	10	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		64	195		D	3	0,5	Calcita	Escalonada	14	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		60	245		C	3	1	SR	Plana-Ondulada	8	Seco	Andesitas		R4	18-jul.	
M98	597073	7572838	5176	Diaclasa		80	225		D	2	0,5	Calcita	Escalonada	14	Seco	Andesitas		R4	18-jul.	
L794	596900	7573093	5084	Falla		80	97		C	1	2	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L795	596900	7573093	5084	Falla		82	165		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L798	596900	7573093	5084	Falla		75	60		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L799	596900	7573093	5084	Falla		60	218		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L800	596900	7573093	5084	Falla	315	87	45		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L804	596900	7573093	5084	Falla		80	50		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L805	596900	7573093	5084	Falla		82	37		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	Desplazamiento 20cm
L790	596900	7573093	5084	Falla Inversa		86	190		C	1	0	SR	Escalonada	6	Seco	Brecha de base		R2	18-jul.	Desplazamiento 3cm
L792	596900	7573093	5084	Falla Inversa		85	201		C	1	0	SR	Escalonada	6	Seco	Brecha de base		R2	18-jul.	Desplazamiento 2cm
L808	596900	7573093	5084	Falla Inversa	335	82	245		C	1	5	SR	Curva	10	Seco	Brecha de base		R2	18-jul.	Desplazamiento 80cm
M96	597309	7573186	5146	Falla Inversa		78	70		C	1	0,5	SR	Plana-Ondulada	10	Seco	Andesitas		R4	18-jul.	Rechazo 14 cm
L786	596900	7573093	5084	Falla Normal		78	212		D	1	0	SR	Escalonada	8	Seco	Brecha de base		R2	18-jul.	Desplazamiento 2cm
L787	596900	7573093	5084	Falla Normal		70	227		D	1	0	SR	Escalonada	8	Seco	Brecha de base		R2	18-jul.	Desplazamiento 7cm
L788	596900	7573093	5084	Falla Normal		84	244		C	1	3	Arenas	Escalonada	6	Seco	Brecha de base		R2	18-jul.	Desplazamiento 4cm
L789	596900	7573093	5084	Falla Normal	333	85	243		C	1	0	SR	Escalonada	6	Seco	Brecha de base		R2	18-jul.	Desplazamiento 2cm
L791	596900	7573093	5084	Falla Normal		83	205		C	1	0	SR	Escalonada	6	Seco	Brecha de base		R2	18-jul.	Desplazamiento 1cm
L796	596900	7573093	5084	Falla Normal		74	72		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L797	596900	7573093	5084	Falla Normal	140	70	230		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L801	596900	7573093	5084	Falla Normal		87	40		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	Desplazamiento 20cm
L802	596900	7573093	5084	Falla Normal		85	42		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	Desplazamiento 20cm
L803	596900	7573093	5084	Falla Normal	300	75	210		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L806	596900	7573093	5084	Falla Normal	310	70	220		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L807	596900	7573093	5084	Falla Normal		80	14		C	1	0	SR	Ondulada	10	Seco	Brecha de base		R2	18-jul.	
L809	596900	7573093	5084	Falla Normal	220	84	130		C	1	0	SR	Plana	10	Seco	Brecha de base		R2	18-jul.	Desplazamiento 1m
M92	597439	7573433	4942	Falla Normal		42	295		C	1	0,5	SR	Plana	6	Seco	Andesitas		R4	18-jul.	
M92	597439	7573433	4942	Falla Normal		62	234		C	1	0	SR	Plana	8	Seco	Andesitas		R4	18-jul.	
M95	597368	7573171	5028	Falla Normal		52	183		C	1	0,5	SR	Plana	12	Seco	Brecha de base		R3	18-jul.	
M96	597309	7573186	5146	Falla Normal		85	188		C	3	0,5	SR	Ondulada-Escalonada	10	Seco	Andesitas		R4	18-jul.	Rechazo 10
M96	597309	7573186	5146	Pseudoestratificación		32	44		C						Seco	Andesitas		R4	18-jul.	
D49	618775	7560372	4641	Diaclasa		78	5		D	2	0,5	Arena	Plana	4	Seco	Dacitas		R4	5-ago.	
L812	619161	7562867	4932	Diaclasa		88	215		D	3	10	Bloques	Plana	8	Seco	Dacitas		R4	5-ago.	
L813	619161	7562867	4932	Diaclasa		89	290		D	3	15	Bloques	Plana	8	Seco	Dacitas		R4	5-ago.	
L814	619161	7562867	4932	Diaclasa		90	330		D	4	10	Bloques	Plana	8	Seco	Dacitas		R4	5-ago.	
L815	619161	7562867	4932	Diaclasa		90	250		D	4	5	Bloques	Plana	8	Seco	Dacitas		R4	5-ago.	
L816	619161	7562867	4932	Diaclasa		80	170		D	2	4	SR	Plana	8	Seco	Dacitas		R4	5-ago.	
L826	619721	7563352	4926	Diaclasa		75	216		C	5	5	SR	Plana	8	Seco	Dacitas		R4	5-ago.	
L827	619721	7563352	4926	Diaclasa		76	54		C	5	3	SR	Plana	8	Seco	Dacitas		R4	5-ago.	
L828	619721	7563352	4926	Diaclasa		81	33		C	3	6	SR	Plana	8	Seco	Dacitas		R4	5-ago.	
L830	619721	7563352	4926	Diaclasa		75	35		C	2	10	Bloques	Plana	8	Seco	Dacitas		R4	5-ago.	
L832	620202	7563755	4924	Diaclasa		88	85		D	4	45	Arena	Plana	8	Seco	Dacitas		R4	5-ago.	
L833	620202	7563755	4924	Diaclasa		89	86		D	3	5	SR	Plana	8	Seco	Dacitas		R4	5-ago.	
L834	620202	7563755	4924	Diaclasa		85	152		D	2	2	SR	Ondulada	8	Seco	Dacitas		R4	5-ago.	
L835	620202	7563755	4924	Diaclasa		70	97		D	5	1	SR	Ondulada	8	Seco	Dacitas		R4	5-ago.	
L836	620202	7563755	4924	Diaclasa		80	91		D	5	2	SR	Ondulada	8	Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Diaclasa		75	35		C	1	1	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Diaclasa		83	65		C	1	0,5	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Diaclasa		85	346		C	2	1	SR	Escalonada	12	Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Diaclasa		72	340		C	2	0	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M103	620070	7563003	4995	Diaclasa	75	86	165		C	2	3	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M103	620070	7563003	4995	Diaclasa		65	9		D	4	0,2	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M103	620070	7563003	4995	Diaclasa		65	11		D	2	0,2	SR	Curva	10	Seco	Dacitas		R4	5-ago.	
M103	620070	7563003	4995	Diaclasa	86	70	356		D	2	1	SR	Curva	10	Seco	Dacitas		R4	5-ago.	
M104	620140	7563342	4975	Diaclasa		80	185		C	2	3	Arenas	Escalonada	10	Seco	Dacitas		R4	5-ago.	
M104	620140	7563342	4975	Diaclasa	184	86	274		D	1	0,5	Arenas	Plana	12	Seco	Dacitas		R4	5-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M105	620177	7563733	4927	Diaclasa		73	270		D	4	2	SR	Escalonada	12	Seco	Dacitas		R4	5-ago.	
M105	620177	7563733	4927	Diaclasa		42	254		D	1	1	SR	Escalonada	12	Seco	Dacitas		R4	5-ago.	
M105	620177	7563733	4927	Diaclasa		76	278		D	2	1	SR	Escalonada	12	Seco	Dacitas		R4	5-ago.	
M107	620237	7563874	4862	Diaclasa		85	110		C	2	4	Arenas	Escalonada	12	Seco	Dacitas		R4	5-ago.	
M99	618901	7561435	4786	Diaclasa		42	164		D	1	2	SR	Ondulada	10	Seco	Dacitas		R4	5-ago.	
M99	618901	7561435	4786	Diaclasa		74	145		D	1	0,5	SR	Plana	10	Seco	Dacitas		R4	5-ago.	
M99	618901	7561435	4786	Diaclasa		70	347		C	2	0,2	SR	Ondulada	12	Seco	Dacitas		R4	5-ago.	
M99	618901	7561435	4786	Diaclasa		74	110		C	2	0	SR	Plana	10	Seco	Dacitas		R4	5-ago.	
M99	618901	7561435	4786	Diaclasa		77	86		C	1	0,2	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
L819	619161	7562867	4932	Falla		45	70		C	1	0	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	
D51	618682	7560076	4716	Falla Inversa		45	150		D	1		SR	Ondulada-Rugosa	12	Seco	Dacitas		R4	5-ago.	Rechazo 5 cm (foto)
D53	618448	7559416	4806	Falla Inversa		68	228		C	1	1 a 2	Arena	Rugosa-Ondulada	10	Seco	Dacitas		R4	5-ago.	Rechazo 4 cm
D54	618230	7558950	4718	Falla Inversa		68	273		C	4	1 a 3	SR	Plana-Ondulada	14	Seco	Dacitas		R4	5-ago.	Rechazo 15 cm
D54	618230	7558950	4718	Falla Inversa		48	267		C	2	0,5	SR	Plana-Rugosa	12	Seco	Dacitas		R4	5-ago.	Rechazo 3 cm
D55	618154	7558784	4737	Falla Inversa		67	109		C	1	0,5 a 6	Arena	Plana	4	Seco	Dacitas		R4	5-ago.	Rechazo 1 cm
D57	617781	7558778	4673	Falla Inversa		46	330		D	1	0,2	SR	Ondulada	4	Seco	Dacitas		R4	5-ago.	Rechazo 12 cm
D58	617670	7558793	4655	Falla Inversa		82	5		C	1	5	SR	Rugosa-Escalonada	14	Seco	Dacitas		R4	5-ago.	Rechazo 4 cm
D61	618656	7560221	4674	Falla Inversa		70	277		C	1	0,5 a 3	Arena	Rugosa	10	Seco	Dacitas		R4	5-ago.	Rechazo 12 cm
D61	618656	7560221	4674	Falla Inversa		79	111		C	1	1 a 5	Arena	Rugosa-Escalonada	14	Seco	Dacitas		R4	5-ago.	Rechazo 8 cm
D61	618656	7560221	4674	Falla Inversa		40	20		C	1	1 a 3	SR	Plana-Ondulada	8	Seco	Dacitas		R4	5-ago.	Rechazo 9 cm
M100	619447	7561488	4936	Falla Inversa		87	335		C	1	1	SR	Plana	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 5cm
M106	620231	7563821	4896	Falla Inversa		83	210		C	1	5	SR	Curva	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 12cm
M107	620237	7563874	4862	Falla Inversa		89	33		C	1	2		Plana	10	Seco	Dacitas		R4	5-ago.	Desplazamiento 14 cm
D49	618775	7560372	4641	Falla Normal		79	100		C	1	2 a 5	Arena	Plana	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 14 cm
D49	618775	7560372	4641	Falla Normal		85	23		C	1	0,5 a 5	Arena	Plana	4	Seco	Dacitas		R4	5-ago.	Desplazamiento 2 cm
D50	618704	7560113	4705	Falla Normal		86	204		C	1	1 a 10	Arena	Plana-Ondulada	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 8 cm
D50	618704	7560113	4705	Falla Normal		78	204		C	1	10 a 30	Arena	Ondulada-Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 7 cm
D52	618580	7559457	4791	Falla Normal		70	315		C	1		SR	Plana-Escalonada	12	Seco	Dacitas		R4	5-ago.	
D52	618580	7559457	4791	Falla Normal		89	95		C	1		SR	Plana-Escalonada	12	Seco	Dacitas		R4	5-ago.	Desplazamiento 11 cm
D52	618580	7559457	4791	Falla Normal		75	14		C	1	1,5 a 5	Arena	Ondulada-Escalonada	14	Seco	Dacitas		R4	5-ago.	Desplazamiento 8 cm
D56	617925	7558777	4698	Falla Normal		41	303		C	1	2	Arena	Rugosa-Ondulada	12	Seco	Dacitas		R4	5-ago.	Desplazamiento 5cm
D56	617923	7558777	4698	Falla Normal		74	280		C	1	2,5 a 5	Arena	Rugosa-Ondulada	12	Seco	Dacitas		R4	5-ago.	Desplazamiento 4 cm
D59	617554	7558848	4640	Falla Normal		87	189		C	1	0,3 a 2	SR	Plana-Ondulada	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 3 cm
D60	618360	7559925	4685	Falla Normal		67	223		C	1	1 a 2	Arena	Plana-Rugosa	10	Seco	Dacitas		R4	5-ago.	Desplazamiento 6 cm
D62	618705	7560315	4640	Falla Normal		78	162		C	1	0,5 a 3	Arena	Ondulada-Rugosa	12	Seco	Dacitas		R4	5-ago.	Desplazamiento 7 cm
L818	619161	7562867	4932	Falla Normal		50	115		C	1	0	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 5 cm
L820	619161	7562867	4932	Falla Normal		40	240		C	1	0	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	
L821	619161	7562867	4932	Falla Normal		87	282		C	1	1	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 2 a 4 cm
L822	619161	7562867	4932	Falla Normal		80	295		C	1	0,5	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 2 a 4 cm
L823	619161	7562867	4932	Falla Normal		86	303		C	1	0	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 2 a 4 cm
L824	619161	7562867	4932	Falla Normal		85	266		C	1	2	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 2 a 4 cm
L825	619161	7562867	4932	Falla Normal		70	310		C	1	1	SR	Rugosa	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 3 cm
L837	620202	7563755	4924	Falla Normal		80	145	170	D	1	0	SR	Ondulada	8	Seco	Dacitas		R4	5-ago.	
L838	620267	7563920	4848	Falla Normal		72	340		D	1	1	SR	Plana	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 2 cm
L839	620267	7563920	4848	Falla Normal		80	333		D	1	0,5	SR	Plana	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 5 cm
L840	620267	7563920	4848	Falla Normal		81	352		D	1	1,5	SR	Plana	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 4 cm
L841	620267	7563920	4848	Falla Normal		83	350		D	1	1	SR	Plana	8	Seco	Dacitas		R4	5-ago.	Desplazamiento 3 cm
M100	619447	7561488	4936	Falla Normal	148	79	238		C	1	2	SR	Ondulada	10	Seco	Dacitas		R4	5-ago.	Desplazamiento 10cm
M100	619447	7561488	4936	Falla Normal	157	73	247		C	1	0,5	SR	Curva	10	Seco	Dacitas		R4	5-ago.	Desplazamiento 15cm
M101	619487	7561521	4942	Falla Normal		70	198		C	1	12	SR	Plana	12	Seco	Dacitas	Argilica	R4	5-ago.	
M102	619994	7562356	5009	Falla Normal		24	194		C	3	0,2	SR	Plana	10	Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Falla Normal		82	55		C	1	0,5	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Falla Normal		76	172		C	1	0,5	SR	Plana	12	Seco	Dacitas		R4	5-ago.	
M105	620177	7563733	4927	Falla Normal	193	79	283		C	1	4	Arenas	Plana	12	Seco	Dacitas		R4	5-ago.	Desplazamiento 8 cm
M107	620237	7563874	4862	Falla Normal		56	157		C	1	5		Plana	10	Seco	Dacitas		R4	5-ago.	Desplazamiento 7cm
M107	620237	7563874	4862	Falla Normal		82	190		C	2	10		Plana	10	Seco	Dacitas		R4	5-ago.	Desplazamiento 5cm
M108	613250	7557802	4676	Falla Normal	160	74	70		C	1	3	SR	Ondulada	10	Seco	Dacita-Andesita		R4	5-ago.	
M99	618901	7561435	4786	Falla Normal		47	140		C	1	12	SR	Plana	12	Seco	Dacitas		R4	5-ago.	Desplazamiento12cm
M99	618901	7561435	4786	Falla Normal		83	100		C	1	1	Arenas	Plana	10	Seco	Dacitas		R4	5-ago.	Desplazamiento13cm
L811	619161	7562867	4932	Foliacion		64	35		C	1	0	SR	Plana	4	Seco	Dacitas		R4	5-ago.	

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SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L817	619161	7562867	4932	Foliacion		58	255		C	1	0	SR	Plana	4	Seco	Dacitas		R4	5-ago.	
L829	619721	7563352	4926	Pseudoestratificación		38	125		C						Seco	Dacitas		R4	5-ago.	
L831	620202	7563755	4924	Pseudoestratificación		72	185		C						Seco	Dacitas		R4	5-ago.	
M102	619994	7562356	5009	Pseudoestratificación		30	216		C						Seco	Dacitas		R4	5-ago.	
M103	620070	7563003	4995	Pseudoestratificación		49	158		D						Seco	Dacitas		R4	5-ago.	
M104	620140	7563342	4975	Pseudoestratificación		32	204		C						Seco	Dacitas		R4	5-ago.	
M107	620237	7563874	4862	Pseudoestratificación		35	250		C						Seco	Dacitas		R4	5-ago.	Desplazamiento 12cm
D63	618033	7557181	4524	Diaclasa		77	178		D	4	0,5	Arena	Plana-Ondulada	8	Seco	Dacitas		R4	6-ago.	
D63	618033	7557181	4524	Diaclasa		84	11		C	3	1 a 2	Arena	Plana-Ondulada	8	Seco	Dacitas		R4	6-ago.	
D63	618033	7557181	4524	Diaclasa		55	293		D	3	0,2	Arena	Rugosa-Plana	12	Seco	Dacitas		R4	6-ago.	
D65	617369	7556982	4547	Diaclasa		78	274		C	2	2	Arena	Ondulada-Rugosa	12	Seco	Dacitas		R4	6-ago.	
D65	617369	7556982	4547	Diaclasa		88	354		D	2	1	Arena	Plana	8	Seco	Dacitas		R4	6-ago.	
D65	617369	7556982	4547	Diaclasa		83	303		D	5	0,5 a 1	Arena	Ondulada-Rugosa	12	Seco	Dacitas		R4	6-ago.	
D65	617369	7556982	4547	Diaclasa		78	214		D	4	0,2 a 2	Arena	Ondulada	12	Seco	Dacitas		R4	6-ago.	
D68	616451	7556569	4618	Diaclasa		82	153		D	1		SR	Rugosa	12	Seco	Dacitas		R4	6-ago.	
D68	616451	7556569	4618	Diaclasa		87	132		D	1	1 a 2	Arena	Rugosa	12	Seco	Dacitas		R4	6-ago.	
D68	616451	7556569	4618	Diaclasa		82	271		C	2	6 a 10	Arena	Plana-Escalonada	14	Seco	Dacitas		R4	6-ago.	
D69	615398	7556204	4632	Diaclasa		83	212		D	2	0,5 a 3	Arena	Plana	4	Seco	Andesitas		R4	6-ago.	
D69	615398	7556204	4632	Diaclasa		83	209		C	2	5	Arena	Rugosa-Escalonada	14	Seco	Andesitas		R4	6-ago.	
D75	615788	7555334	4772	Diaclasa		72	58		C	2		SR	Ondulada-Rugosa	12	Seco	Dacitas		R4	6-ago.	
D75	615788	7555334	4772	Diaclasa		70	40		D	2		SR	Ondulada-Rugosa	12	Seco	Dacitas		R4	6-ago.	
L842	615309	7557748	4616	Diaclasa		59	218		C	3	2	SR	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L843	615309	7557748	4616	Diaclasa		70	245		D	2	10	SR	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L844	615309	7557748	4616	Diaclasa		88	290		D	4	0	SR	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L845	615309	7557748	4616	Diaclasa		72	308		D	2	30	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L846	615309	7557748	4616	Diaclasa		89	178		D	6	3	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L847	615309	7557748	4616	Diaclasa		85	174		D	5	2	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L848	615309	7557748	4616	Diaclasa		89	176		D	4	5	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L849	615309	7557748	4616	Diaclasa		80	196		D	4	2	SR	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L850	615197	7557515	4644	Diaclasa		86	168		D	3	2	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L851	615197	7557515	4644	Diaclasa		72	192		D	3	4	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L852	615197	7557515	4644	Diaclasa		58	150		D	3	2	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L853	615197	7557515	4644	Diaclasa		60	130		D	6	1	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L854	615197	7557515	4644	Diaclasa		85	174		D	4	3	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L855	614626	7557052	4618	Diaclasa		76	60		D	3	3	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L856	614626	7557052	4618	Diaclasa		70	210		D	4	8	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L857	614626	7557052	4618	Diaclasa		87	224		D	3	0	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L858	614626	7557052	4618	Diaclasa		78	100		D	5	3	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L859	614626	7557052	4618	Diaclasa		68	249		C	4	10	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L860	614626	7557052	4618	Diaclasa		72	244		C	4	15	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L861	614626	7557052	4618	Diaclasa		70	211		C	3	0	Arena	Plana	10	Seco	Traquita Andesita		R4	6-ago.	
L862	614626	7557052	4618	Diaclasa		69	192		C	8	0	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L866	613928	7556779	4632	Diaclasa		60	160		C	3	5	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L873	612217	7556193	4826	Diaclasa		85	300		D	2	2	SR	Ondulada	12	Seco	Dacitas		R4	6-ago.	
L876	612217	7556193	4826	Diaclasa		61	154		C	3	2	SR	Ondulada	12	Seco	Dacitas		R4	6-ago.	
L877	612217	7556193	4826	Diaclasa		50	60		C	2	0	SR	Ondulada	12	Seco	Dacitas		R4	6-ago.	
L880	613626	7557506	4678	Diaclasa		60	114		C	2	5	SR	Plana	8	Seco	Dacitas		R4	6-ago.	
L881	613626	7557506	4678	Diaclasa		80	104		D	3	1	SR	Plana	8	Seco	Dacitas		R4	6-ago.	
L882	613626	7557506	4678	Diaclasa		78	357		D	3	0,5	Arena	Plana	8	Seco	Dacitas		R4	6-ago.	
L883	613626	7557506	4678	Diaclasa		62	290		D	2	0	SR	Plana	8	Seco	Dacitas		R4	6-ago.	
L865	613928	7556779	4632	Falla		62	346		C	1	0	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L869	613757	7556479	4645	Falla		45	140		C	1	1	Silice	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L870	613757	7556479	4645	Falla		58	150		C	1	2	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L871	613757	7556479	4645	Falla		51	240		C	1	1	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L872	612217	7556193	4826	Falla		35	80		C	1	0	SR	Ondulada	12	Seco	Traquita Andesita		R4	6-ago.	
L874	612217	7556193	4826	Falla		65	178		C	1	0	SR	Ondulada	12	Seco	Dacitas		R4	6-ago.	
L875	612217	7556193	4826	Falla		70	200		C	1	0	SR	Ondulada	12	Seco	Dacitas		R4	6-ago.	
M109	612815	7557642	4711	Falla	193	78	103		C	1	8	Arena	Plana	8	Seco	Dacita-Andesita		R4	6-ago.	
M110	611661	7556887	4791	Falla	123	84	213		C	1	5	SR	Escalonada	12	Seco	Andesitas		R4	6-ago.	
M108	613250	7557802	4676	Falla	162	84	72		C	1	1	SR	Plana	10	Seco	Dacita-Andesita		R4	6-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M109	612815	7557642	4711	Falla	215	75	125		C	1	10	Arena	Escalonada	8	Seco	Dacita-Andesita		R4	6-ago.	
D64	617822	7557116	4531	Falla Inversa		85	226		C	1	0,2 a 1,5	SR	Rugosa	12	Seco	Dacitas		R4	6-ago.	Rechazo 2 cm
D70	615373	7556217	4631	Falla Inversa		82	176		C	1	1	Arena	Plana-Ondulada	4	Seco	Andesitas		R4	6-ago.	Rechazo 10 cm
D71	614501	7555581	4678	Falla Inversa		71	355		C	1	4	Arena	Plana	4	Seco	Brecha de base		R3	6-ago.	Rechazo 6 cm
D73	614887	7555157	4655	Falla Inversa		86	75		C	1	14	Arena	Rugosa-Ondulada	12	Seco	Andesitas		R4	6-ago.	Rechazo 15 cm
D73	614887	7555157	4655	Falla Inversa		86	220		C	1	6	Arena	Rugosa-Escalonada	14	Seco	Andesitas		R4	6-ago.	Desplazamiento 17 cm
D74	615505	7554591	4704	Falla Inversa		87	280		C	1	0,2	SR	Ondulada	14	Seco	Andesitas		R4	6-ago.	Rechazo 2,5 cm
D74	615505	7554591	4704	Falla Inversa		58	330		D	1	7	SR	Rugosa-Escalonada	14	Seco	Andesitas		R4	6-ago.	Rechazo 10 cm
D76	616196	7555510	4688	Falla Inversa		64	240		C	1	7 a 15	Arena	Escalonada	14	Seco	Brecha de base		R3	6-ago.	Rechazo 20 cm
D66	616887	7556793	4573	Falla Normal		55	304		C	1	4	SR	Ondulada-Rugosa	12	Seco	Brecha de base		R3	6-ago.	Desplazamiento 3 cm
D67	616686	7556673	4633	Falla Normal		74	143		C	1	1 a 5	Arena	Rugosa-Escalonada	14	Seco	Brecha de base		R3	6-ago.	Desplazamiento 3 cm
D72	614517	7555554	4676	Falla Normal		68	15		D	1		SR	Plana	4	Seco	Brecha de base		R3	6-ago.	
E641	611122	7556009	5035	Falla Normal	148	75	58		C	1	10	SR	Escalonada	12	Seco	Andesitas		R4	6-ago.	
E641	611122	7556009	5035	Falla Normal		71	342		C	1	3	SR	Plana	6	Seco	Andesitas		R4	6-ago.	
L864	613928	7556779	4632	Falla Normal		58	175	260	C	1	0	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	
L867	613757	7556479	4645	Falla Normal		59	120		C	1	0	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	Desplazamiento 7cm
L868	613757	7556479	4645	Falla Normal		44	85	185	C	1	0	SR	Ondulada	10	Seco	Traquita Andesita		R4	6-ago.	Desplazamiento 7cm
L879	613626	7557506	4678	Falla Normal		89	165		C	1	2	Arena	Plana	8	Seco	Dacitas		R4	6-ago.	
M108	613250	7557802	4676	Falla Normal	140	83	50		C	2	4	SR	Escalonada	10	Seco	Dacita-Andesita		R4	6-ago.	Desplazamiento 10 cm
M110	611661	7556887	4791	Falla Normal	82	67	352		C	1	2	SR	Escalonada	12	Seco	Andesitas		R4	6-ago.	
M111	611566	7555550	4971	Falla Normal		84	330		C	1	2	SR	Escalonada	10	Seco	Andesitas		R4	6-ago.	
E641	611122	7556009	5035	Pseudoestratificación		20	144		C						Seco	Andesitas		R4	6-ago.	
L863	613928	7556779	4632	Pseudoestratificación		50	220		C						Seco	Traquita Andesita		R4	6-ago.	
L878	613626	7557506	4678	Pseudoestratificación		52	125		C						Seco	Dacitas		R4	6-ago.	
M110	611661	7556887	4791	Pseudoestratificación		29	161		C						Seco	Andesitas		R4	6-ago.	
M111	611566	7555550	4971	Pseudoestratificación		24	168		C						Seco	Andesitas		R4	6-ago.	
D78	610657	7557189	4896	Diaclasa		51	157		C	1	0,2	SR	Plana	4	Seco	Dacitas		R4	7-ago.	
D79	610506	7556996	4918	Diaclasa		78	162		C	3	0,1	SR	Plana-Ondulada	8	Seco	Dacitas		R4	7-ago.	
D79	610506	7556996	4918	Diaclasa		80	60		D	3	0,5	Arena	Plana	8	Seco	Dacitas		R4	7-ago.	
D79	610506	7556996	4918	Diaclasa		82	155		D	1	0,2	Arena	Plana-Ondulada	4	Seco	Dacitas		R4	7-ago.	
D80	609278	7556652	5172	Diaclasa		88	143		D	3		SR	Plana	4	Seco	Andesitas		R4	7-ago.	
D80	609278	7556652	5172	Diaclasa		70	214		C	1	0,2 a 1	SR	Plana	4	Seco	Andesitas		R4	7-ago.	
D80	609278	7556652	5172	Diaclasa		48	242		C	1	1	SR	Plana	4	Seco	Andesitas		R4	7-ago.	
D82	608902	7557115	5318	Diaclasa		80	112		C	1	1 a 3	Arena	Plana	4	Seco	Andesitas		R4	7-ago.	
L884	611059	7563189	4620	Diaclasa		80	88		D	6	0	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L885	611059	7563189	4620	Diaclasa		82	80		D	6	3	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L886	611059	7563189	4620	Diaclasa		89	60		D	5	1	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L887	611059	7563189	4620	Diaclasa		82	65		D	5	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L888	611059	7563189	4620	Diaclasa		85	67		D	5	2	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L889	611059	7563189	4620	Diaclasa		70	60		D	3	3	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L895	611059	7563189	4620	Diaclasa		60	330		C	6	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L896	611059	7563189	4620	Diaclasa		79	319		C	6	3	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L897	611059	7563189	4620	Diaclasa		87	327		C	6	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L898	611059	7563189	4620	Diaclasa		72	320		D	5	2	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L899	611059	7563189	4620	Diaclasa		70	327		D	5	3	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L904	610788	7562551	4680	Diaclasa		79	212		D	2	6	Oxidos de Fe	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L905	610788	7562551	4680	Diaclasa		89	325		D	2	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L906	610788	7562551	4680	Diaclasa		88	350		D	2	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L907	610788	7562551	4680	Diaclasa		87	307		D	2	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L908	610172	7561947	4744	Diaclasa		87	120		C	6	6	SR	Ondulada	12	Seco	Dacitas		R4	7-ago.	
L909	610172	7561947	4744	Diaclasa		88	141		C	6	5	SR	Ondulada	12	Seco	Dacitas		R4	7-ago.	
L910	610172	7561947	4744	Diaclasa		85	136		C	6	10	SR	Ondulada	12	Seco	Dacitas		R4	7-ago.	
L911	610172	7561947	4744	Diaclasa		86	140		C	6	2	SR	Ondulada	12	Seco	Dacitas		R4	7-ago.	
L917	609612	7562546	4758	Diaclasa		42	346		D	2	0	SR	Plana	6	Seco	Dacitas		R4	7-ago.	
L920	609612	7562546	4758	Diaclasa		70	150		D	2	1	SR	Plana	6	Seco	Dacitas		R4	7-ago.	
L923	610442	7564289	4626	Diaclasa		80	276		C	3	10	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L924	610442	7564289	4626	Diaclasa		87	286		D	3	2	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L925	610442	7564289	4626	Diaclasa		89	290		D	3	0	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L926	610442	7564289	4626	Diaclasa		89	320		D	2	10	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L927	610442	7564289	4626	Diaclasa		85	316		D	3	2	SR	Plana	10	Seco	Dacitas		R4	7-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L928	610442	7564289	4626	Diaclasa		68	350		D	2	4	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L929	610442	7564289	4626	Diaclasa		75	306		D	3	0,5	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L930	610442	7564289	4626	Diaclasa		68	80		D	2	0	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
L932	610442	7564289	4626	Diaclasa		65	114		C	2	2	SR	Plana	10	Seco	Dacitas		R4	7-ago.	
M112	611170	7561364	4718	Diaclasa	280	42	190		C	1	8	SR	Plana	14	Seco	Andesitas		R4	7-ago.	
M112	611170	7561364	4718	Diaclasa	232	80	142		C	1	6	SR	Escalonada	12	Seco	Andesitas		R4	7-ago.	
M112	611170	7561364	4718	Diaclasa	243	72	333		C	1	2	SR	Escalonada	14	Seco	Andesitas		R4	7-ago.	
M112	611170	7561364	4718	Diaclasa	240	81	150		C	4	0,5	Arena	Plana	6	Seco	Andesitas		R4	7-ago.	
M113	609090	7560900	5009	Diaclasa		60	165		C	1	2	SR	Escalonada	14	Seco	Andesitas		R4	7-ago.	
M113	609090	7560900	5009	Diaclasa		78	130		C	1	2	SR	Plana	12	Seco	Andesitas		R4	7-ago.	
M114	609095	7560829	5023	Diaclasa	220	70	130		C	2	4	SR	Plana	12	Seco	Andesitas		R4	7-ago.	
M114	609095	7560829	5023	Diaclasa	226	74	136		C	2	3	SR	Escalonada	12	Seco	Andesitas		R4	7-ago.	
M114	609095	7560829	5023	Diaclasa	228	79	138		C	1	2	SR	Plana	12	Seco	Andesitas		R4	7-ago.	
M114	609095	7560829	5023	Diaclasa	193	71	283		C	1	1	SR	Plana	12	Seco	Andesitas		R4	7-ago.	
M115	608335	7560314	5154	Diaclasa	160	82	250		D	1	2	SR	Escalonada	12	Seco	Brecha de base	Argilica	R3	7-ago.	
M117	608451	7560271	5123	Diaclasa	262	75	172		D	4	2	SR	Escalonada	8	Seco	Andesitas		R4	7-ago.	
M117	608451	7560271	5123	Diaclasa	270	76	180		D	2	4	SR	Escalonada	8	Seco	Andesitas		R4	7-ago.	
L912	609801	7562092	4741	Falla		70	135		C	1	2	SR	Ondulada	12	Seco	Brecha de base		R3	7-ago.	
L913	609801	7562092	4741	Falla		62	147		C	1	0	SR	Ondulada	12	Seco	Brecha de base		R3	7-ago.	
L914	609801	7562092	4741	Falla		72	130		C	1	0	SR	Ondulada	12	Seco	Brecha de base		R3	7-ago.	
L915	609801	7562092	4741	Falla		88	100		C	1	0	SR	Ondulada	12	Seco	Brecha de base		R3	7-ago.	
L916	609801	7562092	4741	Falla		78	122		C	1	0	SR	Ondulada	12	Seco	Brecha de base		R3	7-ago.	
L918	609612	7562546	4758	Falla		55	100		D	1	0	SR	Plana	6	Seco	Dacitas		R4	7-ago.	
L919	609612	7562546	4758	Falla		32	80		D	1	0	SR	Plana	6	Seco	Dacitas		R4	7-ago.	
L922	609612	7562546	4758	Falla		84	197		C	1	1	Arena	Plana	6	Seco	Dacitas		R4	7-ago.	
M113	609090	7560900	5009	Falla		73	134		D	1	2	SR	Escalonada	14	Seco	Andesitas		R4	7-ago.	
L903	610788	7562551	4680	Falla Dextral		28	135		D	1	0	SR	Plana	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 5 cm
D78	610657	7557189	4896	Falla Inversa		85	257		C	3	0,2 a 1,5	SR	Rugosa-Escalonada	12	Seco	Dacitas		R4	7-ago.	Rechazo 5 cm
D78	610657	7557189	4896	Falla Inversa		75	262		D	3	0,5	SR	Rugosa	12	Seco	Dacitas		R4	7-ago.	Rechazo 2cm (microfalla)
D82	608902	7557115	5318	Falla Inversa		38	305		D	1	1	SR	Rugosa-Ondulada	12	Seco	Andesitas		R4	7-ago.	
E-656	609104	7560874	5004	Falla Inversa		74	285	122	C	1	5	SR	Escalonada	12	Seco	Andesitas		R4	7-ago.	Desplazamiento 8cm
M115	608335	7560314	5154	Falla Inversa	160	70	70		C	1	5	SR	Escalonada	12	Seco	Brecha de base	Argilica	R3	7-ago.	
M115	608335	7560314	5154	Falla Inversa	161	64	251		C	1	0,5	Milonita	Escalonada	6	Seco	Andesitas		R4	7-ago.	Rechazo 18 cm
M116	608392	7560302	5137	Falla Inversa		43	275		C	1	1	SR	Plana	14	Seco	Andesitas	Argilica	R4	7-ago.	Rechazo 10 cm
M119	608956	7560247	5036	Falla Inversa	203	54	113		C	1	12	SR	Plana	14	Seco	Andesitas		R4	7-ago.	
D78	610657	7557189	4896	Falla Normal		78	98		D	1	0,5	SR	Rugosa	12	Seco	Dacitas		R4	7-ago.	Desplazamiento 2 cm
D80	609278	7556652	5172	Falla Normal		45	240		C	1	1 a 10	Arena	Plana	4	Seco	Andesitas		R4	7-ago.	Desplazamiento 27 cm
D81	608738	7556960	5355	Falla Normal		50	58		C	1	0,5 a 2	SR	Rugosa-Escalonada	14	Seco	Andesitas		R4	7-ago.	
E-656	609104	7560874	5004	Falla Normal		70	287		C	1	15	SR	Plana	10	Seco	Andesitas		R4	7-ago.	
L890	611059	7563189	4620	Falla Normal		79	62		C	7	2	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 1cm
L891	611059	7563189	4620	Falla Normal		84	60		C	7	1	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 3cm
L892	611059	7563189	4620	Falla Normal		80	70		C	7	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 4cm
L893	611059	7563189	4620	Falla Normal		75	51		C	7	8	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 5cm
L894	611059	7563189	4620	Falla Normal		86	45		C	7	1	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 10cm
L900	611059	7563189	4620	Falla Normal		70	20		D	3	5	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 15 cm
L901	611059	7563189	4620	Falla Normal		70	23		D	1	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L902	611059	7563189	4620	Falla Normal		70	86		D	1	0	SR	Ondulada	10	Seco	Dacitas		R4	7-ago.	
L921	609612	7562546	4758	Falla Normal		44	10		D	1	15	SR	Plana	6	Seco	Dacitas		R4	7-ago.	Desplazamiento 10 cm
L931	610442	7564289	4626	Falla Normal		87	122		C	1	1	SR	Plana	10	Seco	Dacitas		R4	7-ago.	Desplazamiento 5 cm
M113	609090	7560900	5009	Falla Normal	200	80	110		C	1	7	SR	Escalonada	12	Seco	Andesitas		R4	7-ago.	Desplazamiento 30 cm
M113	609090	7560900	5009	Falla Normal	265	61	175		C	1	1	Arena	Escalonada	12	Seco	Andesitas		R4	7-ago.	
M114	609095	7560829	5023	Falla Normal	230	74	140		C	1	2	SR	Plana	12	Seco	Andesitas		R4	7-ago.	Desplazamiento 9cm
M114	609095	7560829	5023	Falla Normal	315	76	225		C	1	4	SR	Plana	10	Seco	Andesitas		R4	7-ago.	Desplazamiento 2 cm
M115	608335	7560314	5154	Falla Normal	250	86	340		C	1	2	SR	Plana	8	Seco	Andesitas		R4	7-ago.	
M115	608335	7560314	5154	Falla Normal		85	59		C	1	2	SR	Escalonada	8	Seco	Andesitas		R4	7-ago.	Desplazamiento 3cm
M115	608335	7560314	5154	Falla Normal		76	64		C	1	1	SR	Escalonada	8	Seco	Andesitas		R4	7-ago.	Desplazamiento 2cm
M116	608392	7560302	5137	Falla Normal	183	82	93		C	1	2	SR	Escalonada	14	Seco	Andesitas	Argilica	R4	7-ago.	
M116	608392	7560302	5137	Falla Normal		43	120	45	C	1	10	SR	Escalonada	12	Seco	Andesitas		R4	7-ago.	Desplazamiento 15 cm
M117	608451	7560271	5123	Falla Normal	250	80	160		C	2	8	SR	Escalonada	14	Seco	Andesitas		R4	7-ago.	
M118	608840	7560260	5042	Falla Normal	183	83	273		C	1	5	SR	Escalonada	8	Seco	Andesitas		R4	7-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M118	608840	7560260	5042	Falla Normal	180	68	90		C	1	8	SR	Escalonada	14	Seco	Andesitas		R4	7-ago.	Desplazamiento 3 cm
M119	608956	7560247	5036	Falla Normal	190	65	100		C	1	2	SR	Escalonada	12	Seco	Andesitas		R4	7-ago.	Desplazamiento 8 cm
D79	610506	7556996	4918	Falla Sinestral		73	148		D	1	0,2	SR	Plana-Ondulada	4	Seco	Dacitas		R4	7-ago.	Desplazamiento 1 cm
M119	608956	7560247	5036	Falla Sinestral		66	144		C	1	10	SR	Plana	14	Seco	Andesitas		R4	7-ago.	
D80	609278	7556652	5172	Pseudoestratificación		55	232		C						Seco	Andesitas		R4	7-ago.	
D82	608902	7557115	5318	Pseudoestratificación		21	195		C						Seco	Andesitas		R4	7-ago.	
M113	609090	7560900	5009	Pseudoestratificación		33	220		C						Seco	Andesitas		R4	7-ago.	
D84	609855	7574238	4746	Diaclasa		87	160		D	2		SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	
D84	609855	7574238	4746	Diaclasa		80	40		D	2		SR	Rugosa-Ondulada	12	Seco	Ignimbritas		R3	8-ago.	
D85	609371	7574022	4722	Diaclasa		74	145		C	6	1	SR	Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D85	609371	7574022	4722	Diaclasa		84	340		C	2		SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	8-ago.	
D85	609371	7574022	4722	Diaclasa		73	25		C	2		SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D87	607313	7573578	4645	Diaclasa		47	275		D	2		SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	
D87	607313	7573578	4645	Diaclasa		46	312		D	3		SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	
D88	607318	7573582	4645	Diaclasa		87	308		C	3		SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D89	608189	7572805	4654	Diaclasa		69	22		D	2	1	SR	Ondulada-Rugosa	8	Seco	Ignimbritas		R3	8-ago.	
D89	608189	7572805	4654	Diaclasa		87	109		C	2	3,5	SR	Plana-Rugosa	8	Seco	Ignimbritas		R3	8-ago.	
D89	608189	7572805	4654	Diaclasa		70	35		D	2	4	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D89	608189	7572805	4654	Diaclasa		88	305		C	3		SR	Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D91	608065	7575005	4744	Diaclasa		88	105		C	4	0,5	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D91	608065	7575005	4744	Diaclasa		64	287		C	1	0,5	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D92	609034	7575516	4933	Diaclasa		62	92		C	4	5	Arena	Plana-Ondulada	8	Seco	Dacitas		R4	8-ago.	
D92	609034	7575516	4933	Diaclasa		88	285		D	3		SR	Plana-Ondulada	8	Seco	Dacitas		R4	8-ago.	
D92	609034	7575516	4933	Diaclasa		60	45		C	5	1	Arena	Plana-Ondulada	8	Seco	Dacitas		R4	8-ago.	
D94	608703	7575868	4958	Diaclasa		50	51		D	4	1 a 3	SR	Plana-Ondulada	8	Seco	Andesitas		R4	8-ago.	
D94	608703	7575868	4958	Diaclasa		88	160		D	2	1 a 3	Arena	Rugosa	12	Seco	Andesitas		R4	8-ago.	
D94	608703	7575868	4958	Diaclasa		84	112		D	2		SR	Rugosa	12	Seco	Andesitas		R4	8-ago.	
D95	608547	7576002	4883	Diaclasa		70	210		C	2	0,5	SR	Ondulada-Rugosa	14	Seco	Andesitas		R4	8-ago.	
D95	608547	7576002	4883	Diaclasa		86	40		D	1		SR	Rugosa	12	Seco	Andesitas		R4	8-ago.	
E666	608841	7572358	4801	Diaclasa		51	202		D	4	0,2	SR	Ondulada	12	Seco	Andesitas		R4	8-ago.	
E666	608841	7572358	4801	Diaclasa		74	50		D	3	3	SR	Plana	4	Seco	Andesitas		R4	8-ago.	
E666	608841	7572358	4801	Diaclasa		83	340		D	2	1	SR	Plana	4	Seco	Andesitas		R4	8-ago.	
E666	608841	7572358	4801	Diaclasa		86	77		C	1	4	SR	Plana	4	Seco	Andesitas		R4	8-ago.	
E668	608878	7573144	4700	Diaclasa		86	129		C	3	2	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	
L937	611730	7569645	4838	Diaclasa		79	315		C	5	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L938	611730	7569645	4838	Diaclasa		72	310		C	4	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L939	611730	7569645	4838	Diaclasa		50	260		D	2	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L940	611730	7569645	4838	Diaclasa		65	284		D	3	1	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L941	611730	7569645	4838	Diaclasa		74	278		D	3	1	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L962	609326	7571795	4807	Diaclasa		80	330		C	6	1	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L963	609326	7571795	4807	Diaclasa		83	319		C	6	1	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L964	609326	7571795	4807	Diaclasa		80	320		C	5	2	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L968	609326	7571795	4807	Diaclasa		78	140		C	5	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L969	609326	7571795	4807	Diaclasa		84	356		C	2	2	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L970	609326	7571795	4807	Diaclasa		88	165		C	3	1	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L971	609326	7571795	4807	Diaclasa		80	330		C	2	4	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L972	609326	7571795	4807	Diaclasa		85	300		C	2	10	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L973	609060	7571207	4909	Diaclasa		80	159		D	2	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L974	609060	7571207	4909	Diaclasa		85	200		D	2	7	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L975	609060	7571207	4909	Diaclasa		87	315		D	1	1	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L976	609060	7571207	4909	Diaclasa		68	330		D	2	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
M120	611107	7573414	4807	Diaclasa	184	76	94		D	4	1	SR	Ondulada	16	Seco	Dacitas		R4	8-ago.	
M121	610856	7573402	4895	Diaclasa	280	88	190		C	4	3	SR	Ondulada	12	Seco	Dacitas		R4	8-ago.	
M121	610856	7573402	4895	Diaclasa	195	86	285		C	1	2	SR	Ondulada	12	Seco	Dacitas		R4	8-ago.	
M121	610856	7573402	4895	Diaclasa		76	310		C	1	3	SR	Ondulada	14	Seco	Dacitas		R4	8-ago.	
M121	610856	7573402	4895	Diaclasa	275	78	5		C	2	2	SR	Escalonada	14	Seco	Dacitas		R4	8-ago.	
M121	610856	7573402	4895	Diaclasa	128	84	38		D	1	1	SR	Escalonada	12	Seco	Dacitas		R4	8-ago.	
M122	610305	7572478	4863	Diaclasa		73	91		D	1	5	Arena	Plana	10	Seco	Dacitas		R4	8-ago.	
M122	610305	7572478	4863	Diaclasa		68	341		D	2	1	Arena	Plana	8	Seco	Dacitas		R4	8-ago.	
M122	610305	7572478	4863	Diaclasa		71	333		C	1	2	Arena	Plana	12	Seco	Dacitas		R4	8-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M123	609298	7572282	4831	Diaclasa		80	354		D	1	2	SR	Curva	6	Seco	Dacitas		R4	8-ago.	
M124	609120	7572404	4821	Diaclasa		72	314		C	1	3	SR	Plana	12	Seco	Dacitas		R4	8-ago.	
M124	609120	7572404	4821	Diaclasa		72	318		C	3	2	SR	Plana	12	Seco	Dacitas		R4	8-ago.	
M124	609120	7572404	4821	Diaclasa		54	50		C	1	1	SR	Plana	12	Seco	Dacitas		R4	8-ago.	
M124	609120	7572404	4821	Diaclasa		83	44		C	1	3	SR	Plana	12	Seco	Dacitas		R4	8-ago.	
M125	608657	7572711	4694	Diaclasa		90	125		C	5	2	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M125	608657	7572711	4694	Diaclasa		76	324		C	1	1	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M126	608523	7572924	4688	Diaclasa		78	320		C	2	10	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M126	608523	7572924	4688	Diaclasa		70	225		C	1		SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M126	608523	7572924	4688	Diaclasa		78	200		C	1	5	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M126	608523	7572924	4688	Diaclasa		70	54		C	2	4	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M127	604516	7575804	4650	Diaclasa		66	145		C	3	1	Arena	Plana	8	Seco	Dacitas		R4	8-ago.	
M127	604516	7575804	4650	Diaclasa		80	140		C	2	2	Arena	Plana	8	Seco	Dacitas		R4	8-ago.	
M128	605329	7576347	4682	Diaclasa		79	150		C	2	0,5	SR	Curva	4	Seco	Ignimbritas		R3	8-ago.	
M128	605329	7576347	4682	Diaclasa		82	10		C	2	0,5	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	
M129	607164	7579290	4822	Diaclasa		75	213		C	2	10	Arena	Escalonada	4	Seco	Ignimbritas		R3	8-ago.	
M129	607164	7579290	4822	Diaclasa		86	344		D	1	5	SR	Plana	8	Seco	Ignimbritas		R3	8-ago.	
M130	607691	7580515	4929	Diaclasa	355	88	265		C	1	1	SR	Plana	8	Seco	Andesitas		R4	8-ago.	
L933	611730	7569645	4838	Falla		84	173		C	1	1	Arena	Plana	10	Seco	Dacitas		R4	8-ago.	
L934	611730	7569645	4838	Falla		75	188		C	1	0	Arena	Plana	10	Seco	Dacitas		R4	8-ago.	
L935	611730	7569645	4838	Falla		50	166	255	C	1	0	Arena	Plana	10	Seco	Dacitas		R4	8-ago.	
L942	611155	7571642	4899	Falla		88	165		C	1	2	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L943	611155	7571642	4899	Falla		60	176		C	1	2	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L945	611155	7571642	4899	Falla		79	282		C	1	3	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L946	611155	7571642	4899	Falla		75	254		C	1	0	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L947	611155	7571642	4899	Falla		88	263		C	1	0	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L948	611155	7571642	4899	Falla		83	244		C	1	0	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L950	611155	7571642	4899	Falla		8	210		C	1	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L951	611155	7571642	4899	Falla		43	108		C	1	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L952	611155	7571642	4899	Falla		52	112		C	1	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L953	611155	7571642	4899	Falla		33	97		C	1	0	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L965	609326	7571795	4807	Falla		87	132		C	1	2	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L966	609326	7571795	4807	Falla		89	348		D	1	10	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
L967	609326	7571795	4807	Falla		83	356		C	1	3	SR	Plana	10	Seco	Dacitas		R4	8-ago.	
M120	611107	7573414	4807	Falla	232	69	322		C	1	8	Arena	Escalonada	16	Seco	Dacitas		R4	8-ago.	
M130	607691	7580515	4929	Falla	109	85	19		C	1	5	SR	Plana	10	Seco	Andesitas		R4	8-ago.	
E668	608878	7573144	4700	Falla		54	252		C	1	4	SR	Plana	2	Seco	Ignimbritas		R3	8-ago.	
D93	609041	7575521	4936	Falla Dextral		57	115		D	1		SR	Rugosa	12	Seco	Andesitas		R4	8-ago.	Desplazamiento 5,5 cm
D83	610977	7574001	4743	Falla Inversa		81	200		C	1	1,5	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	Rechazo 3 cm
D83	610977	7574001	4743	Falla Inversa		89	55		C	1	0,5 a 2,5	SR	Plana-Rugosa	8	Seco	Ignimbritas		R3	8-ago.	Rechazo 4cm
D83	610977	7574001	4743	Falla Inversa		82	94		C	1	1	Arena	Ondulada-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	Rechazo 1,5 cm
D87	607313	7573578	4645	Falla Inversa		89	305		C	1	0,5	SR	Rugosa-Ondulada	12	Seco	Ignimbritas		R3	8-ago.	Rechazo 1,5 cm
D89	608189	7572805	4654	Falla Inversa		50	230		C	1	1,5	SR	Plana-Rugosa	10	Seco	Ignimbritas		R3	8-ago.	
D89	608189	7572805	4654	Falla Inversa		70	25		C	1	1	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	8-ago.	
D90	608400	7572855	4676	Falla Inversa		64	85		D	1	1	SR	Ondulada-Escalonada	14	Seco	Ignimbritas		R3	8-ago.	
D92	609034	7575516	4933	Falla Inversa		45	105		D	1		SR	Ondulada-Escalonada	12	Seco	Dacitas		R4	8-ago.	Rechazo 1 cm (microfalla)
L936	611730	7569645	4838	Falla Inversa		65	182		C	1	0	Arena	Plana	10	Seco	Dacitas		R4	8-ago.	Desplazamiento 30 cm
M125	608657	7572711	4694	Falla Inversa		79	295		C	1	2	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	Rechazo 12 cm
M128	605329	7576347	4682	Falla Inversa		22	268	96	C	1	2	SR	Escalonada	4	Seco	Ignimbritas		R3	8-ago.	Rechazo 4cm
M128	605329	7576347	4682	Falla Inversa		25	264		C	1	2	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	
M128	605329	7576347	4682	Falla Inversa		10	170		C	2	1	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	Rechazo 35
M129	607164	7579290	4822	Falla Inversa		83	187		C	1	0,5	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	Rechazo 3 cm
D83	610977	7574001	4743	Falla Normal		85	62		D	1	0,2	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 3,5 cm
D84	609855	7574238	4746	Falla Normal		85	185		D	1	5	Arena	Ondulada-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 2 cm
D85	609371	7574022	4722	Falla Normal		56	215		C	1	2	SR	Ondulada-Escalonada	14	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 5,5cm
D91	608065	7575005	4744	Falla Normal		68	270		D	1	2	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 1,5 cm
D91	608065	7575005	4744	Falla Normal		79	110		D	1	1 a 4	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 1 cm
D92	609034	7575516	4933	Falla Normal		65	140		C	1	0,5 a 3	Arena	Plana	4	Seco	Dacitas		R4	8-ago.	Desplazamiento2,5
E666	608841	7572358	4801	Falla Normal	167	81	257		C	1		SR	Curva	6	Seco	Andesitas		R4	8-ago.	
E668	608878	7573144	4700	Falla Normal	212	81	122	59	C	1	0,5	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 5cm

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SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L944	611155	7571642	4899	Falla Normal		65	266		C	1	0	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	Desplazamiento 15 cm
L949	611155	7571642	4899	Falla Normal		62	268		C	1	0	SR	Rugosa	14	Seco	Dacitas		R4	8-ago.	
L954	611250	7572012	4769	Falla Normal		88	10		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 5 cm
L955	611250	7572012	4769	Falla Normal		70	8		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 10 cm
L956	611250	7572012	4769	Falla Normal		85	196		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 3 cm
L957	611250	7572012	4769	Falla Normal		62	260	350	C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	8-ago.	
L958	611250	7572012	4769	Falla Normal		84	275		C	1	10	SR	Plana	6	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 5 cm
L959	611250	7572012	4769	Falla Normal		55	23		C	1	2	Oxidos de Fe	Plana	6	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 10 cm
L960	611250	7572012	4769	Falla Normal		63	350	260	D	1	2	SR	Plana	6	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 80 cm
M123	609298	7572282	4831	Falla Normal	264	66	174		C	1	2	Arena	Plana	12	Seco	Dacitas		R4	8-ago.	
M125	608657	7572711	4694	Falla Normal		72	120		D	1	0,5	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 3cm
M125	608657	7572711	4694	Falla Normal		62	232		C	1	4	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 15 cm
M125	608657	7572711	4694	Falla Normal		68	10		C	1	4	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	
M126	608523	7572924	4688	Falla Normal		82	330		C	1	7	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 10 cm
M126	608523	7572924	4688	Falla Normal		76	315		C	1	3	SR	Plana	10	Seco	Ignimbritas		R3	8-ago.	Desplazamiento 15 cm
M127	604516	7575804	4650	Falla Normal		69	104		C	1	8	SR	Ondulada	8	Seco	Dacitas		R4	8-ago.	Desplazamiento 15 cm
M128	605329	7576347	4682	Falla Normal		80	146		C	1	0,5	SR	Curva	4	Seco	Ignimbritas		R3	8-ago.	
M128	605329	7576347	4682	Falla Normal		85	144		C	1	2	SR	Plana	4	Seco	Ignimbritas		R3	8-ago.	
M130	607691	7580515	4929	Falla Normal		87	270		C	1	5	Arena	Plana	6	Seco	Andesitas		R4	8-ago.	
D86	609312	7574025	4728	Falla Sinestral		78	139	165	C	1	1	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	8-ago.	Rechazo 2,5 cm
M122	610305	7572478	4863	Falla Sinestral	146	53	236		D	1	5	Arena	Plana	10	Seco	Dacitas		R4	8-ago.	Desplazamiento 30 cm
M130	607691	7580515	4929	Falla Sinestral		80	185		D	1	1	Arena	Plana	12	Seco	Andesitas		R4	8-ago.	Desplazamiento 10cm
D94	608703	7575868	4958	Pseudoestratificación		72	194		C						Seco	Andesitas		R4	8-ago.	
L961	609326	7571795	4807	Pseudoestratificación		50	265		C						Seco	Ignimbritas		R2	8-ago.	
M121	610856	7573402	4895	Pseudoestratificación		73	264		C						Seco	Dacitas		R4	8-ago.	
M122	610305	7572478	4863	Pseudoestratificación		62	2		C						Seco	Dacitas		R4	8-ago.	
M123	609298	7572282	4831	Pseudoestratificación		60	260		C						Seco	Dacitas		R4	8-ago.	
M124	609120	7572404	4821	Pseudoestratificación		60	358		C						Seco	Dacitas		R4	8-ago.	
M127	604516	7575804	4650	Pseudoestratificación		80	205		C						Seco	Ignimbritas		R3	8-ago.	
D100	617997	7570897	4892	Diaclasa	72	65	162		C	7	5		Plana	8	Seco	Riodacita		R3	9-ago.	
D102	622441	7567165	4912	Diaclasa		87	18		C	8	0,5	Arena	Curva	8	Seco	Andesitas		R4	9-ago.	
D102	622441	7567165	4912	Diaclasa		77	197		C	8	4	Arena	Plana	8	Seco	Andesitas		R4	9-ago.	
D103	622768	7566782	4934	Diaclasa		74	162		D	14	2	Arena	Escalonada	8	Seco	Andesitas		R4	9-ago.	
D103	622768	7566782	4934	Diaclasa		81	198		D	14	1	Arena	Escalonada	12	Seco	Andesitas		R4	9-ago.	
D103	622768	7566782	4934	Diaclasa		65	195		D	14	3	Arena	Escalonada	8	Seco	Andesitas		R4	9-ago.	
D104	622984	7566570	4959	Diaclasa		66	87		D	5	1	SR	Escalonada	14	Seco	Riodacita		R3	9-ago.	
D104	622984	7566570	4959	Diaclasa		71	97		D	6	1	SR	Escalonada	14	Seco	Riodacita		R3	9-ago.	
D96	617299	7571991	4683	Diaclasa		56	300		D	2	0,2	SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R2	9-ago.	
D96	617299	7571991	4683	Diaclasa		85	180		D	1	5	Arena	Plana-Rugosa	10	Seco	Ignimbritas		R2	9-ago.	
D96	617299	7571991	4683	Diaclasa		87	300		C	2	2	SR	Plana	4	Seco	Ignimbritas		R2	9-ago.	
D96	617299	7571991	4683	Diaclasa		78	220		D	1	3,5	Arena	Plana	4	Seco	Ignimbritas		R2	9-ago.	
D96	617299	7571991	4683	Diaclasa		79	110		C	2		SR	Plana-Ondulada	8	Seco	Ignimbritas		R2	9-ago.	
D96	617299	7571991	4683	Diaclasa		42	190		C	3	1,2	SR	Plana	4	Seco	Ignimbritas		R2	9-ago.	
D97	617448	7570775	4778	Diaclasa		89	255		C	3		SR	Plana-Ondulada	8	Seco	Ignimbritas		R2	9-ago.	
D97	617448	7570775	4778	Diaclasa		84	320		C	2	2	SR	Ondulada-Rugosa	14	Seco	Ignimbritas		R2	9-ago.	
D97	617448	7570775	4778	Diaclasa		88	90		C	4	2	SR	Plana	4	Seco	Ignimbritas		R2	9-ago.	
D98	618020	7570917	4891	Diaclasa		71	140		C	3	1,5	SR	Plana-Rugosa	12	Seco	Riodacita		R3	9-ago.	
D99	618093	7570880	4894	Diaclasa		44	30		C	2	2	SR	Plana-Ondulada	8	Seco	Riodacita		R3	9-ago.	
D99	618093	7570880	4894	Diaclasa		60	260		D	3	0,5 a 1,5	SR	Plana-Ondulada	10	Seco	Riodacita		R3	9-ago.	
L977	614946	7581806	4944	Diaclasa		88	130		C	5	10	Arena	Plana	8	Seco	Riolita		R4	9-ago.	
L978	614946	7581806	4944	Diaclasa		87	146		C	4	5	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L979	614946	7581806	4944	Diaclasa		89	182		C	5	4	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L980	614946	7581806	4944	Diaclasa		80	126		C	5	6	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L981	614946	7581806	4944	Diaclasa		72	135		C	5	2	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L982	614946	7581806	4944	Diaclasa		85	144		C	5	4	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L983	614946	7581806	4944	Diaclasa		88	130		C	3	3	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L985	614992	7581319	4975	Diaclasa		65	205		C	7	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L986	614992	7581319	4975	Diaclasa		50	208		C	7	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L987	614992	7581319	4975	Diaclasa		63	182		D	5	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L988	614992	7581319	4975	Diaclasa		70	190		C	5	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L989	614992	7581319	4975	Diaclasa		74	196		C	5	2	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L990	614992	7581319	4975	Diaclasa		61	198		C	5	2	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L991	614468	7580994	5047	Diaclasa		70	160		D	6	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L992	614468	7580994	5047	Diaclasa		80	162		C	6	4	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L993	614468	7580994	5047	Diaclasa		83	156		C	6	2	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L994	614468	7580994	5047	Diaclasa		84	164		C	6	5	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L995	614468	7580994	5047	Diaclasa		79	168		C	6	4	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L996	613975	7580155	5065	Diaclasa		4	105		C	5	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	
M131	617404	7572096	4727	Diaclasa	325	74	235		C	1	1	SR	Plana	14	Seco	Riodacita		R2	9-ago.	
M131	617404	7572096	4727	Diaclasa		70	255		D	2	2	Arena	Rugosa	14	Seco	Riodacita		R2	9-ago.	
M131	617404	7572096	4727	Diaclasa		67	310		C	4	2	SR	Plana	12	Seco	Riodacita		R2	9-ago.	
M131	617404	7572096	4727	Diaclasa		61	192		D	2	4	SR	Curva	12	Seco	Riodacita		R2	9-ago.	
M131	617404	7572096	4727	Diaclasa		49	25		C	2	2	SR	Plana	12	Seco	Riodacita		R2	9-ago.	
M131	617404	7572096	4727	Diaclasa		28	270		C	1	3	SR	Plana	10	Seco	Riodacita		R2	9-ago.	
M131	617404	7572096	4727	Diaclasa		85	225		C	1	3	SR	Plana	10	Seco	Riodacita		R2	9-ago.	
M132	618511	7571123	4738	Diaclasa		77	295		C	10		SR	Plana	10	Seco	Ignimbritas		R2	9-ago.	
M132	618511	7571123	4738	Diaclasa		78	170		C	2	0,5	SR	Curva	8	Seco	Ignimbritas		R2	9-ago.	
M135	619349	7570946	4752	Diaclasa		78	65		C	3	9	SR	Plana	14	Seco	Dacita-Andesita		R4	9-ago.	
M135	619349	7570946	4752	Diaclasa		61	227		C	4	2	Arena	Curva	12	Seco	Dacita-Andesita		R4	9-ago.	
M135	619349	7570946	4752	Diaclasa		60	225		D	3	1	SR	Escalonada	14	Seco	Dacita-Andesita		R4	9-ago.	
M136	622803	7569507	4918	Diaclasa		74	28		D	4	7	SR	Plana	8	Seco	Andesitas		R4	9-ago.	
M136	622803	7569507	4918	Diaclasa		24	155		C	2	1	SR	Ondulada	8	Seco	Andesitas		R4	9-ago.	
M137	623827	7569602	4918	Diaclasa		85	55		C	6	1	SR	Plana	6	Seco	Ignimbritas		R2	9-ago.	
M137	623827	7569602	4918	Diaclasa		60	170		D	1	6	SR	Rugosa	10	Seco	Ignimbritas		R2	9-ago.	
M137	623827	7569602	4918	Diaclasa		72	233		C	2	3	SR	Ondulada	8	Seco	Ignimbritas		R2	9-ago.	
M137	623827	7569602	4918	Diaclasa		71	298		D	3		SR	Rugosa	12	Seco	Ignimbritas		R2	9-ago.	
M138	624793	7570051	4893	Diaclasa		87	255		C	3		SR	Plana-Rugosa	10	Seco	Ignimbritas		R2	9-ago.	
M138	624793	7570051	4893	Diaclasa		84	335		C	2		SR	Ondulada	10	Seco	Ignimbritas		R2	9-ago.	
M138	624793	7570051	4893	Diaclasa		45	270		D	2	1	SR	Rugosa	14	Seco	Ignimbritas		R2	9-ago.	
M138	624793	7570051	4893	Diaclasa		32	95		D	4	1	SR	Ondulada	8	Seco	Ignimbritas		R2	9-ago.	
D104	622984	7566570	4959	Falla	221	84	131		C	1	10	Arena	Plana	12	Seco	Riodacita		R3	9-ago.	
L1000	613975	7580155	5065	Falla		86	30	290	C	1	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	
L997	613975	7580155	5065	Falla Dextral		5	265		C	1	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	Desplzamiento 10 cm
L998	613975	7580155	5065	Falla Dextral		6	260		C	1	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	Desplzamiento 5 cm
L999	613975	7580155	5065	Falla Dextral		4	272		C	1	0	SR	Plana	8	Seco	Riolita		R4	9-ago.	Desplzamiento 7 cm
D100	617997	7570897	4892	Falla Inversa		62	240		C	1	2,5		Plana-Escalonada	12	Seco	Riodacita		R3	9-ago.	Rechazo 4 cm
D97	617448	7570775	4778	Falla Inversa		58	180		D	1	1	SR	Plana-Ondulada	8	Seco	Ignimbritas		R2	9-ago.	Rechazo 4 cm
M131	617404	7572096	4727	Falla Inversa		36	18		C	1	4	SR	Escalonada	12	Seco	Riodacita		R2	9-ago.	
M133	618616	7571018	4746	Falla Inversa	198	38	288	352	C	1	0,5	SR	Plana	10	Seco	Ignimbritas		R2	9-ago.	Rechazo 3 cm
M133	618616	7571018	4746	Falla Inversa		88	280		C	1		SR	Plana	10	Seco	Ignimbritas		R2	9-ago.	
M133	618616	7571018	4746	Falla Inversa		74	185	70 N	D	1	1	SR	Plana	8	Seco	Ignimbritas		R2	9-ago.	
D101	622260	7568660	4896	Falla Normal	215	78	125		C	1	5	Arena	Escalonada	8	Seco	Andesitas		R4	9-ago.	
D96	617299	7571991	4683	Falla Normal		60	120		D	1		SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R2	9-ago.	Desplazamiento 1cm
M133	618616	7571018	4746	Falla Normal		73	274		C	1	0,5	Arena	Plana	10	Seco	Ignimbritas		R2	9-ago.	Desplazamiento3cm
M133	618616	7571018	4746	Falla Normal		73	318		C	1	0,5	Arena	Plana	10	Seco	Ignimbritas		R2	9-ago.	
M133	618616	7571018	4746	Falla Normal		64	70		C	1	3	SR	Escalonada	10	Seco	Ignimbritas		R2	9-ago.	Desplazamiento 1 cm
M133	618616	7571018	4746	Falla Normal		77	74		C	4	2	SR	Plana	10	Seco	Ignimbritas		R2	9-ago.	
M133	618616	7571018	4746	Falla Normal		84	82		D	1		SR	Plana	8	Seco	Ignimbritas		R2	9-ago.	
M134	618664	7570973	4790	Falla Normal		85	265		C	2	0,5	SR	Plana	8	Seco	Ignimbritas		R2	9-ago.	Desplazamiento 5cm
M134	618664	7570973	4790	Falla Normal		83	269		C	2	0,2	SR	Plana	8	Seco	Ignimbritas		R2	9-ago.	Desplazamiento 4cm
M134	618664	7570973	4790	Falla Normal		70	60		C	1	2	SR	Escalonada	12	Seco	Ignimbritas		R2	9-ago.	Desplazamiento 3cm
M134	618664	7570973	4790	Falla Normal		82	90		C	1	1	SR	Plana	8	Seco	Ignimbritas		R2	9-ago.	Desplazamiento 4cm
L984	614946	7581806	4944	Falla Sinestral		87	35		C	1	10	SR	Plana	8	Seco	Riolita		R4	9-ago.	Desplzamiento 30 cm
L1002	627233	7578330	4605	Diaclasa		35	125		C	2	2	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1004	627233	7578330	4605	Diaclasa		78	162		C	6	5	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1005	627233	7578330	4605	Diaclasa		85	160		C	2	2	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1006	627233	7578330	4605	Diaclasa		87	130		C	2	6	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1007	627233	7578330	4605	Diaclasa		89	155		C	2	1	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1008	627233	7578330	4605	Diaclasa		89	127		C	4	0	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1009	627233	7578330	4605	Diaclasa		84	136		C	3	0	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L1010	611364	7567270	4630	Diaclasa		86	284		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1011	611364	7567270	4630	Diaclasa		87	276		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1013	611364	7567270	4630	Diaclasa		89	31		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1014	611364	7567270	4630	Diaclasa		89	26		C	3	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1015	611364	7567270	4630	Diaclasa		89	10		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1016	611364	7567270	4630	Diaclasa		89	27		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1017	611364	7567270	4630	Diaclasa		86	250		C	2	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1003	627233	7578330	4605	Falla		80	154		C	1	2	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	
L1012	611364	7567270	4630	Falla Dextral		10	18		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	Desplazamiento 10 cm
L1018	611364	7567270	4630	Falla Dextral		5	37		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1019	611364	7567270	4630	Falla Dextral		4	340		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1020	611364	7567270	4630	Falla Dextral		9	18		C	1	0	SR	Plana	6	Seco	Ignimbritas		R3	10-ago.	
L1001	627233	7578330	4605	Falla normal		55	295		C	1	10	SR	Plana	8	Seco	Ignimbritas		R3	10-ago.	Deplazamiento 40 cm
D105	617813	7557987	4545	Diaclasa		85	173		C	2		SR	Ondulada	12	Seco	Dacitas		R3	11-ago.	
D105	617813	7557987	4545	Diaclasa		35	290		D	2	2	Arena	Ondulada-Rugosa	10	Seco	Dacitas		R3	11-ago.	
D105	617813	7557987	4545	Diaclasa		52	250		D	3	0,2	Arena	Rugosa	12	Seco	Dacitas		R3	11-ago.	
D105	617813	7557987	4545	Diaclasa		74	213		D	1	0,3 a 1	Arena	Plana	8	Seco	Dacitas		R3	11-ago.	
D105	617813	7557987	4545	Diaclasa		81	353		D	1	0,5	Arena	Plana	4	Seco	Dacitas		R3	11-ago.	
D106	617745	7559901	4586	Diaclasa		72	216		C	2	2,5	SR	Ondulada	14	Seco	Dacitas		R3	11-ago.	
D108	616449	7560044	4592	Diaclasa		90	226		D	1	1	Arena	Ondulada-Rugosa	12	Seco	Ignimbritas		R2	11-ago.	
D109	616951	6560855	4616	Diaclasa		76	338		C	1	1a 5	SR	Plana-Ondulada	10	Seco	Ignimbritas		R2	11-ago.	
D109	616951	6560855	4616	Diaclasa		84	226		C	2	0,5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D110	616787	7561791	4632	Diaclasa		78	160		D	2	0,5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D110	616787	7561791	4632	Diaclasa		80	272		C	3		SR	Ondulada	8	Seco	Ignimbritas		R2	11-ago.	
D110	616787	7561791	4632	Diaclasa		86	70		C	1		SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D110	616787	7561791	4632	Diaclasa		21	25		C	4		SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D111	616902	7562247	4641	Diaclasa		76	3		C	3		SR	Plana-Rugosa	10	Seco	Ignimbritas		R2	11-ago.	
D111	616902	7562247	4641	Diaclasa		69	237		C	7	1 a 2	SR	Rugosa-Escalonada	12	Seco	Ignimbritas		R2	11-ago.	
D111	616902	7562247	4641	Diaclasa		82	65		C	2		SR	Plana-Escalonada	12	Seco	Ignimbritas		R2	11-ago.	
D112	618012	7562867	4707	Diaclasa		88	0		C	2		SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D112	618012	7562867	4707	Diaclasa		69	334		C	3	0,2 a 2	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D113	616277	7562808	4638	Diaclasa		88	135		D	1	2	Arena	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D113	616277	7562808	4638	Diaclasa		87	25		D	1		SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D114	615291	7561002	4589	Diaclasa		88	133		C	3	0,5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D114	615291	7561002	4589	Diaclasa		90	148		C	2	0,5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D114	615291	7561002	4589	Diaclasa		52	94		C	1	1	SR	Escalonada	12	Seco	Ignimbritas		R2	11-ago.	
D107	617757	7559906	4599	Falla Inversa		78	184		C	1	4,5	SR	Plana	10	Seco	Dacitas		R3	11-ago.	Rechazo 20 cm
D108	616449	7560044	4592	Falla Inversa		79	222		C	1	3	SR	Escalonada	14	Seco	Ignimbritas		R2	11-ago.	Rechazo 8 cm
D112	618012	7562867	4707	Falla Inversa		12	315		C	1		SR	Rugosa-Escalonada	14	Seco	Ignimbritas		R2	11-ago.	Rechazo 2,5 cm
D112	618012	7562867	4707	Falla Inversa		78	280		C	1	0,5	Arena	Curva	12	Seco	Ignimbritas		R2	11-ago.	Rechazo 1,5 cm
D107	617757	7559906	4599	Falla Normal		50	200		D	1	1 a 3	Arena	Rugosa-Escalonada	14	Seco	Dacitas		R3	11-ago.	
D108	616449	7560044	4592	Falla Normal		84	320		C	1	0,5 a 5	Arena	Plana-Rugosa	12	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 1 cm
D108	616449	7560044	4592	Falla Normal		72	184		C	1	0,5	SR	Escalonada	10	Seco	Ignimbritas		R2	11-ago.	
D109	616951	6560855	4616	Falla Normal		88	227		C	1	1 a 2	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 13 cm
D109	616951	6560855	4616	Falla Normal		89	128		C	1	6	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	
D111	616902	7562247	4641	Falla Normal		70	54		C	1	0,2 a 1	SR	Rugosa-Escalonada	12	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 1 cm
D111	616902	7562247	4641	Falla Normal		90	305		C	1	0,5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 6 cm
D112	618012	7562867	4707	Falla Normal		87	312		C	1	3	Arena	Plana-Ondulada	8	Seco	Ignimbritas		R2	11-ago.	
D113	616277	7562808	4638	Falla Normal		88	28		D	1	0,7	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 1,5 cm
D113	616277	7562808	4638	Falla Normal		88	130		D	1	0,5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 3 cm
D114	615291	7561002	4589	Falla Normal		88	140		C	1	0,2	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 5 cm
D114	615291	7561002	4589	Falla Normal		88	138		C	1	5	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 3 cm
D114	615291	7561002	4589	Falla Normal		84	245		C	1	6	SR	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 10 cm
D114	615291	7561002	4589	Falla Normal		90	50		C	1	0,2	Arena	Plana	4	Seco	Ignimbritas		R2	11-ago.	Desplazamiento 1 cm
D106	617745	7559901	4586	Falla Sinestral		88	227		C	1	0,5 a 2	SR	Rugosa-Escalonada	12	Seco	Dacitas		R3	11-ago.	Desplazamiento 25 cm
D105	617813	7557987	4545	Pseudoestratificación		63	160		C						Seco	Dacitas		R3	11-ago.	
L1021	620523	7566509	4944	Diaclasa		87	280		C	2	0,5	SR	Plana	8	Seco	Riodacita		R3	12-ago.	
L1023	620523	7566509	4944	Diaclasa		51	300		C	2	0,5	SR	Plana	8	Seco	Riodacita		R3	12-ago.	
L1027	620164	7567362	4937	Diaclasa		75	149		C	2	0	SR	Rugosa	12	Seco	Riodacita		R3	12-ago.	
L1028	620164	7567362	4937	Diaclasa		73	170		D	2	1	SR	Rugosa	12	Seco	Riodacita		R3	12-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L1029	619936	7568104	4937	Diaclasa		79	330		C	2	10	SR	Ondulada	14	Seco	Riodacita		R3	12-ago.	
L1031	619936	7568104	4937	Diaclasa		55	73		D	2	1,5	SR	Plana	4	Seco	Riodacita		R3	12-ago.	
L1033	620642	7567794	4897	Diaclasa		62	275		D	3	3	SR	Plana	8	Seco	Riodacita		R3	12-ago.	
L1034	620642	7567794	4897	Diaclasa		53	200		D	3	0	SR	Ondulada	8	Seco	Riodacita		R3	12-ago.	
L1035	620716	7567637	4900	Diaclasa		50	105		C	2	1	SR	Rugosa	12	Seco	Riodacita		R3	12-ago.	
L1036	620716	7567637	4900	Diaclasa		78	100		C	2	1,5	SR	Rugosa	12	Seco	Riodacita		R3	12-ago.	
L1038	621142	7567015	4929	Diaclasa		88	34		C	7	2	SR	Plana	8	Seco	Riodacita		R3	12-ago.	
L1039	621142	7567015	4929	Diaclasa		42	260		D	3	0	SR	Plana	8	Seco	Riodacita		R3	12-ago.	
L1040	621142	7567015	4929	Diaclasa		50	255		D	3	0,5	SR	Plana	8	Seco	Riodacita		R3	12-ago.	
L1042	621516	7566044	4947	Diaclasa		78	175		D	2	1	SR	Ondulada	10	Seco	Riodacita		R3	12-ago.	
L1043	621516	7566044	4947	Diaclasa		73	102		D	2	4	SR	Ondulada	8	Seco	Riodacita		R3	12-ago.	
M142	618556	7564328	4750	Diaclasa		70	83		C	3	0,2 a 1	Arena	Ondulada	8	Seco	Ignimbritas		R2	12-ago.	
M142	618556	7564328	4750	Diaclasa		66	45		D	1	1	SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R2	12-ago.	
M143	612243	7567874	4649	Diaclasa		88	232		C	2	2	SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	
M144	612181	7569025	4668	Diaclasa		88	280		C	2	2	SR	Escalonada	14	Seco	Ignimbritas		R2	12-ago.	
M146	613579	7572268	4717	Diaclasa		75	161		C	2	0,5	SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	
M146	613579	7572268	4717	Diaclasa		74	167		C	1	0,1	SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	
M145	612652	7570194	4763	Falla Dextral		77	180		C	2	0,5 a 1,5	SR	Ondulada-Escalonada	14	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 6 cm
L1022	620523	7566509	4944	Falla Inversa		37	135		C	1	0,5	SR	Escalonada	12	Seco	Riodacita		R3	12-ago.	Desplazamiento 2 cm
M139	615008	7561896	4599	Falla Inversa		90	233		C	1	0,2 a 1	SR	Plana	10	Seco	Ignimbritas		R2	12-ago.	Rechazo 2 cm
M139	615008	7561896	4599	Falla Inversa		89	283		C	1	0,5 a 1	Arena	Plana	4	Seco	Ignimbritas		R2	12-ago.	Rechazo 5 cm
M141	615604	7562988	4632	Falla Inversa		87	88		C	1	1 a 3	SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	Rechazo 15 cm
M141	615604	7562988	4632	Falla Inversa		73	183		C	1	1 a 2	SR	Ondulada	12	Seco	Ignimbritas		R2	12-ago.	Rechazo 40 cm
M144	612181	7569025	4668	Falla Inversa		45	10	90	C	1	3	SR	Plana-Ondulada	14	Seco	Ignimbritas		R2	12-ago.	Rechazo 7 cm
L1024	620523	7566509	4944	Falla normal		80	250		C	1	2,5	SR	Escalonada	12	Seco	Riodacita		R3	12-ago.	Desplazamiento 2 cm
L1025	620523	7566509	4944	Falla normal		79	90		C	1	1	SR	Escalonada	12	Seco	Riodacita		R3	12-ago.	Desplazamiento 1 cm
L1026	620164	7567362	4937	Falla normal		78	198		C	1	1	SR	Rugosa	12	Seco	Riodacita		R3	12-ago.	Desplazamiento 4,5 cm
L1030	619936	7568104	4937	Falla normal		85	145		D	1	2	SR	Escalonada	12	Seco	Riodacita		R3	12-ago.	Desplazamiento 5 cm
L1032	620642	7567794	4897	Falla normal		56	92	72	C	1	3,5	SR	Plana	8	Seco	Riodacita		R3	12-ago.	Desplazamiento 7 cm
L1037	620716	7567637	4900	Falla normal		66	348	65	C	1	0	SR	Rugosa	12	Seco	Riodacita		R3	12-ago.	
L1041	621516	7566044	4947	Falla normal		61	150		D	1	2,5	SR	Ondulada	14	Seco	Riodacita		R3	12-ago.	Desplazamiento 3 cm
M139	615008	7561896	4599	Falla normal		82	81		C	1	1	SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 2 cm
M140	614483	7561752	4596	Falla normal		71	300		C	1	0,5 a 1	Arena	Plana-Ondulada	8	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 4 cm
M140	614483	7561752	4596	Falla normal		84	295		C	1	0,5	SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 29 cm
M141	615604	7562988	4632	Falla normal		67	89		C	2		SR	Plana	4	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 2,5 cm
M141	615604	7562988	4632	Falla normal		75	70		C	2	0,5 a 2	SR	Rugosa	12	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 1 cm
M143	612243	7567874	4649	Falla normal		90	238		C	1	0,3 a 3	Arena	Plana-Rugosa	8	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 3 cm
M144	612181	7569025	4668	Falla normal		78	232		C	1	1 a 5	SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 4,5 cm
M144	612181	7569025	4668	Falla normal		71	192	105	C	1	0,5 a 2	SR	Plana	12	Seco	Ignimbritas		R2	12-ago.	Desplazamiento 2 cm
L1046	597770	7584802	4571	Diaclasa		52	154		C	4	1	SR	Plana	8	Seco	Andesitas		R4	13-ago.	
L1050	600821	7583743	4563	Diaclasa		75	186		D	2	0	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	13-ago.	
L1051	600821	7583743	4563	Diaclasa		82	208		C	4	1	Arena	Plana	12	Seco	Ignimbritas		R3	13-ago.	
L1052	600821	7583743	4563	Diaclasa		80	260		C	1	1	Arena	Plana-Rugosa	12	Seco	Ignimbritas		R3	13-ago.	
L1054	601652	7578478	4580	Diaclasa		70	260		D	2	0,5	Arena	Plana	12	Seco	Ignimbritas		R3	13-ago.	
L1056	603811	7577292	4636	Diaclasa		89	151		C	3	2	SR	Plana	12	Seco	Ignimbritas		R3	13-ago.	
L1060	605940	7577810	4735	Diaclasa		86	26		C	2	0	SR	Rugosa	12	Seco	Ignimbritas		R3	13-ago.	
L1061	605940	7577810	4735	Diaclasa		81	27		D	2	0	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	13-ago.	
M147	596817	7576184	4752	Diaclasa		53	35		D	3	0,5 a 1	SR	Ondulada	8	Seco	Andesitas		R4	13-ago.	
M147	596817	7576184	4752	Diaclasa		59	45		C	2		SR	Ondulada	8	Seco	Andesitas		R4	13-ago.	
M147	596817	7576184	4752	Diaclasa		81	210		D	2	0,5	SR	Ondulada	12	Seco	Andesitas		R4	13-ago.	
M148	597729	7585067	4592	Diaclasa		81	180		D	2		SR	Rugosa	12	Seco	Andesitas		R4	13-ago.	
M148	597729	7585067	4592	Diaclasa		84	135		D	5		SR	Rugosa	12	Seco	Andesitas		R4	13-ago.	
M149	600731	7583586	4562	Diaclasa		77	187		D	1	3	SR	Plana	4	Seco	Ignimbritas		R2	13-ago.	
M149	600731	7583586	4562	Diaclasa		84	244		D	6	0,5	SR	Plana	4	Seco	Ignimbritas		R2	13-ago.	
M150	601635	7578500	4577	Diaclasa		84	315		C	1	10	SR	Plana	4	Seco	Ignimbritas		R2	13-ago.	
M150	601635	7578500	4577	Diaclasa		74	255		C	3	13	Arena	Plana-Escalonada	12	Seco	Ignimbritas		R2	13-ago.	
M150	601635	7578500	4577	Diaclasa		42	164		D	3	0,5	SR	Plana-Rugosa	8	Seco	Ignimbritas		R2	13-ago.	
M151	603698	7577194	4624	Diaclasa		88	143		C	2	2	SR	Plana-Escalonada	8	Seco	Ignimbritas		R2	13-ago.	
M151	603698	7577194	4624	Diaclasa		85	95		D	1		SR	Plana-Escalonada	8	Seco	Ignimbritas		R2	13-ago.	
M151	603698	7577194	4624	Diaclasa		87	170		C	3	4	SR	Plana-Ondulada	10	Seco	Ignimbritas		R2	13-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
M152	604390	7577400	4690	Diaclasa		85	202		C	1	1	SR	Plana-Rugosa	10	Seco	Ignimbritas		R2	13-ago.	
M152	604390	7577400	4690	Diaclasa		60	330		D	1	0,5	SR	Plana	4	Seco	Ignimbritas		R2	13-ago.	
M152	604390	7577400	4690	Diaclasa		88	164		C	3	2	SR	Plana	4	Seco	Ignimbritas		R2	13-ago.	
M154	604865	7576273	4652	Diaclasa		48	225		C	3	0,5	SR	Plana	4	Seco	Ignimbritas		R2	13-ago.	
M154	604865	7576273	4652	Diaclasa		81	154		C	5	0,5	SR	Plana-Escalonada	8	Seco	Ignimbritas		R2	13-ago.	
M147	596817	7576184	4752	Falla Dextral		80	204		D	1	0,5 a 3,5	SR	Plana	4	Seco	Andesitas		R4	13-ago.	
L1044	597770	7584802	4571	Falla Inversa		87	170		C	1	2	SR	Plana-Ondulada	8	Seco	Andesitas		R4	13-ago.	Desplazamiento 5 cm
L1047	597770	7584802	4571	Falla Inversa		77	347		C	1	1	SR	Plana	8	Seco	Andesitas		R4	13-ago.	Desplazamiento 10 cm
L1057	603811	7577292	4636	Falla Inversa		83	166		C	1	0	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	13-ago.	Desplazamiento 0,5 cm
L1059	604905	7576271	4657	Falla Inversa		65	290		C	3	0	SR	Rugosa	12	Seco	Ignimbritas		R3	13-ago.	Desplazamiento 1 cm
M155	605749	7577656	4710	Falla Inversa		82	0		C	1		SR	Plana-Escalonada	14	Seco	Ignimbritas		R2	13-ago.	Rechazo 1cm
L1049	597770	7584802	4571	Falla Normal		68	150	133	C	1	0	SR	Plana-Rugosa	12	Seco	Andesitas		R4	13-ago.	Desplazamiento 7 cm
L1053	601652	7578478	4580	Falla Normal		87	346		C	1	0,5	Arena	Plana-Rugosa	4	Seco	Ignimbritas		R3	13-ago.	Desplazamiento 15 cm
L1055	601652	7578478	4580	Falla Normal		82	348		C	8	1	SR	Rugosa	10	Seco	Ignimbritas		R3	13-ago.	Desplazamiento 2 cm
L1058	604905	7576271	4657	Falla Normal		60	51		C	1	0	SR	Rugosa	14	Seco	Ignimbritas		R3	13-ago.	Desplazamiento 4 cm
M149	600731	7583586	4562	Falla Normal		80	10		C	2	2	Arena	Plana-Rugosa	12	Seco	Ignimbritas		R2	13-ago.	Desplazamiento 2,5 cm
M150	601635	7578500	4577	Falla Normal		89	237		D	1	6	SR	Escalonada	10	Seco	Ignimbritas		R2	13-ago.	Desplazamiento 4 cm
M155	605749	7577656	4710	Falla Normal		80	217		C	1		SR	Ondulada-Rugosa	12	Seco	Ignimbritas		R2	13-ago.	Desplazamiento 1cm
L1048	597770	7584802	4571	Falla Sinestral		78	213		C	1	0	SR	Ondulada	12	Seco	Andesitas		R4	13-ago.	Desplazamiento 10 cm
L1045	597770	7584802	4571	Pseudoestratificación		17	212		C						Seco	Andesitas		R4	13-ago.	
M148	597729	7585067	4592	Pseudoestratificación		22	225		C						Seco	Andesitas		R4	13-ago.	
M153	604484	7576684	4683	Pseudoestratificación		68	70		C						Seco	Ignimbritas		R3	13-ago.	
D115	598469	7569289	5004	Diaclasa		62	8		D	3	1	SR	Ondulada-Escalonada	8	Seco	Andesitas		R4	14-ago.	
D115	598469	7569289	5004	Diaclasa		86	105		D	2		SR	Plana-Ondulada	8	Seco	Andesitas		R4	14-ago.	
D117	597826	7569662	5192	Diaclasa		89	225		C	6	1 a 3	SR	Plana-Escalonada	10	Seco	Brecha de base		R3	14-ago.	
D118	597724	7569710	5310	Diaclasa		73	163		C	3		SR	Ondulada-Rugosa	10	Seco	Brecha de base		R3	14-ago.	
D118	597724	7569710	5310	Diaclasa		25	125		C	4		SR	Plana-Escalonada	12	Seco	Brecha de base		R3	14-ago.	
D119	598579	7568906	4895	Diaclasa		74	305		C	2	2	SR	Ondulada	8	Seco	Dacitas		R4	14-ago.	
D120	598736	7568818	4904	Diaclasa		82	109		C	4	5,5	SR	Plana-Ondulada	10	Seco	Andesitas		R4	14-ago.	
D121	599289	7568787	4765	Diaclasa		85	350		C	2		SR	Plana-Ondulada	8	Seco	Brecha de base		R3	14-ago.	
D121	599289	7568787	4765	Diaclasa		84	192		D	2		SR	Ondulada	10	Seco	Brecha de base		R3	14-ago.	
D121	599289	7568787	4765	Diaclasa		50	330		D	1		SR	Plana	4	Seco	Brecha de base		R3	14-ago.	
J64	597748	7569452	5143	Diaclasa		88	264		C	3			Plana	4	Seco	Andesitas		R4	14-ago.	
J66	598087	7568856	4990	Diaclasa		88	302		C	3	0,2	SR	Plana-Ondulada	8	Seco	Brecha de base		R3	14-ago.	
J68	598175	7568758	4965	Diaclasa		58	100		C	2	0,5	SR	Plana	4	Seco	Andesitas		R4	14-ago.	
L1121	602641	7565806	4410	Diaclasa		89	220		C	6	30	SR	Plana	12	Seco	Ignimbritas		R2	14-ago.	
L1122	602641	7565806	4410	Diaclasa		87	216		C	3	2	SR	Plana	12	Seco	Ignimbritas		R2	14-ago.	
L1123	602641	7565806	4410	Diaclasa		85	240		C	3	3	SR	Plana	12	Seco	Ignimbritas		R2	14-ago.	
L1124	602641	7565806	4410	Diaclasa		83	216		C	4	0	SR	Plana	12	Seco	Ignimbritas		R2	14-ago.	
M156	597494	7568993	5216	Diaclasa		60	110		C	6	1	SR	Escalonada	6	Seco	Dacitas		R3	14-ago.	
M156	597494	7568993	5216	Diaclasa		81	91		C	3	0,5	SR	Escalonada	6	Seco	Dacitas		R3	14-ago.	
M157	597510	7568984	5230	Diaclasa		78	240		D	3	3	SR	Plana	6	Seco	Dacitas		R3	14-ago.	
M158	597748	7569125	5990	Diaclasa		88	185		C	3	0,5	SR	Escalonada	6	Humedo	Brecha de base		R3	14-ago.	
M158	597748	7569125	5990	Diaclasa		81	205		C	2	3	SR	Plana	12	Seco	Brecha de base		R3	14-ago.	
M160	598281	7568633	4921	Diaclasa		74	270		C	1	3	SR	Plana	4	Seco	Dacitas		R3	14-ago.	
M160	598281	7568633	4921	Diaclasa		84	151		C	1	5	SR	Plana	4	Seco	Dacitas		R3	14-ago.	
M160	598281	7568633	4921	Diaclasa		42	350		C	1	0,5	SR	Ondulada	8	Seco	Dacitas		R3	14-ago.	
M161	598442	7567690	4710	Diaclasa		84	90		D	1	4	Arena	Curva	16	Seco	Riodacita		R3	14-ago.	
M161	598442	7567690	4710	Diaclasa		52	115		D	4	0,5	SR	Ondulada	16	Seco	Riodacita		R3	14-ago.	
M161	598442	7567690	4710	Diaclasa		77	232		C	2	12		Plana	14	Seco	Riodacita		R3	14-ago.	
M162	598451	7567687	4755	Diaclasa		79	35		D	3	12	SR	Plana	12	Seco	Riodacita		R3	14-ago.	
M163	598451	7567687	4755	Diaclasa		82	238		D	1	10	SR	Ondulada	16	Seco	Riodacita		R3	14-ago.	
M163	598512	7567634	4728	Diaclasa		60	245		D	1	5	SR	Escalonada-Plana	12	Seco	Riodacita		R3	14-ago.	
L1063	601072	7566210	4377	Falla		84	232		C	1	1	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1064	601072	7566210	4377	Falla		89	60		C	1	2	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1065	601072	7566210	4377	Falla		88	50		C	1	2	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1068	601106	7566245	4372	Falla		83	160		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1070	601277	7566265	4385	Falla		85	120		C	1	0	SR	Rugosa	14	Seco	Flujo de detritos		R2	14-ago.	
L1073	601373	7566277	4381	Falla		70	156		C	1	1	SR	Rugosa	14	Seco	Flujo de detritos		R2	14-ago.	
L1083	601583	7566209	4397	Falla		88	96		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	

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SERGEOMIN SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L1085	601583	7566209	4397	Falla		85	80		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	
L1086	601583	7566209	4397	Falla		48	125		C	1	0	SR	Ondulada	10	Seco	Ignimbritas		R3	14-ago.	
L1087	601583	7566209	4397	Falla		88	86		C	1	0	SR	Ondulada	10	Seco	Ignimbritas		R3	14-ago.	
L1091	601583	7566209	4397	Falla		87	94		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1092	601583	7566209	4397	Falla		89	134		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1096	601583	7566209	4397	Falla		89	130		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1099	601583	7566209	4397	Falla		88	300		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1101	601583	7566209	4397	Falla		89	344		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1102	601583	7566209	4397	Falla		88	144		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1103	601583	7566209	4397	Falla		89	330		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1104	602190	7565866	4400	Falla		80	43		C	1	2	SR	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1105	602190	7565866	4400	Falla		84	79		C	1	1	SR	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1106	602190	7565866	4400	Falla		75	150		C	1	0	SR	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1107	602190	7565866	4400	Falla		86	265		C	1	0	SR	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1108	602190	7565866	4400	Falla		89	335		C	1	0	SR	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1109	602190	7565866	4400	Falla		89	286		C	1	3	Micro Brecha	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1110	602190	7565866	4400	Falla		86	340		C	1	1	Micro Brecha	Plana	10	Seco	Flujo de detritos		R2	14-ago.	
L1113	602190	7565866	4400	Falla		73	160		C	1	4	Micro Brecha	Ondulada	12	Seco	Flujo de detritos		R2	14-ago.	
L1114	602190	7565866	4400	Falla		85	334		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1115	602190	7565866	4400	Falla		83	68		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1116	602190	7565866	4400	Falla		83	160		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1117	602190	7565866	4400	Falla		88	352		C	1	6	Micro Brecha	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
M156	597494	7568993	5216	Falla	225	70	135		C	1	0,5	SR	Plana	6	Seco	Dacitas		R3	14-ago.	
M157	597510	7568984	5230	Falla		88	70		C	6	2	SR	Escalonada	8	Seco	Dacitas		R3	14-ago.	
M159	597926	7569007	5012	Falla	180	78	90		C	1	5	SR	Ondulada	4	Seco	Dacitas		R3	14-ago.	
L1075	601373	7566277	4381	Falla		87	330		C	1	0	SR	Rugosa	14	Seco	Flujo de detritos		R2	14-ago.	
M158	597748	7569125	5990	Falla	192	84	282		C	1	1	SR	Escalonada	8	Seco	Dacitas		R3	14-ago.	
M158	597748	7569125	5990	Falla		88	115		C	1	0,5	SR	Escalonada	8	Seco	Dacitas		R3	14-ago.	Desplazamiento 14 cm
M159	597926	7569007	5012	Falla	270	54	180		C	1	0,5	SR	Plana-Curva	4	Seco	Dacitas		R3	14-ago.	
M163	598512	7567634	4728	Falla		82	198		C	1	6	SR	Plana	12	Seco	Riodacita		R3	14-ago.	
L1062	601072	7566210	4377	Falla Dextral		85	30		C	1	1,5	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	
L1077	601583	7566209	4397	Falla Dextral		80	25		C	1	2	SR	Rugosa	14	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 100 cm
D118	597724	7569710	5310	Falla Inversa		43	320		D	1	0,5	SR	Ondulada-Rugosa	12	Seco	Brecha de base		R3	14-ago.	Rechazo 6 cm
D120	598736	7568818	4904	Falla Inversa		78	320		C	1	1,5	SR	Plana-Ondulada	10	Seco	Andesitas		R4	14-ago.	Rechazo 5 cm
L1078	601583	7566209	4397	Falla Inversa		89	350		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 180 cm
L1100	601583	7566209	4397	Falla Inversa		85	340		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 45 cm
L1111	602190	7565866	4400	Falla Inversa		89	80		C	1	0	SR	Plana	10	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 10 cm
D115	598469	7569289	5004	Falla Normal		71	175		C	1	1,5	Arena	Plana	4	Seco	Andesitas		R4	14-ago.	Desplazamiento 3 cm
D116	597535	7569602	5161	Falla Normal		62	305		C	1	2	SR	Ondulada-Escalonada	12	Seco	Brecha de base		R3	14-ago.	Desplazamiento 4 cm
D116	597535	7569602	5161	Falla Normal		76	285		C	1	0,5 a 10	SR	Plana-Ondulada	8	Seco	Brecha de base		R3	14-ago.	Desplazamiento 13 cm
D117	597826	7569662	5192	Falla Normal		72	210		D	1	1	SR	Ondulada-Escalonada	12	Seco	Brecha de base		R3	14-ago.	Desplazamiento 20 cm
D119	598579	7568906	4895	Falla Normal		89	105		D	1	1,5	SR	Ondulada	8	Seco	Dacitas		R4	14-ago.	Desplazamiento 8 cm
D120	598736	7568818	4904	Falla Normal		40	43		C	1	2	SR	Plana	8	Seco	Andesitas		R4	14-ago.	Desplazamiento 3,5 cm
J64	597748	7569452	5143	Falla Normal		88	25		C	1			Plana	4	Seco	Andesitas		R4	14-ago.	Desplazamiento 3 cm
J65	597780	7569165	5035	Falla Normal		50	310		C	1	0,2	SR	Plana	4	Seco	Andesitas		R4	14-ago.	Desplazamiento 2 cm
J66	598087	7568856	4990	Falla Normal		86	195		C	1	1 a 3	SR	Ondulada-Escalonada	14	Seco	Brecha de base		R3	14-ago.	Desplazamiento 2 cm
J67	598170	7568758	4965	Falla Normal		85	121		D	1	2 a 5	SR	Plana-Escalonada	14	Seco	Andesitas		R4	14-ago.	Desplazamiento 8 cm
J68	598175	7568758	4965	Falla Normal		69	140		C	1	3 a 5	SR	Ondulada-Escalonada	14	Humedo	Andesitas		R4	14-ago.	Desplazamiento 5 cm
J70	598305	7568607	4915	Falla Normal		70	310		C	1	0,5	SR	Plana	4	Seco	Andesitas		R4	14-ago.	Desplazamiento 15 cm
L1066	601106	7566245	4372	Falla Normal		85	225		C	1	3	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 10 cm
L1067	601106	7566245	4372	Falla Normal		88	234		C	1	2	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 30 cm
L1069	601182	7566260	4382	Falla Normal		84	80		D	1	0	SR	Plana	12	Seco	Ignimbritas		R2	14-ago.	Desplazamiento 10 cm
L1071	601373	7566277	4381	Falla Normal		67	226		C	1	3	SR	Rugosa	14	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 10 cm
L1072	601373	7566277	4381	Falla Normal		40	214		C	1	0	SR	Rugosa	14	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 5 cm
L1074	601373	7566277	4381	Falla Normal		82	84		C	1	0	SR	Rugosa	14	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 20 cm
L1076	601583	7566209	4397	Falla Normal		84	280		C	1	3	SR	Rugosa	14	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 5 cm
L1079	601583	7566209	4397	Falla Normal		80	86		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 15 cm
L1080	601583	7566209	4397	Falla Normal		88	16		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	
L1081	601583	7566209	4397	Falla Normal		72	70		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 5 cm
L1082	601583	7566209	4397	Falla Normal		84	320		C	1	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 20 cm

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SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L1084	601583	7566209	4397	Falla Normal		88	30		C	2	0	SR	Plana	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 40 cm
L1088	601583	7566209	4397	Falla Normal		80	130		C	1	0	SR	Plana-rugosa	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 20 cm
L1089	601583	7566209	4397	Falla Normal		89	154		C	1	0	SR	Plana-rugosa	10	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 10 cm
L1090	601583	7566209	4397	Falla Normal		88	105		C	1	2	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 5 cm
L1093	601583	7566209	4397	Falla Normal		89	21		C	2	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 30 cm
L1094	601583	7566209	4397	Falla Normal		89	110		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 15 cm
L1095	601583	7566209	4397	Falla Normal		89	314		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	
L1097	601583	7566209	4397	Falla Normal		89	96		C	1	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 2 cm
L1098	601583	7566209	4397	Falla Normal		89	34		C	2	0	SR	Plana-rugosa	12	Seco	Ignimbritas		R3	14-ago.	Desplazamiento 30 cm
L1112	602190	7565866	4400	Falla Normal		70	150		C	1	0	SR	Ondulada	10	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 5 cm
L1118	602309	7565830	4401	Falla Normal		87	160		C	1	1	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 5 cm
L1119	602309	7565830	4401	Falla Normal		88	290		C	1	1,5	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 6 cm
L1120	602309	7565830	4401	Falla Normal		80	175		C	1	20	SR	Plana	12	Seco	Flujo de detritos		R2	14-ago.	Desplazamiento 30 cm
L1125	602641	7565806	4410	Falla Normal		86	60		D	1	0	SR	Plana	12	Seco	Ignimbritas		R2	14-ago.	Desplazamiento 10 cm
M158	597748	7569125	5990	Falla Normal	170	77	260		C	1	5	SR	Plana	8	Seco	Dacitas		R3	14-ago.	
M158	597748	7569125	5990	Falla Normal	205	79	115		C	1	10	SR	Curva	6	Seco	Dacitas		R3	14-ago.	
M158	597748	7569125	5990	Falla Normal		61	175		C	1	0,5	SR	Plana-Curva	4	Seco	Dacitas		R3	14-ago.	Desplazamiento 42 cm
M158	597748	7569125	5990	Falla Normal		68	164		C	1	10	SR	Curva	4	Seco	Dacitas		R3	14-ago.	Desplazamiento 5 cm
J69	598206	7568715	4951	Falla Sinestral		59	108		C	1	2	SR	Plana	4	Seco	Andesitas		R4	14-ago.	Desplazamiento 3 cm
D119	598579	7568906	4895	Pseudoestratificación		52	342		C						Seco	Dacitas		R5	14-ago.	
D120	598736	7568818	4904	Pseudoestratificación		34	55		C						Seco	Andesitas		R4	14-ago.	
M156	597494	7568993	5216	Pseudoestratificación		18	200		C						Seco	Dacitas		R3	14-ago.	
M161	598442	7567690	4710	Pseudoestratificación		35	215		C						Seco	Riodacita		R3	14-ago.	
D124	605207	7575500	4699	Diaclasa		45	55		C	1	1	Arena	Plana-Rugosa	10	Seco	Dacitas		R3	15-ago.	
D124	605207	7575500	4699	Diaclasa		74	316		C	1	1 a 5	Arena	Rugosa	12	Seco	Dacitas		R3	15-ago.	
D125	605202	7575087	4710	Diaclasa		71	106		C	6	0,4 a 1	SR	Plana	4	Seco	Dacitas		R3	15-ago.	
D125	605202	7575087	4710	Diaclasa		60	254		D	2	1	SR	Plana-Rugosa	12	Seco	Dacitas		R3	15-ago.	
D126	605345	7574958	4736	Diaclasa		90	168		C	4	1 a 3	Arena	Plana	4	Seco	Dacitas		R3	15-ago.	
D126	605345	7574958	4736	Diaclasa		74	221		D	2	4	Arena	Plana-Ondulada	14	Seco	Dacitas		R3	15-ago.	
D126	605345	7574958	4736	Diaclasa		83	315		D	2	0,5 a 2	Arena	Rugosa-Escalonada	14	Seco	Dacitas		R3	15-ago.	
D128	606024	7574532	4686	Diaclasa		74	125		D	2		SR	Rugosa-Escalonada	14	Seco	Dacitas		R3	15-ago.	
D128	606024	7574532	4686	Diaclasa		23	195		C	1		SR	Rugosa-Escalonada	14	Seco	Dacitas		R3	15-ago.	
D129	607686	7571340	4700	Diaclasa		85	36		C	1		SR	Plana	4	Seco	Ignimbritas		R3	15-ago.	
D129	607686	7571340	4700	Diaclasa		83	105		C	3	1	SR	Plana-Rugosa	12	Seco	Ignimbritas		R3	15-ago.	
L1127	600532	7566425	4385	Falla		20	347		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	15-ago.	
L1133	600636	7566129	4349	Falla		87	308		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	
L1135	600630	7565970	4343	Falla		88	18		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	
L1136	600630	7565970	4343	Falla		87	7		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	
L1144	600503	7565662	4319	Falla		87	17		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	
D123	604874	7575809	4709	Falla Dextral		83	150		D	1	0,2 a 2	Arena	Plana-Rugosa	10	Seco	Dacitas		R3	15-ago.	Desplazamiento 5 cm
L1137	600630	7565970	4343	Falla Dextral		85	210		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 50 cm
L1145	600503	7565662	4319	Falla Dextral		89	10	100	C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 30 cm
L1146	600188	7565406	4327	Falla Dextral		78	233		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 100 cm
D122	604848	7575867	4674	Falla Inversa		58	297		C	1		SR	Plana-Rugosa	12	Seco	Dacitas		R3	15-ago.	Rechazo 5 cm
D129	607686	7571340	4700	Falla Inversa		33	95		D	1	1 a 5	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	15-ago.	Rechazo 3 cm
D129	607686	7571340	4700	Falla Inversa		46	273		C	1	1	SR	Plana-Ondulada	8	Seco	Ignimbritas		R3	15-ago.	Rechazo 2 cm
L1126	600532	7566425	4385	Falla Inversa		50	330		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	15-ago.	Desplazamiento 5 cm
L1128	600532	7566425	4385	Falla Inversa		75	342		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	15-ago.	Desplazamiento 3 cm
L1129	600532	7566425	4385	Falla Inversa		47	290		C	1	0	SR	Plana	12	Seco	Flujo de detritos		R2	15-ago.	Desplazamiento 7 cm
D127	605702	7575092	4716	Falla Normal		78	300		D	1	1	Arena	Ondulada-Escalonada	14	Seco	Dacitas		R3	15-ago.	Desplazamiento 10 cm
D128	606024	7574532	4686	Falla Normal		81	331		C	1	0,5	Arena	Rugosa-Escalonada	14	Seco	Dacitas		R3	15-ago.	Desplazamiento 2 cm
L1130	600677	7566311	4375	Falla Normal		89	310		C	1	0	SR	Rugosa	12	Seco	Flujo de detritos		R2	15-ago.	Desplazamiento 5 cm
L1131	600677	7566311	4375	Falla Normal		89	304		C	1	0	SR	Rugosa	12	Seco	Flujo de detritos		R2	15-ago.	Desplazamiento 2 cm
L1132	600636	7566129	4349	Falla Normal		83	10		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 15 cm
L1134	600636	7566129	4349	Falla Normal		87	20		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 10 cm
L1138	600630	7565970	4343	Falla Normal		88	29		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 5 cm
L1139	600630	7565970	4343	Falla Normal		85	26		C	1	1	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 10 cm
L1140	600630	7565970	4343	Falla Normal		87	30		C	1	1	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 5 cm
L1141	600587	7565829	4320	Falla Normal		89	11		C	1	1	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 20 cm
L1143	600587	7565829	4320	Falla Normal		90	335		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 10 cm

DIRECCIÓN TÉCNICA DE PROSPECCIÓN Y EXPLORACIÓN
"ESTUDIO GEOLOGICO-ESTRUCTURAL DEL AREA
CIRCUNDANTE DEL MANANTIAL DEL SILALA"

SERGEOMIN
SERVICIO GEOLÓGICO MINERO

PTO.	ESTE	NORTE	ELEV.	TIPO	Az	Bz	DipDir	Pitch	CONTINUIDAD	PERSISTENCIA (10m)	ABERTURA (cm)	RELLENO	FORMA	JRC	AGUA	TIPO ROCA	ALTERACION	DUREZA	FECHA	OBSERVACIONES
L1147	600188	7565406	4327	Falla Normal		70	45		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 6 cm
L1148	600188	7565406	4327	Falla Normal		89	52		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 5 cm
L1149	600188	7565406	4327	Falla Normal		87	62		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 10 cm
L1150	600188	7565406	4327	Falla Normal		88	58		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 10 cm
L1142	600587	7565829	4320	Falla Sinestral		89	5		C	1	0	SR	Plana	12	Seco	Ignimbritas		R3	15-ago.	Desplazamiento 30 cm
D124	605207	7575500	4699	Pseudoestratificación		42	142		C						Seco	Dacitas		R3	15-ago.	
D125	605202	7575087	4710	Pseudoestratificación		65	238		C						Seco	Dacitas		R3	15-ago.	

CONVENIO DE COOPERACIÓN INTERINSTITUCIONAL Y
CONTRATO DE CONSULTORIA DIREMAR - SERGEOMIN

SERGEOMIN
SERVICIO GEOLÓGICO MINERO

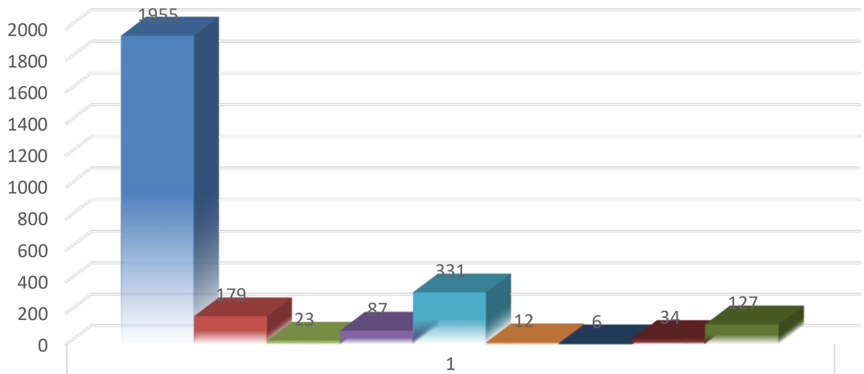
ESTADÍSTICA CUANTITATIVA Y CUALITATIVA DE ESTRUCTURAS

Calle Federico Suazo Nº 1673 Esquina Reyes Ortiz – La Paz - Bolivia
Telf. (591 – 2) 2330981 – 2331236 - Fax 2391725 – 2318295
www.sergeomin.gob.bo

Anexo

Estadística cuantitativa y cualitativa del proyecto "Estudio Geológico-Estructural del área Circundante al Manantial Silala"

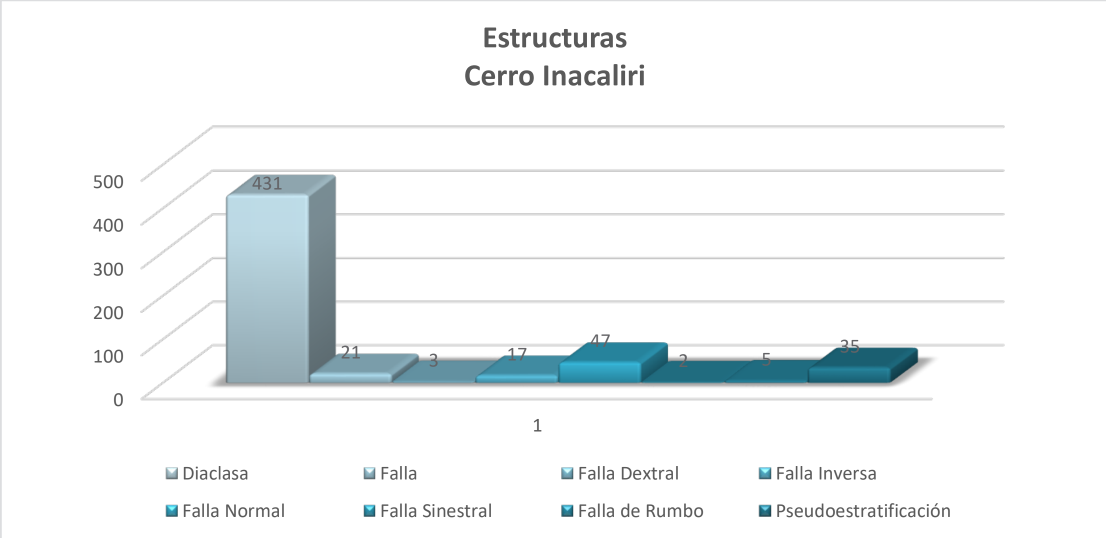
ESTRUCTURAS GEOLOGICAS-PROYECTO SILALA



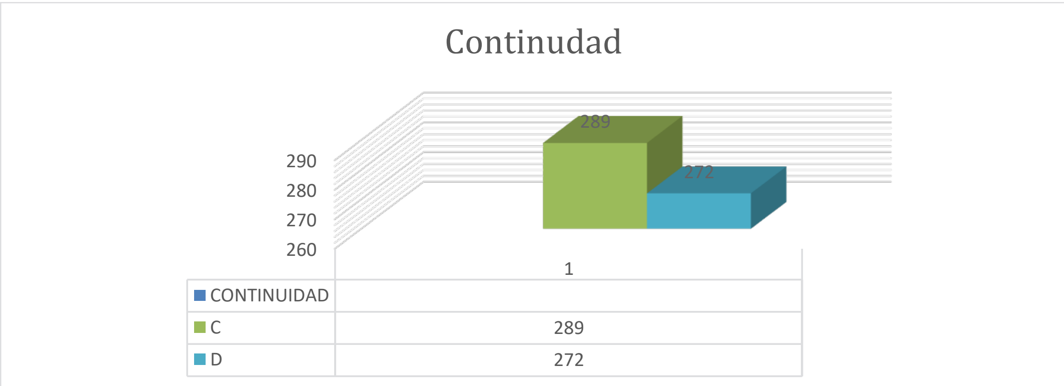
	1
Diaclasa	1955
Falla	179
Falla Dextral	23
Falla Inversa	87
Falla Normal	331
Falla Sinestral	12
Falla de Rumbo	6
Falla inversa	34
Pseudoestratificación	127

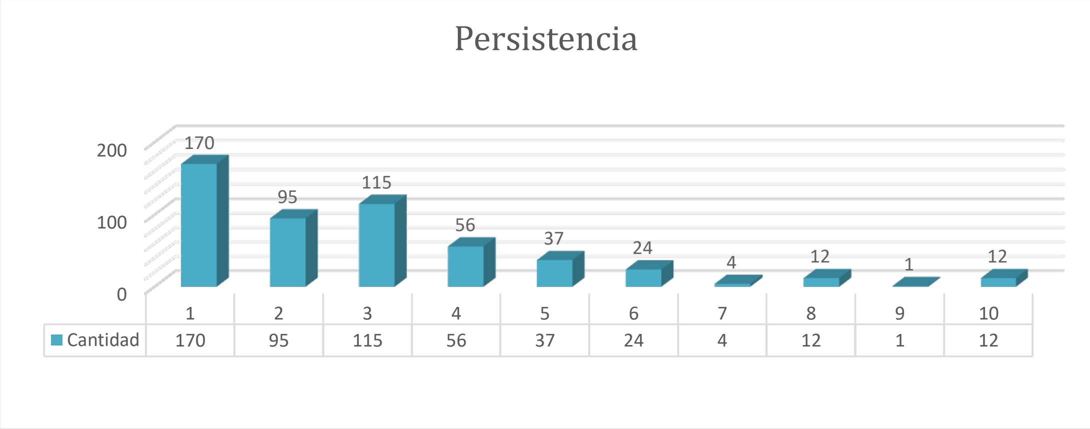
ESTRUCTURAS	CANTIDAD
Diaclasa	1955
Falla	179
Falla Dextral	23
Falla Inversa	87
Falla Normal	331
Falla Sinestral	12
Falla de Rumbo	6
Falla inversa	34
Pseudoestratificación	127
Total Estructuras	**2754**

Cerro Inacaliri

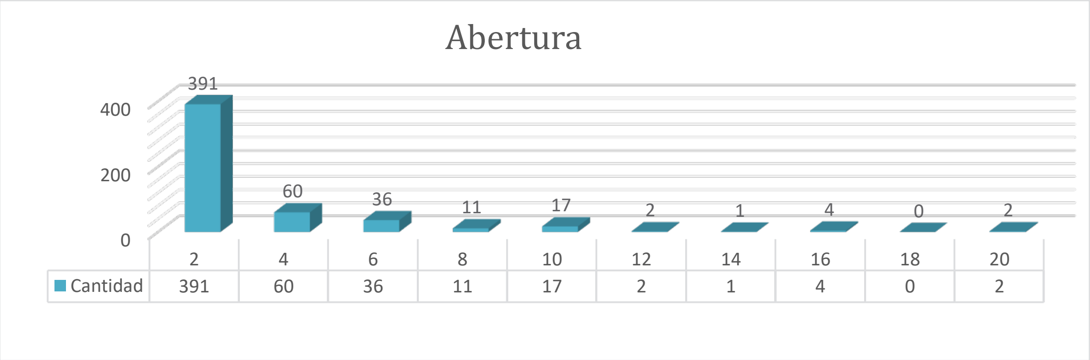


ESTRUCTURAS	
Diaclasa	431
Falla	21
Falla Dextral	3
Falla Inversa	17
Falla Normal	47
Falla Sinestral	2
Falla de Rumbo	5
Pseudoestratificación	35

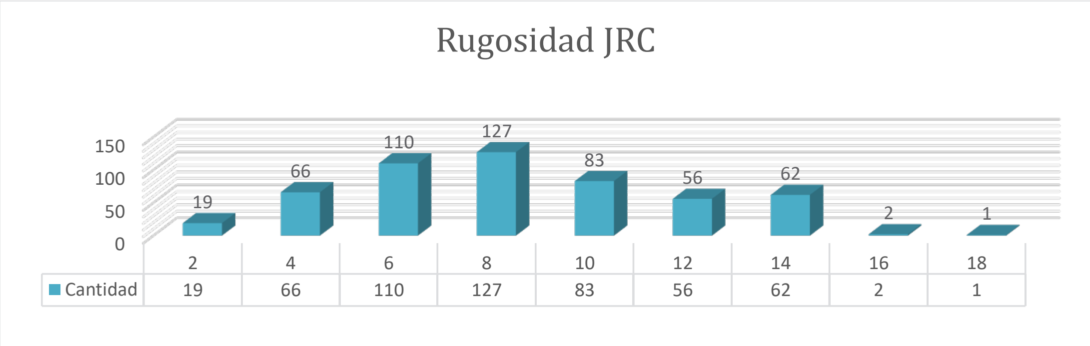




	1	2	3	4	5	6	7	8	9	10
Cantidad	170	95	115	56	37	24	4	12	1	12

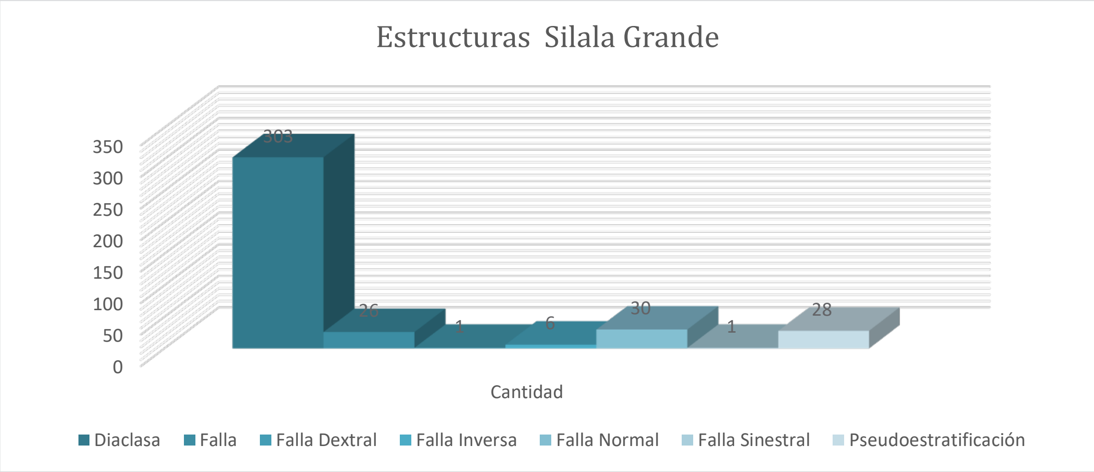


	2	4	6	8	10	12	14	16	18	20
Cantidad	391	60	36	11	17	2	1	4	0	2

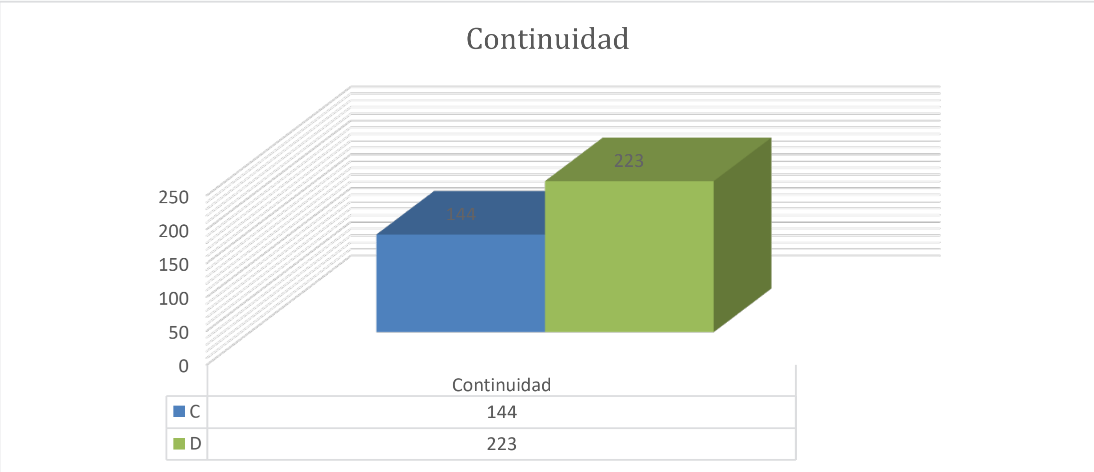


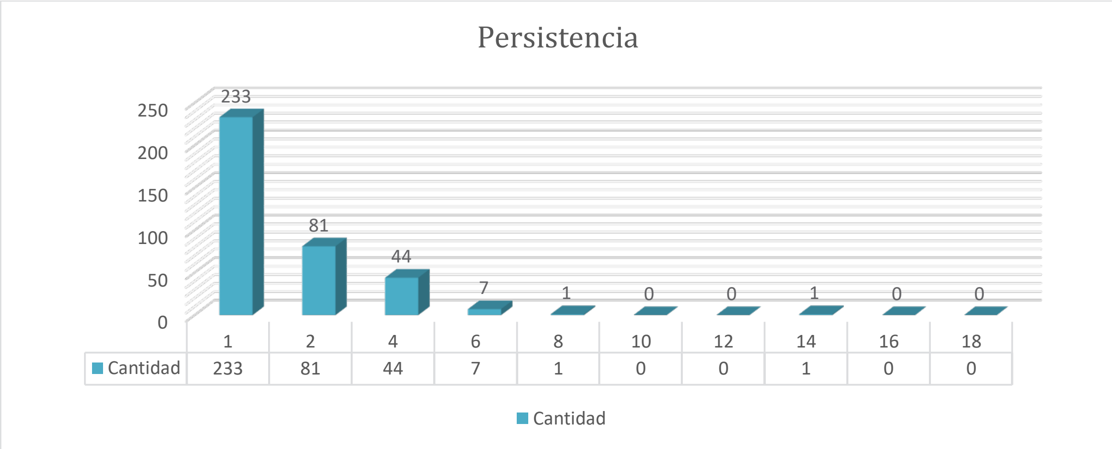
	2	4	6	8	10	12	14	16	18
Cantidad	19	66	110	127	83	56	62	2	1

Silala Grande

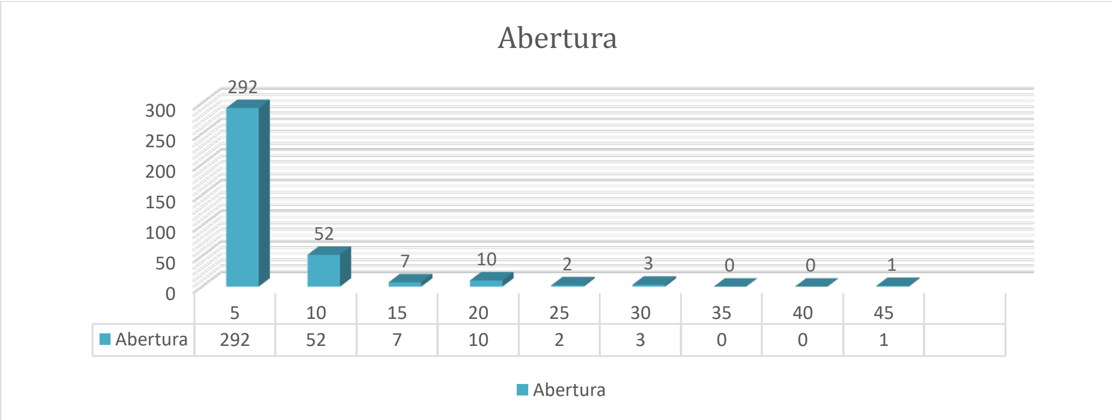


Estructuras	Cantidad
Diaclasa	303
Falla	26
Falla Dextral	1
Falla Inversa	6
Falla Normal	30
Falla Sinestral	1
Pseudoestratificación	28

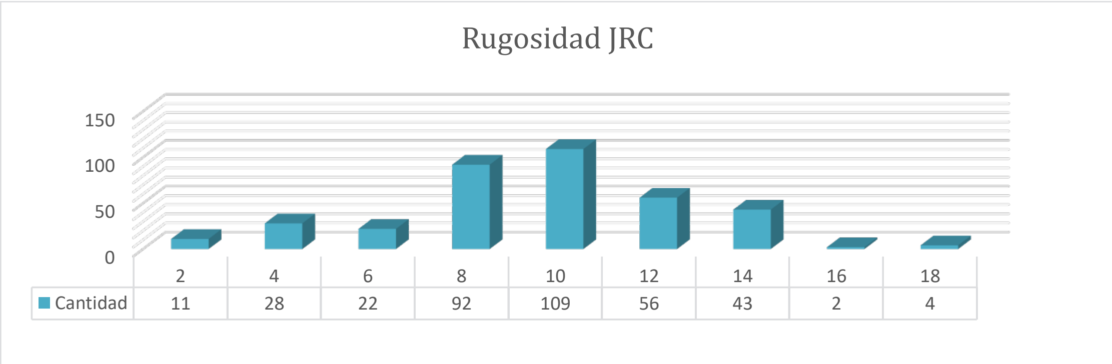




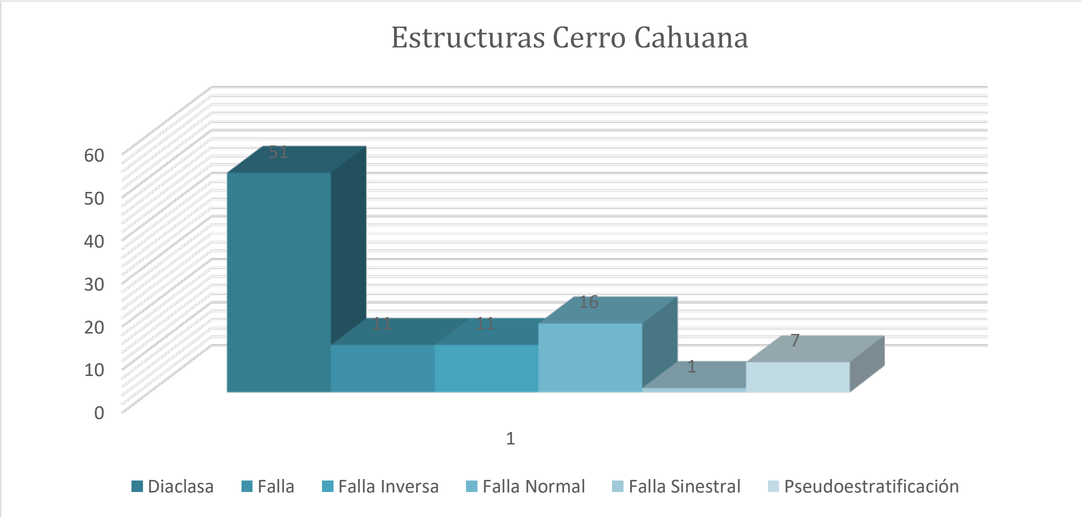
	1	2	4	6	8	10	12	14	16	18
Cantidad	233	81	44	7	1	0	0	1	0	0



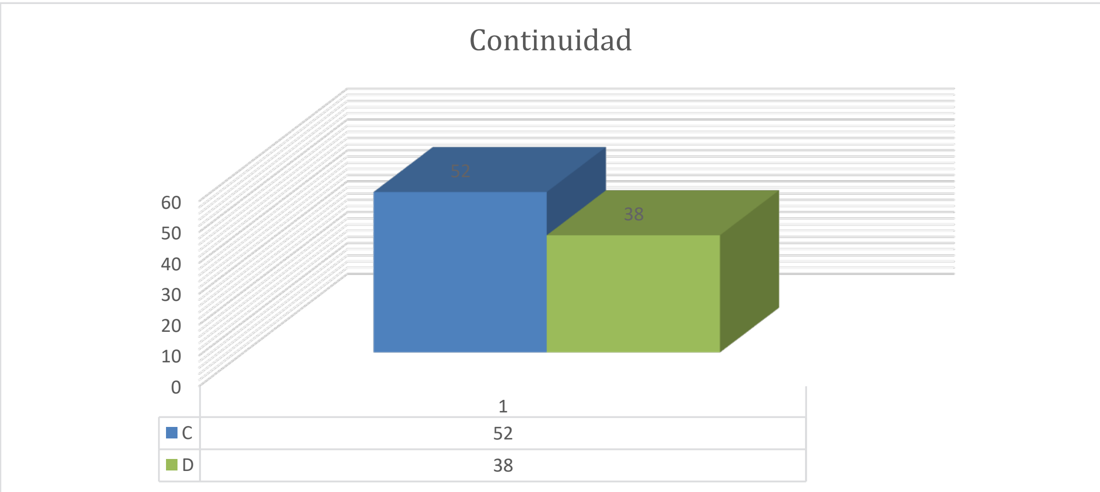
	5	10	15	20	25	30	35	40	45	
Abertura	292	52	7	10	2	3	0	0	1	

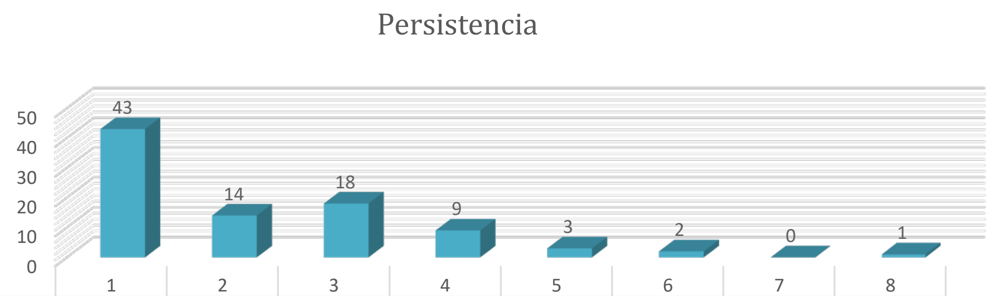


	2	4	6	8	10	12	14	16	18
Cantidad	11	28	22	92	109	56	43	2	4

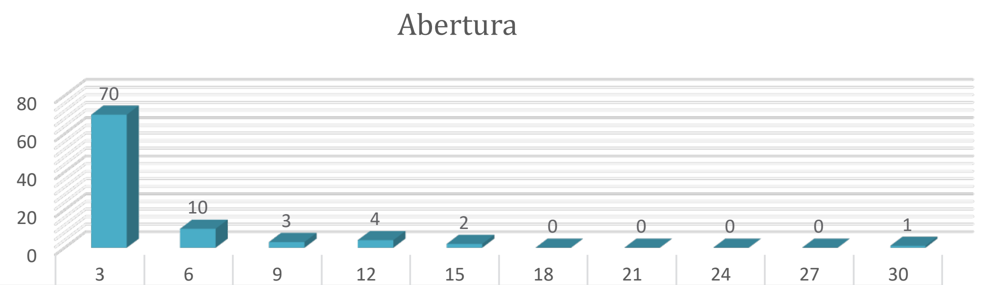


Estructuras	Cantidad
Diaclasa	51
Falla	11
Falla Inversa	11
Falla Normal	16
Falla Sinestral	1
Pseudoestratificación	7

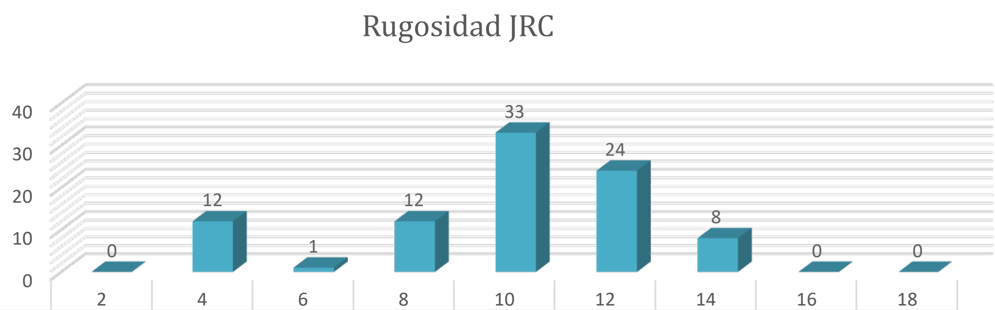




	1	2	3	4	5	6	7	8
Cantidad	43	14	18	9	3	2	0	1

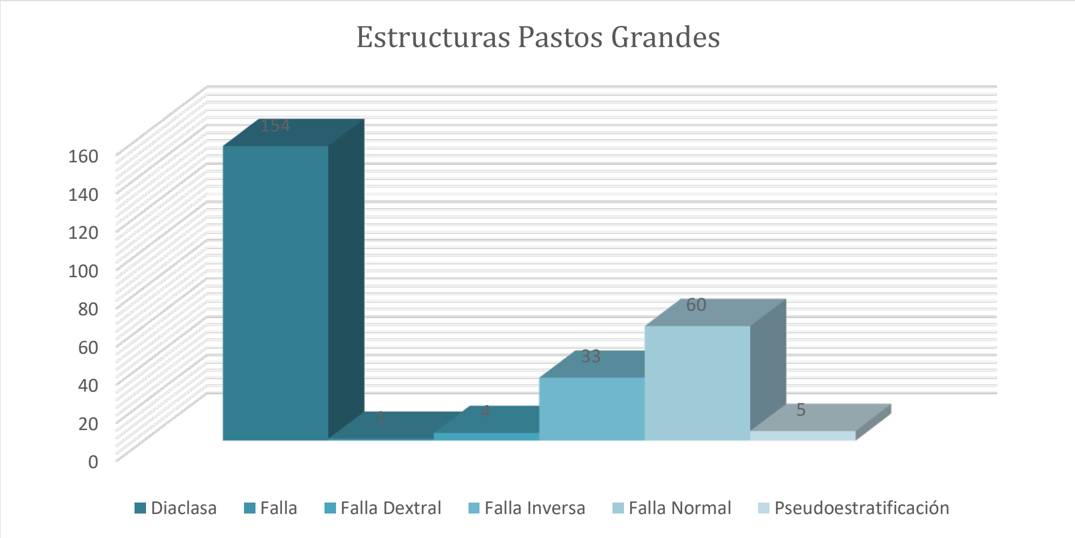


	3	6	9	12	15	18	21	24	27	30
Cantidad	70	10	3	4	2	0	0	0	0	1

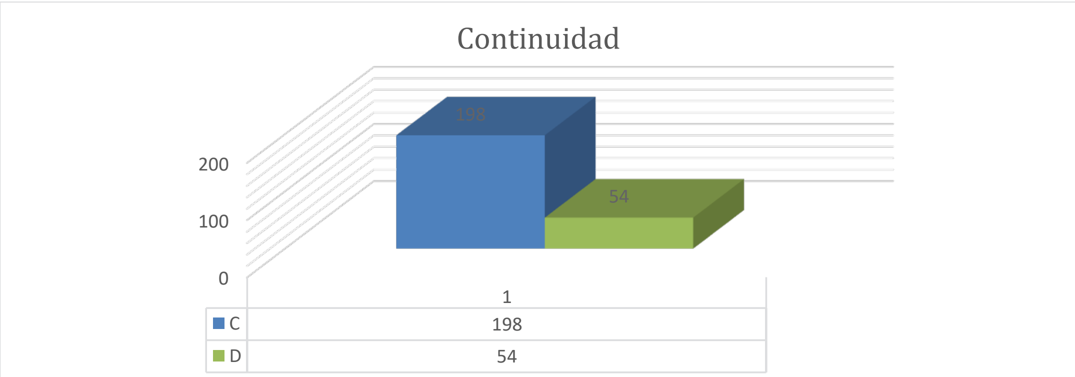


	2	4	6	8	10	12	14	16	18
Cantidad	0	12	1	12	33	24	8	0	0

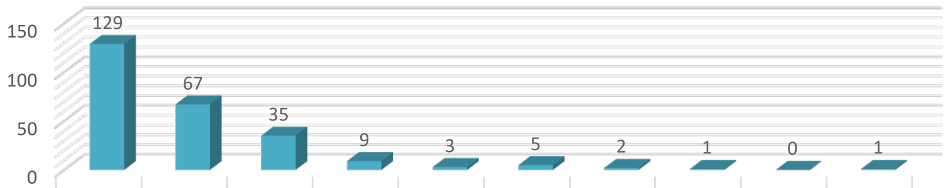
Pastos Grandes



Estructuras	Cantidad
Diaclasa	154
Falla	1
Falla Dextral	4
Falla Inversa	33
Falla Normal	60
Pseudoestratificación	5

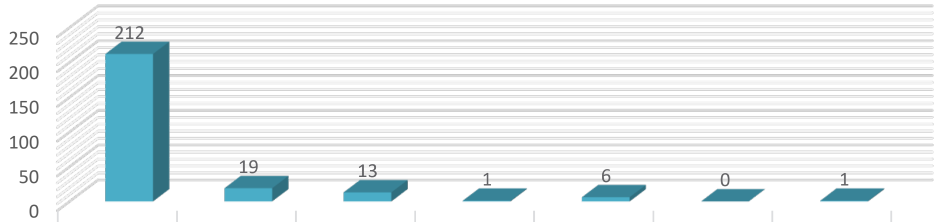


Persistencia



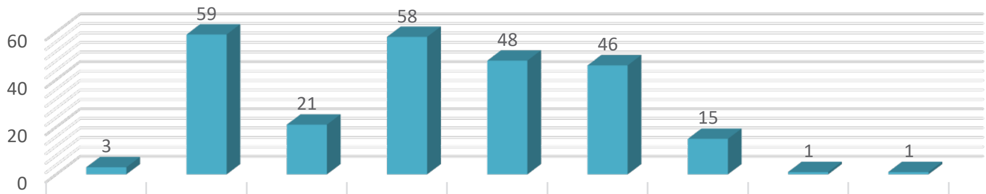
	1	2	3	4	5	6	7	8	9	10
Cantidad	129	67	35	9	3	5	2	1	0	1

Abertura



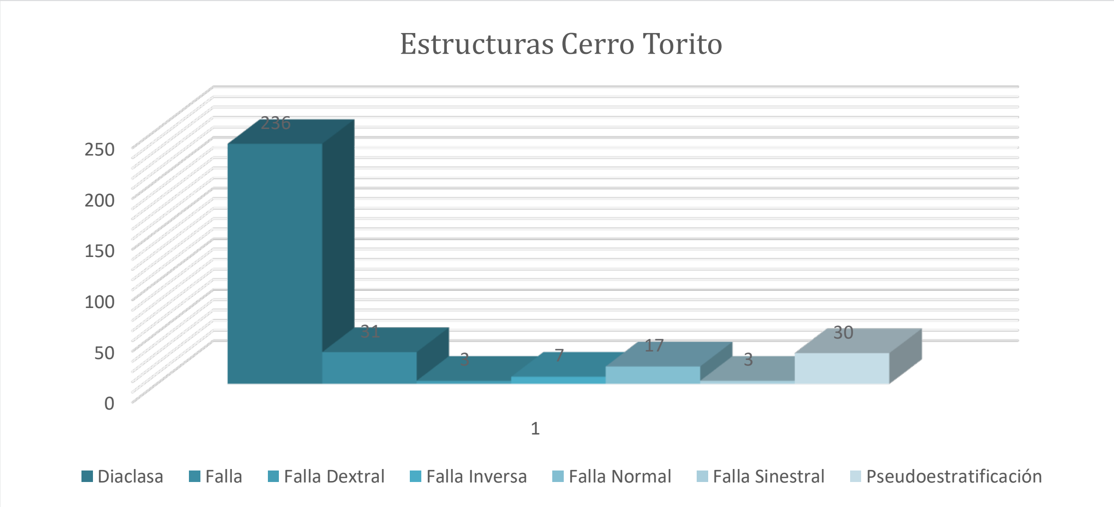
	2	4	6	8	10	12	14
Cantidad	212	19	13	1	6	0	1

Rugosidad JRC

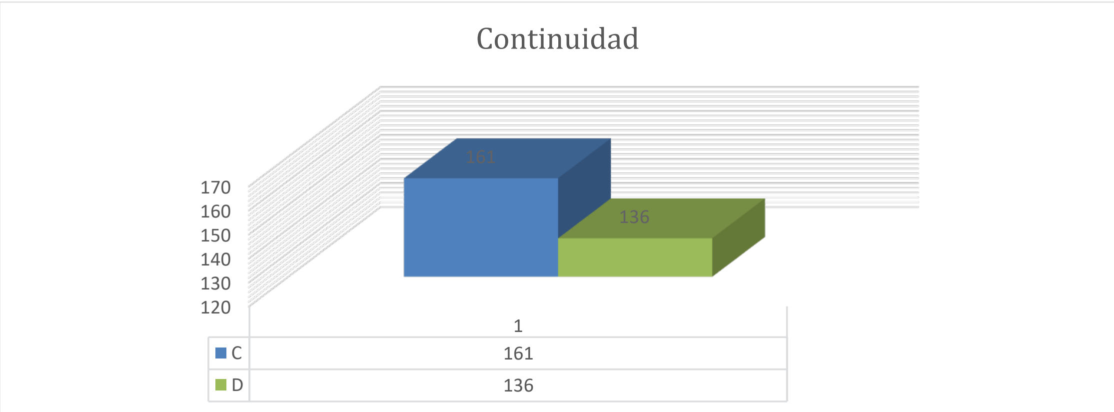


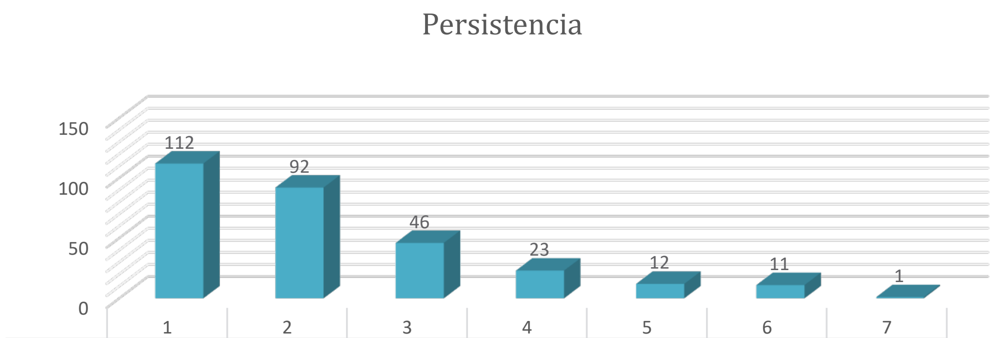
	2	4	6	8	10	12	14	16	18
Cantidad	3	59	21	58	48	46	15	1	1

Cerro Torito

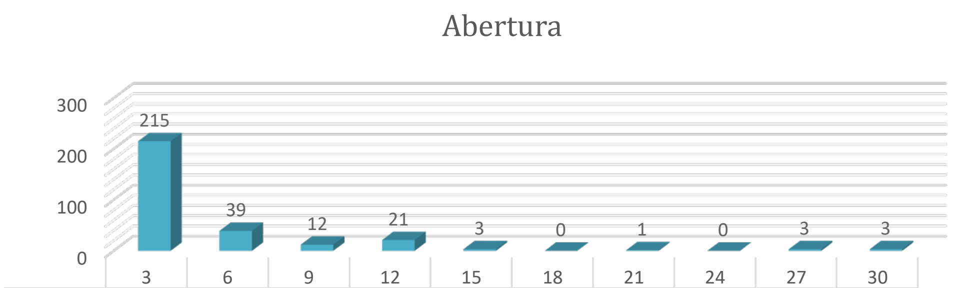


Estructura	Cantidad
Diaclasa	236
Falla	31
Falla Dextral	3
Falla Inversa	7
Falla Normal	17
Falla Sinestral	3
Pseudoestratificación	30

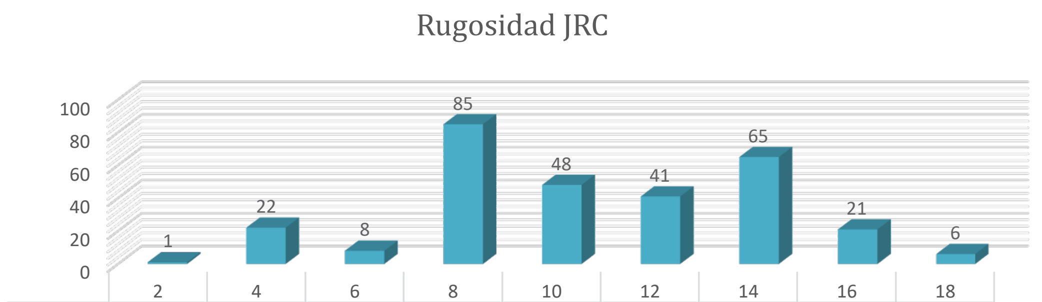




	1	2	3	4	5	6	7
Cantidad	112	92	46	23	12	11	1

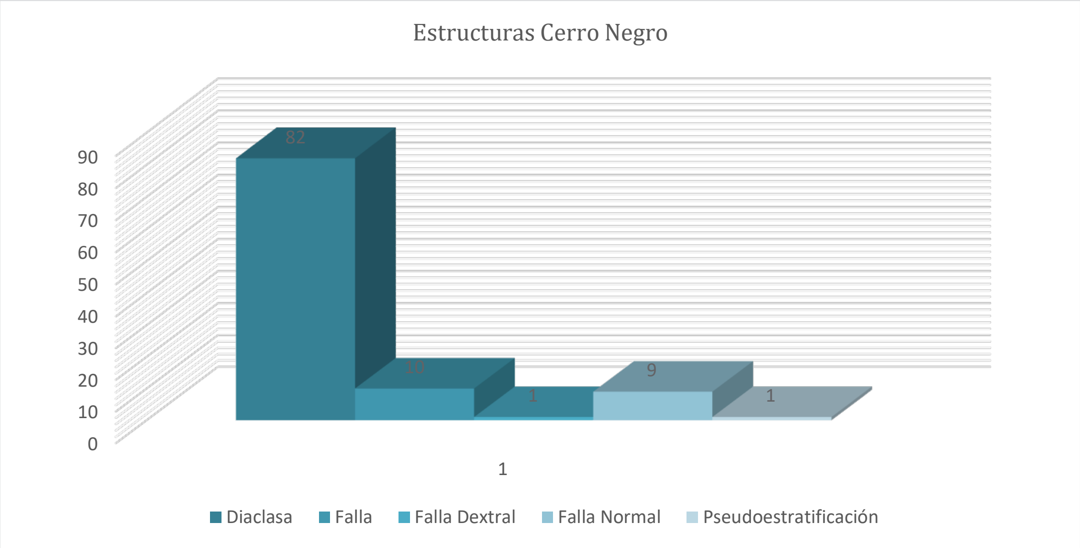


	3	6	9	12	15	18	21	24	27	30
Cantidad	215	39	12	21	3	0	1	0	3	3

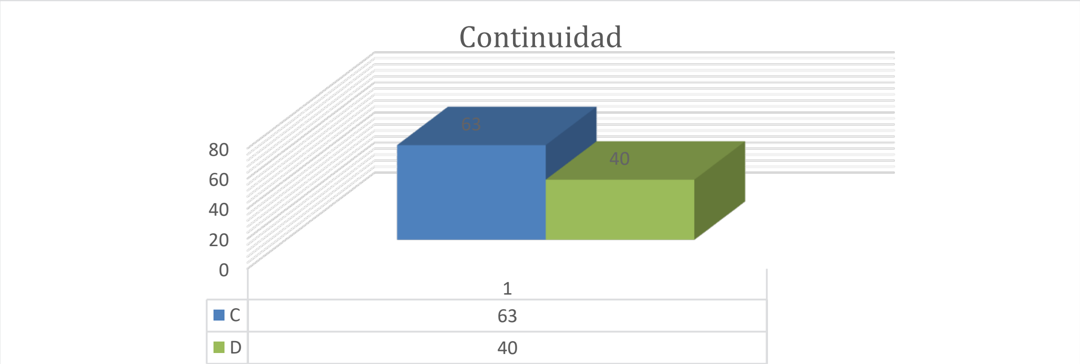


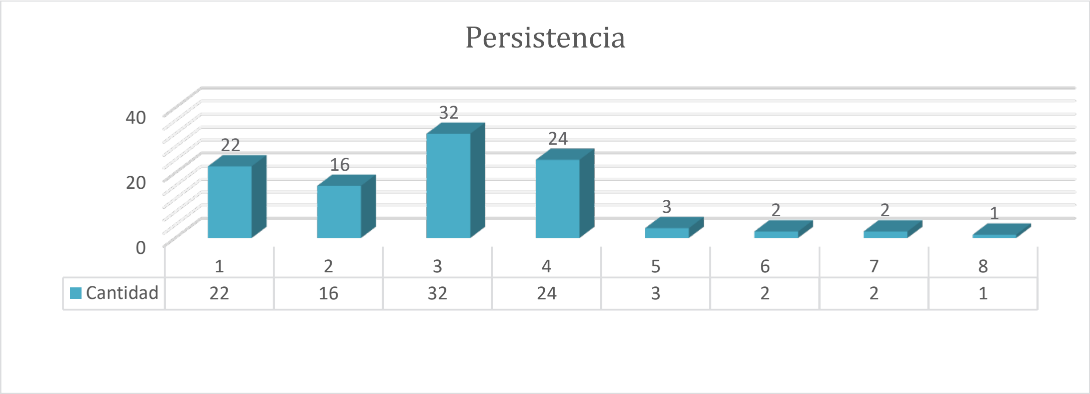
	2	4	6	8	10	12	14	16	18
Cantidad	1	22	8	85	48	41	65	21	6

Cerro Negro



Estructuras	Cantidad
Diaclasa	82
Falla	10
Falla Dextral	1
Falla Normal	9
Pseudoestratificación	1

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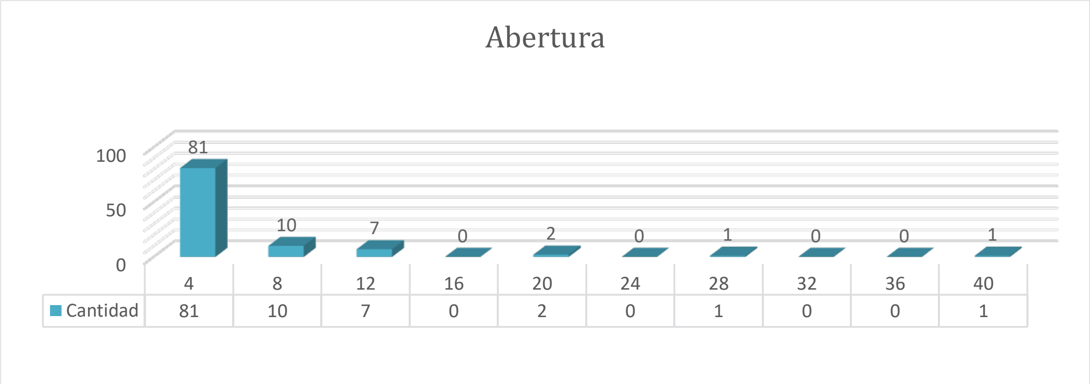
Cantidad 22 16 32 24 3 2 2 1


Abertura
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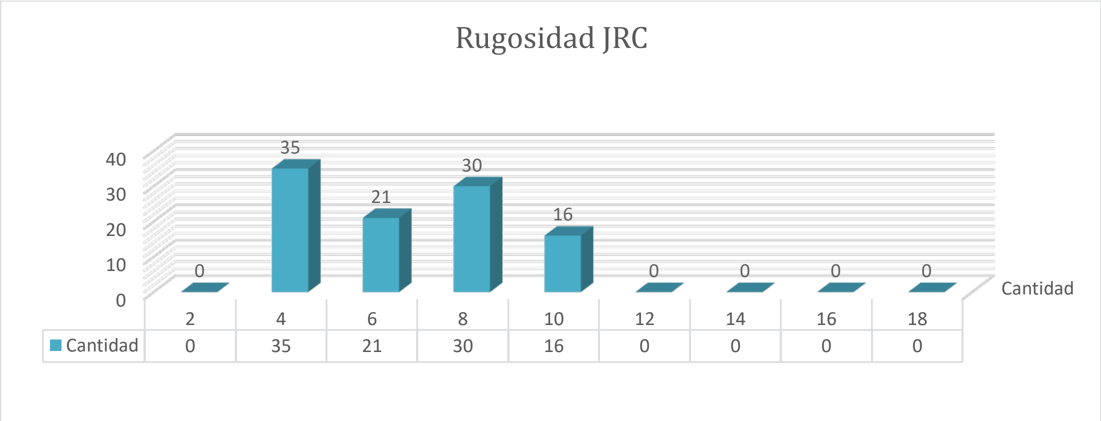
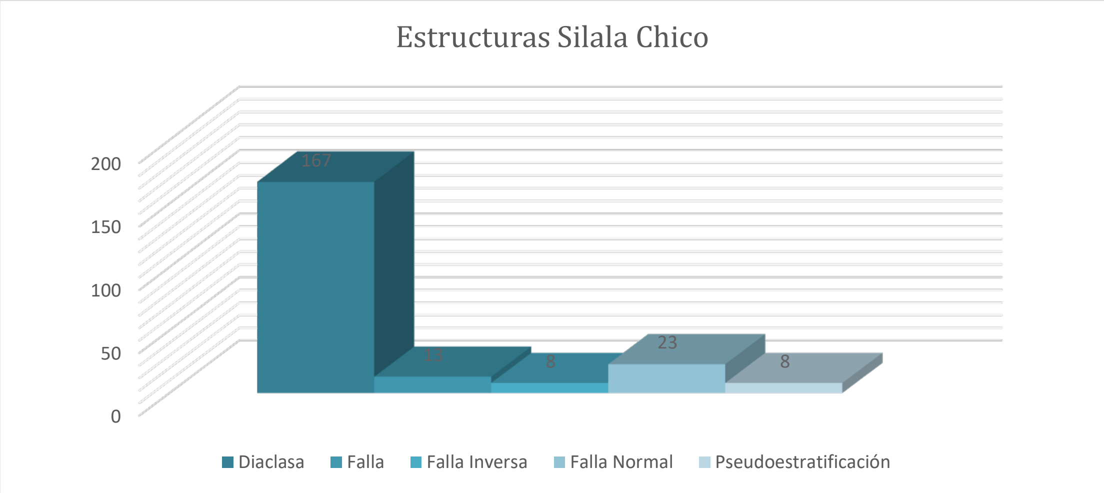
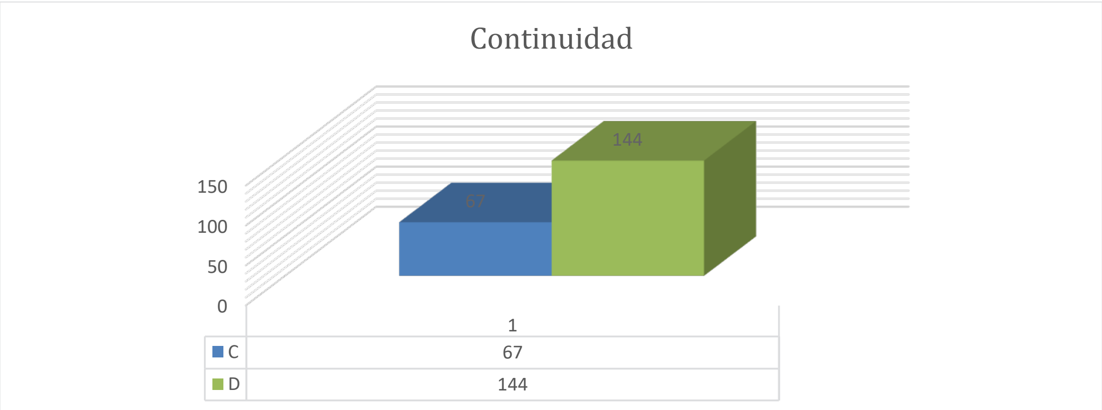
Cantidad 81 10 7 0 2 0 1 0 0 1


Rugosidad JRC
40
30
20
10
0
Cantidad
2 4 6 8 10 12 14 16 18
Cantidad 0 35 21 30 16 0 0 0 0

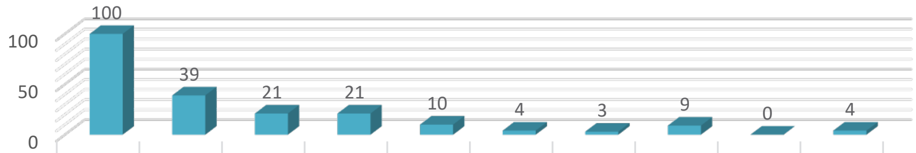
Silala Chico



Estructuras	Continuidad
Diaclasa	167
Falla	13
Falla Inversa	8
Falla Normal	23
Pseudoestratificación	8

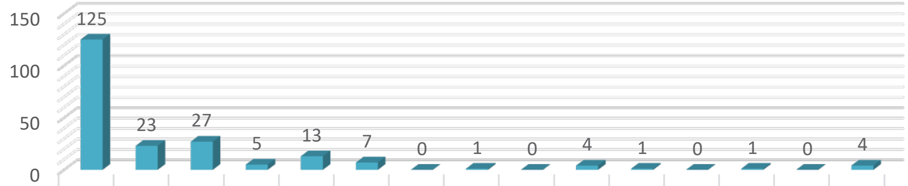


Persistencia



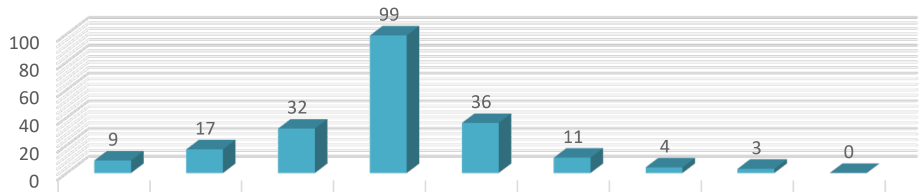
	1	2	3	4	5	6	7	8	9	10
Cantidad	100	39	21	21	10	4	3	9	0	4

Abertura



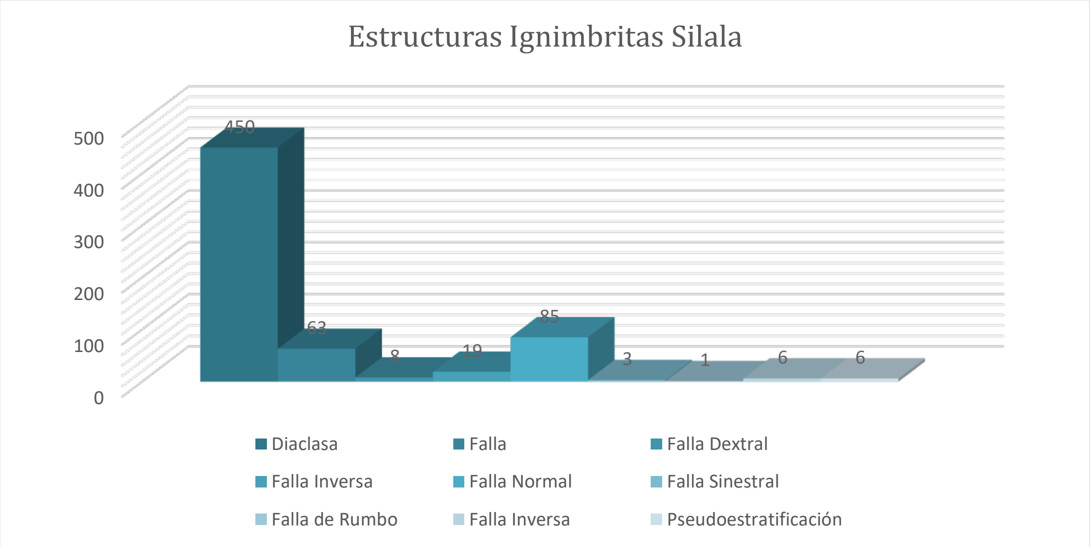
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Cantidad	125	23	27	5	13	7	0	1	0	4	1	0	1	0	4

Rugosidad JRC

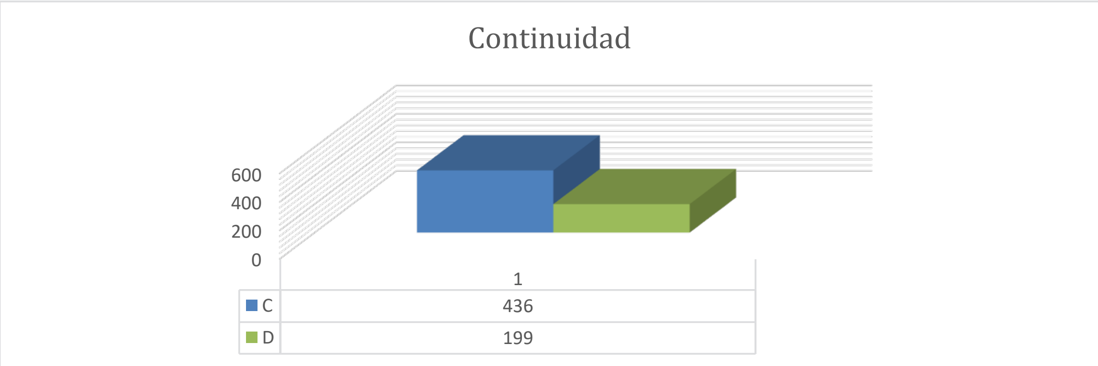


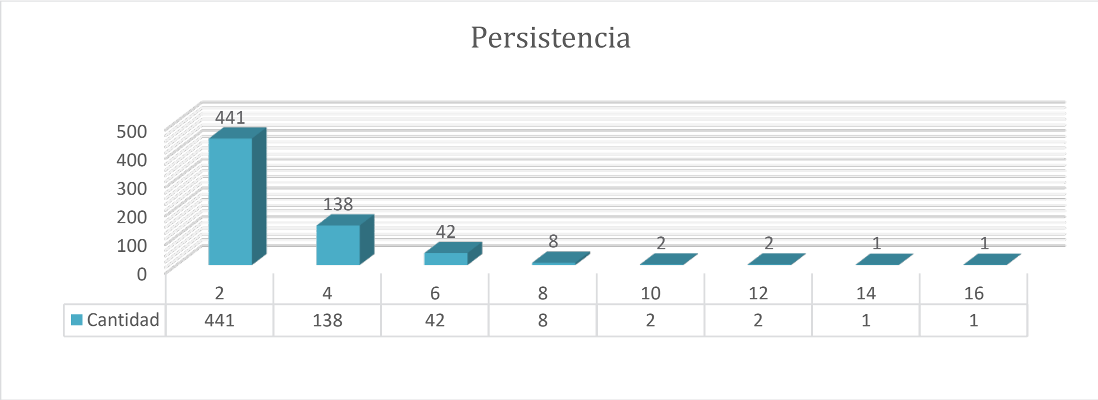
	2	4	6	8	10	12	14	16	18
Cantidad	9	17	32	99	36	11	4	3	0

Ignimbritas Silala

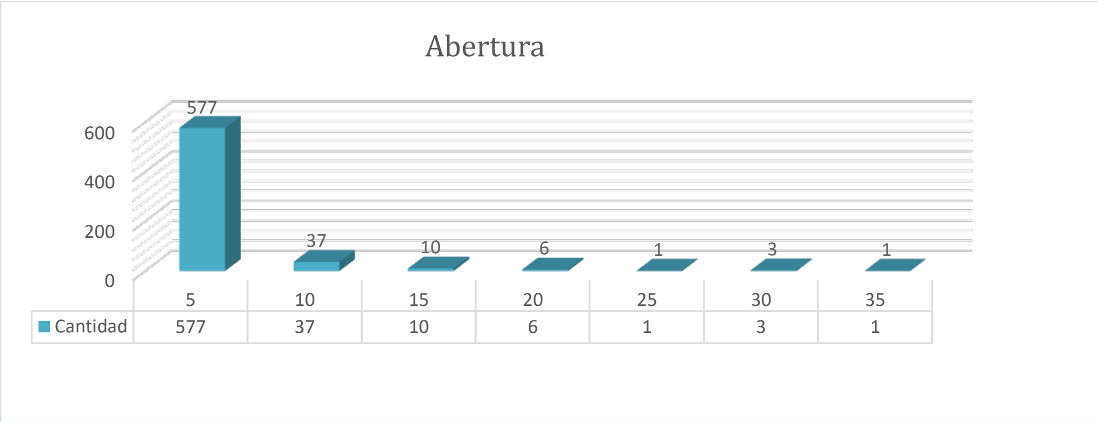


ESTRUCTURAS	Cantidad
Diaclasa	450
Falla	63
Falla Dextral	8
Falla Inversa	19
Falla Normal	85
Falla Sinestral	3
Falla de Rumbo	1
Falla Inversa	6
Pseudoestratificación	6

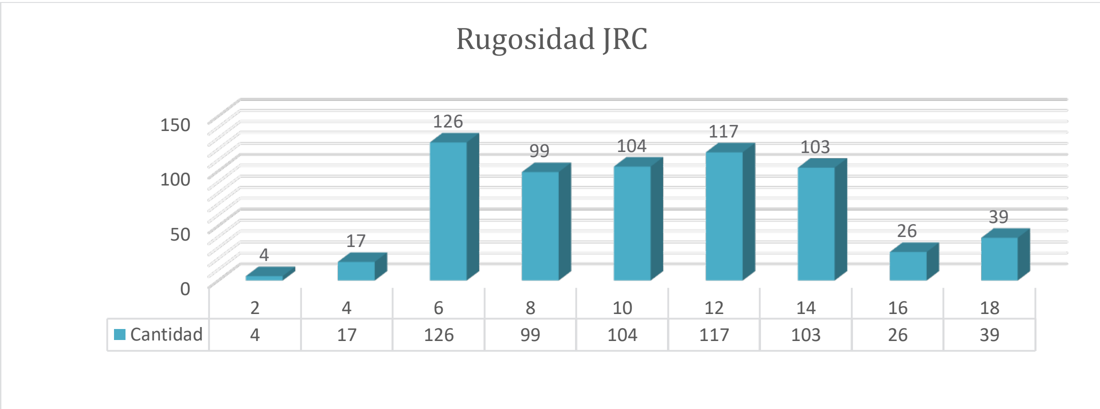




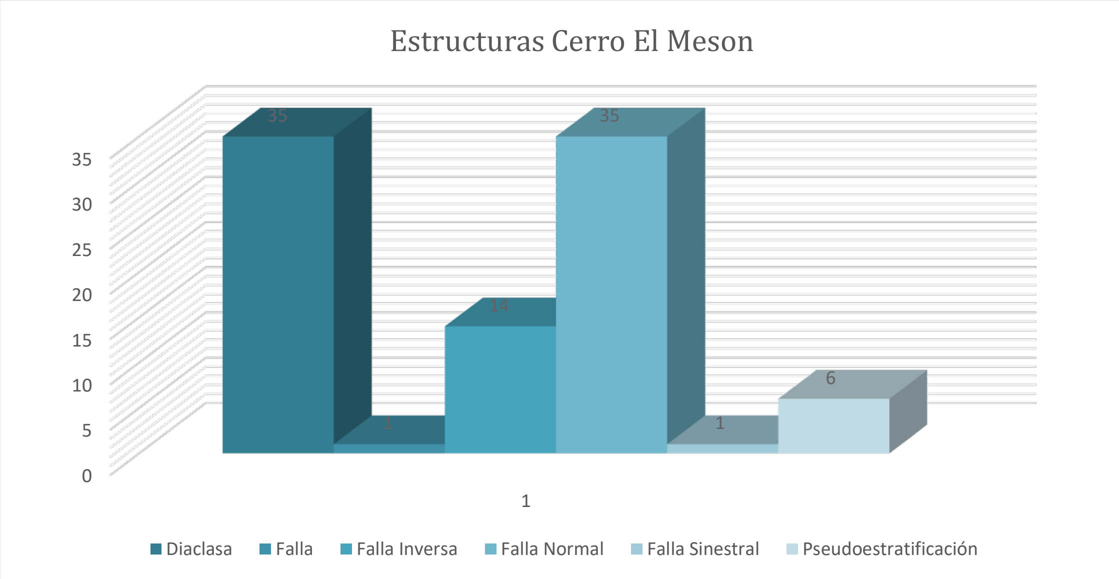
	2	4	6	8	10	12	14	16
Cantidad	441	138	42	8	2	2	1	1



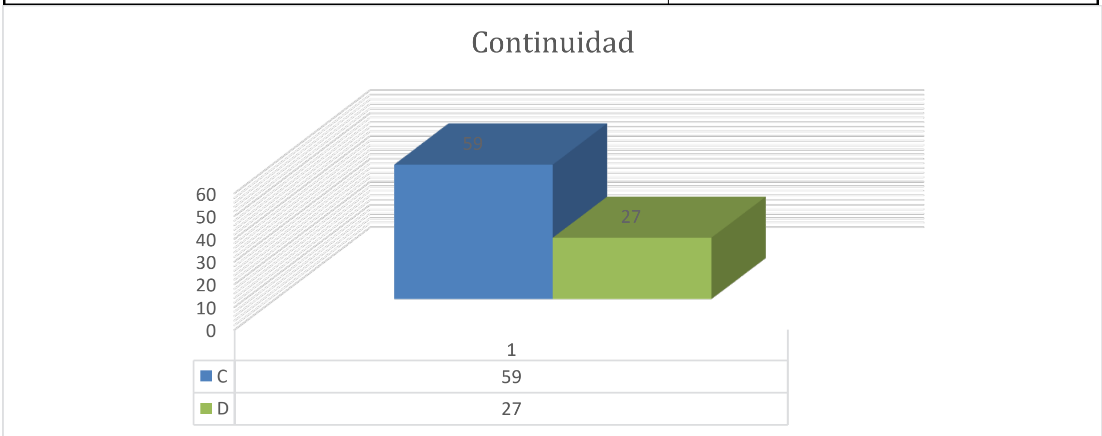
	5	10	15	20	25	30	35
Cantidad	577	37	10	6	1	3	1

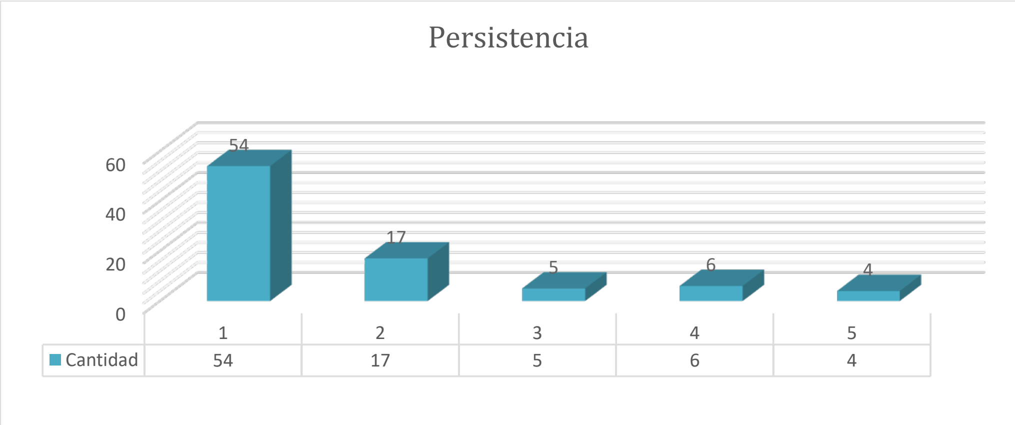


	2	4	6	8	10	12	14	16	18
Cantidad	4	17	126	99	104	117	103	26	39



Estructuras	Cantidad
Diaclasa	35
Falla	1
Falla Inversa	14
Falla Normal	35
Falla Sinestral	1
Pseudoestratificación	6




Persistencia
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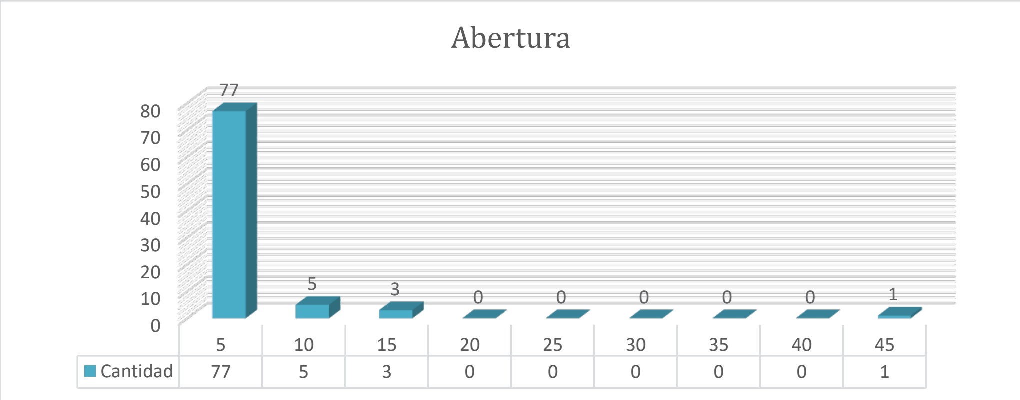
17
5
6
4
1 2 3 4 5
Cantidad 54 17 5 6 4


Abertura
80
70
60
50
40
30
20
10
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3
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0
0
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0
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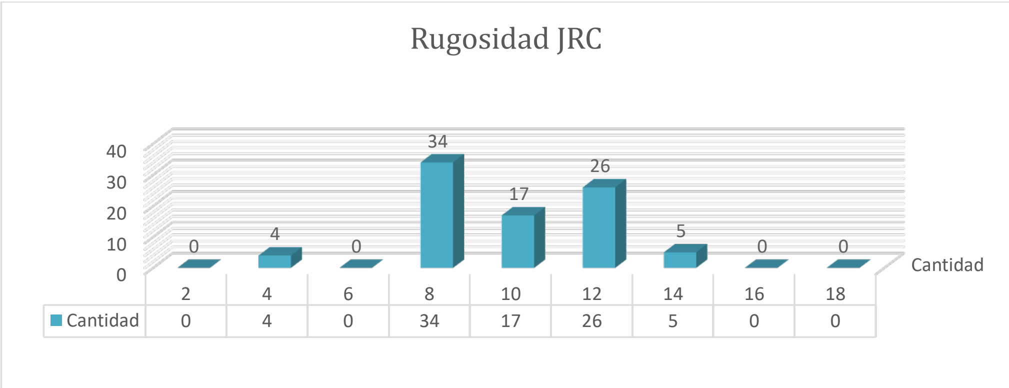
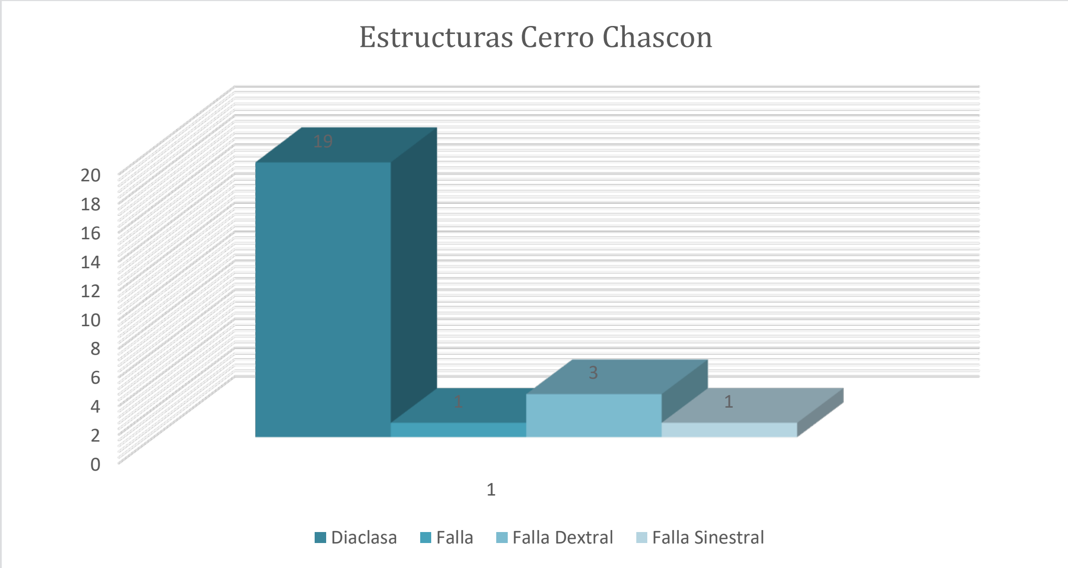
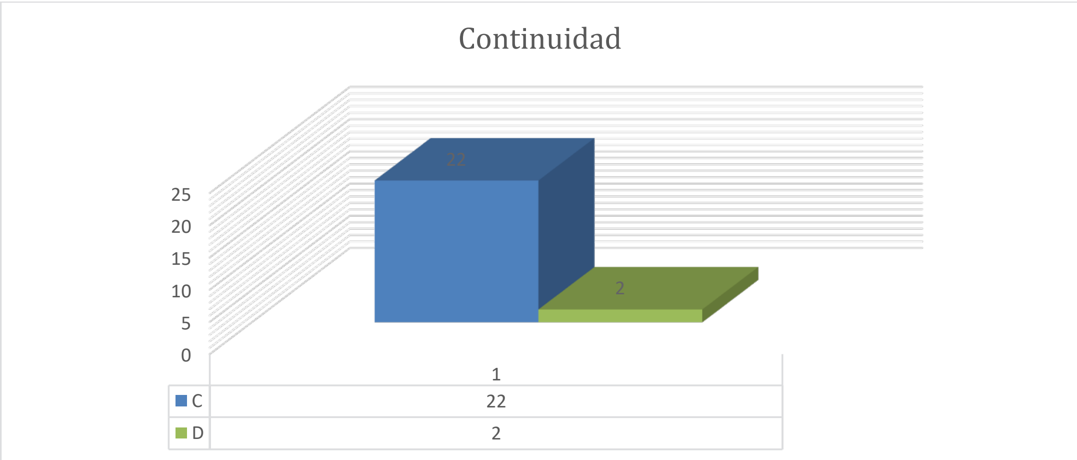
Cantidad 77 5 3 0 0 0 0 0 1


Rugosidad JRC
40
30
20
10
0
0
4
0
34
17
26
5
0
0
Cantidad
2 4 6 8 10 12 14 16 18
Cantidad 0 4 0 34 17 26 5 0 0

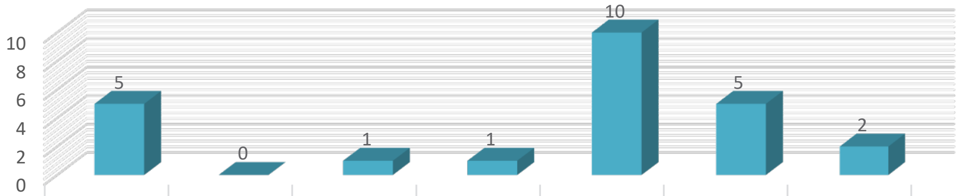
Cerro Chascón



ESTRUCTURAS	Cantidad
Diaclasa	19
Falla	1
Falla Dextral	3
Falla Sinestral	1

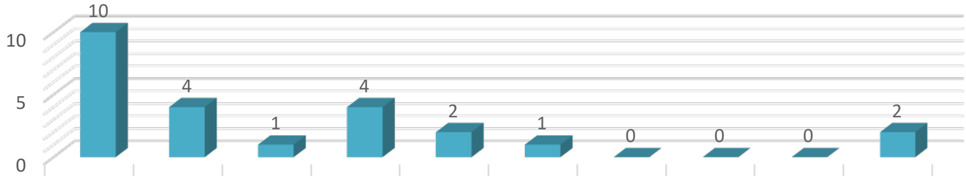


Persistencia



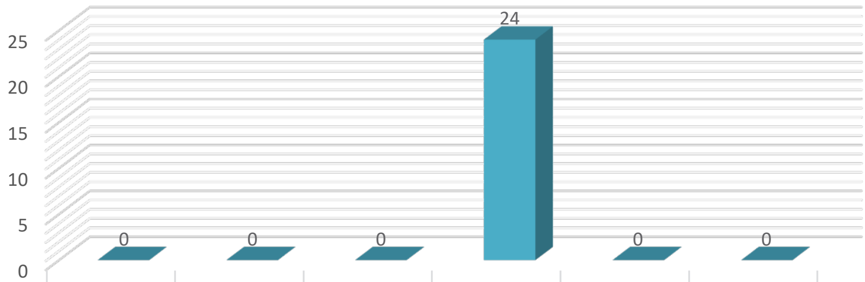
	1	2	3	4	5	6	7
Cantidad	5	0	1	1	10	5	2

Abertura



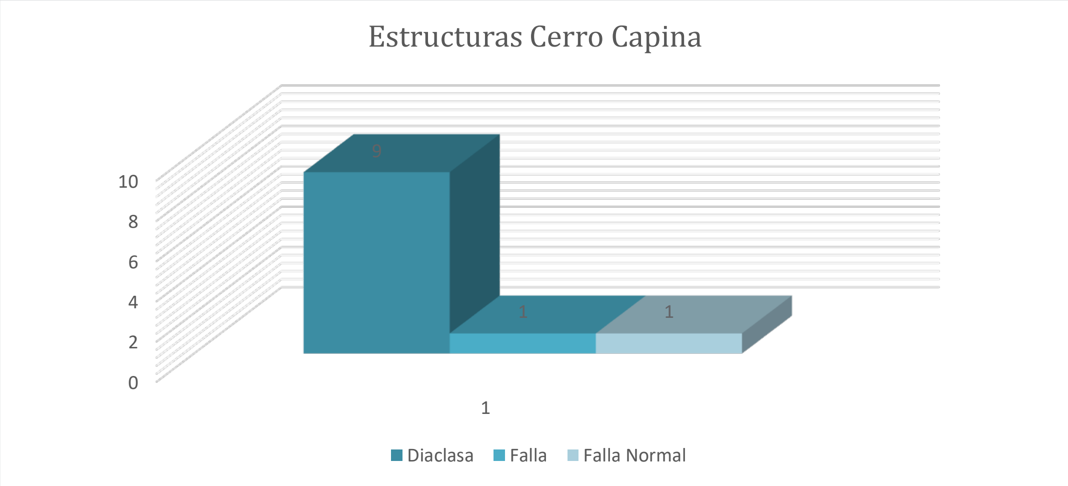
	1	2	3	4	5	6	7	8	9	10
Cantidad	10	4	1	4	2	1	0	0	0	2

Rugosidad JRC

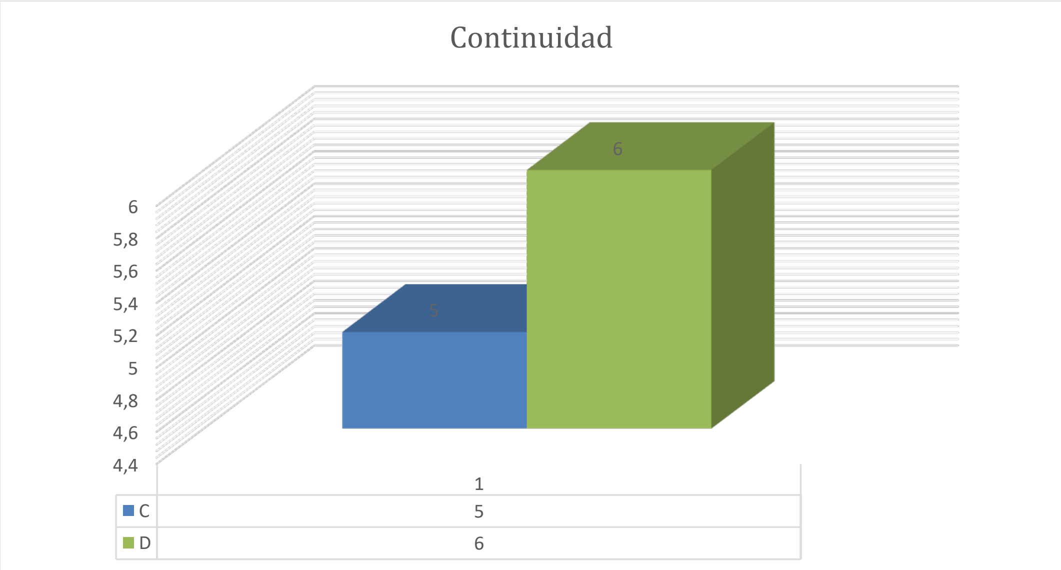


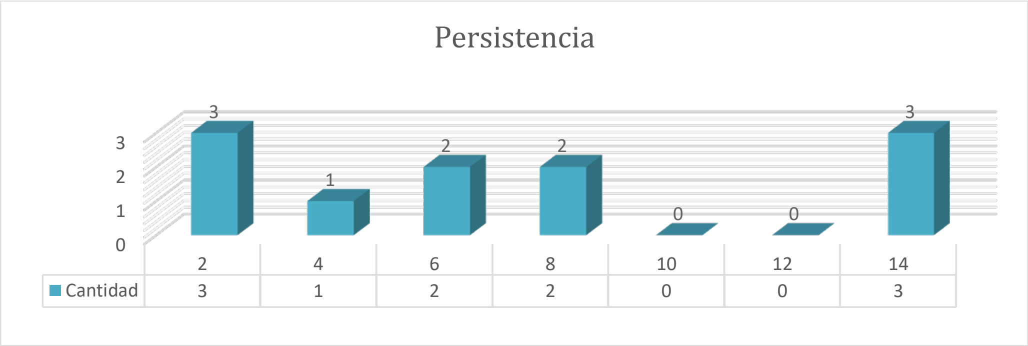
	5	6	7	8	9	10
Cantidad	0	0	0	24	0	0

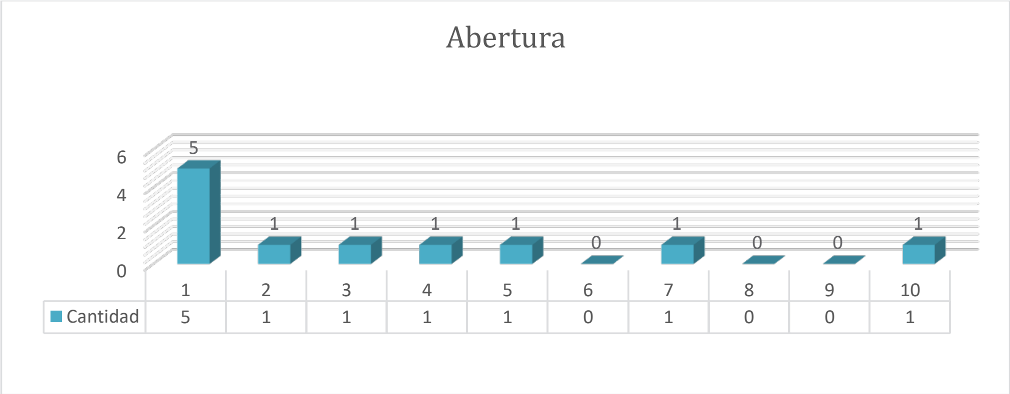
Cerro Capina

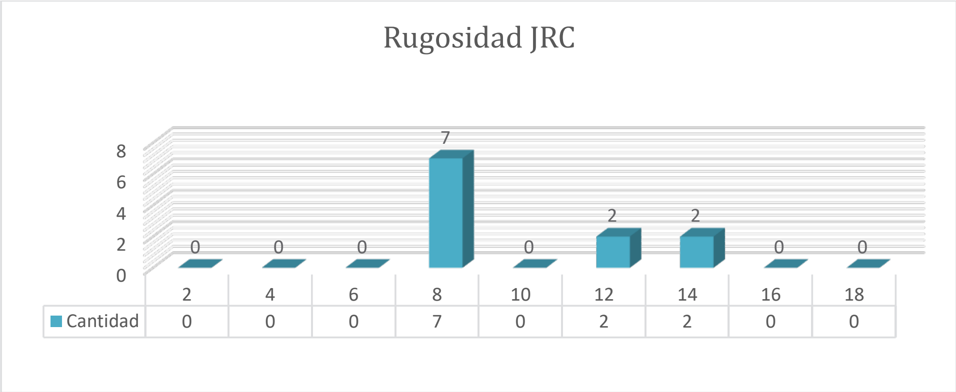


ESTRUCTURAS	Cantidad
Diaclasa	9
Falla	1
Falla Normal	1




Persistencia
0
1
2
3
2 4 6 8 10 12 14
Cantidad 3 1 2 2 0 0 3


Abertura
0
2
4
6
1 2 3 4 5 6 7 8 9 10
Cantidad 5 1 1 1 1 0 1 0 0 1


Rugosidad JRC
0
2
4
6
8
2 4 6 8 10 12 14 16 18
Cantidad 0 0 0 7 0 2 2 0 0