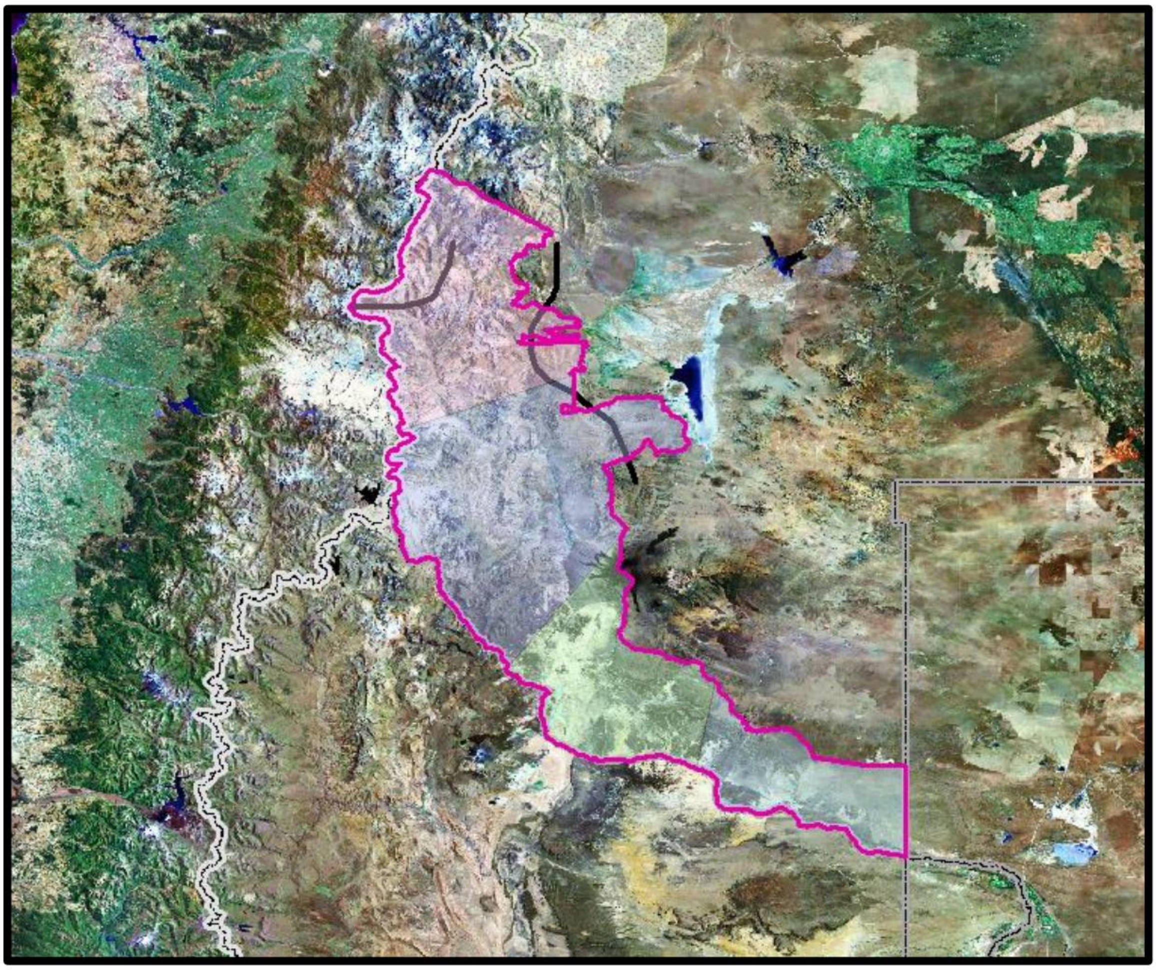
TECHNICAL REPORT

IDENTIFICATION OF AREAS OF INTEREST WITH MINING POTENTIAL

MALARGÜE DEPARTMENT
PROVINCE OF MENDOZA



Ready for

IMPULSA MENDOZA SA

By

HYTEC ALTO AMERICAS SA

December 2023

TECHNICAL REPORT

IDENTIFICATION OF AREAS OF INTEREST WITH MINING POTENTIAL

MALARGÜE DEPARTMENT
PROVINCE OF MENDOZA

Ready for

IMPULSA MENDOZA SA

By

HYTEC ALTO AMERICAS SA

December 2023

HytecAltoAmericas Hyperspectral Remote Sensing

REPORT

IDENTIFICATION OF AREAS OF INTEREST WITH MINING POTENTIAL

Malargüe Department, Province of Mendoza Argentinian republic

EXECUTIVE SUMMARY

- The studied sector of the Department of Malargüe, Province of Mendoza, covers approximately 22,000 km2 and has an environment geological and tectonic favorable for the existence of mineral deposits of interest.

- From the processing, analysis and interpretation of images satellite services provided by various remote sensors, as well as the evaluation of the available geological and mining information, They identified an area of interest with mining potential.

- Three (3) images corresponding to the LandSat 8 satellite were used, sixteen (16) to the ASTER sensor and nine (9) SRTM radar images.
- The identification of areas of mining interest was based on the analysis spectral that allowed detecting and identifying areas of alteration mineralogical - clays, iron oxides and carbonates, among others –, of soils and vegetation; of structural analysis, which allowed the identification of tectonic and structural patterns and analysis geomorphological through the digital elevation model generated from of radar images.

- The prospective areas correspond mainly to three models depositional: Copper Porphyries, Copper in Sediments and Skarns Polymetallic.

- A total of eighty-six (86) areas of interest were identified:

  - o Twenty-six (26) areas with potential mineralization related to Copper porphyries,
  - o Twenty-eight (28) corresponding to Copper – associated with others elements- in Sediments and
  - o Thirty-two (32) with potential mineralization associated with Skarns Polymetallic.

- Of this total of areas, considering the greatest agreement of the Spectral responses with geology, structures and geochemistry of the outcrops in them, the following were prioritized:

  - o Eleven (11) of those corresponding to the Copper Porphyries,
  - o Twelve (12) to Copper in Sediments and
  - o Fourteen (14) to the Polymetallic Skarns.

- The selected areas were also categorized by their logistical conditions and their situation regarding their social license in the province.

REPORT

IDENTIFICATION OF AREAS OF INTEREST WITH MINING POTENTIAL

Malargüe Department, Province of Mendoza Argentinian republic

INDEX

1. INTRODUCTION

The tasks and results described in this report correspond to the requirement by the company IMPULSA MENDOZA to proceed with the identification of areas with mining potential in the western sector of the Department of Malargüe, Province of Mendoza, from the processing, analysis and interpretation of satellite images provided by various sensors remote areas, as well as the evaluation of geological and mining information available.

The work area, approximately 22,000 km2 encompasses mainly the western sector of the Department of Malargüe and extends following the contour of the southern limit of the department.

The studied sector has a geological and tectonic environment favorable for the existence of mineral deposits of interest. sayings Geological conditions create an environment conducive to the existence of deposits high and low sulfidation hydrothermals, many related to porphyries of copper, deposits of base metals – silver, lead and zinc, deposits of contact metasomatism –skarns- of iron, sedimentary-type deposits of copper and copper and uranium in sandstones, among others.

The tasks were carried out in the office, beginning with a phase initial search and collection of bibliographic background in organisms and various scientific publications, both national and foreign. Put on special emphasis on the information available on mining projects in the region and surrounding areas, particularly those identified in the neighboring Republic of Chile.

The first phase of the tasks also included the selection and acquisition day and night multispectral remote sensing images and radar for the entire study area, with various spatial resolutions and spectral.

In the case of multispectral images, three (3) were used acquired by the LandSat 8 satellite and sixteen (16) by the ASTER sensor, this last aboard the TERRA satellite. On the other hand, a total of nine (9) SRTM images obtained by the Radar Topographic Mission, flown in the Endeavor Space Shuttle.

The next stage corresponded to the Processing Phase, which consisted of two parts: an initial pre-processing part, where the satellite data and subsequent processing, in the strict sense. He Processing consists of the digital processing of data through application of highlights, band algebra, statistical analysis, transformations spectral and classification techniques.

We then proceeded to interpret all the processed data, applying spectral analysis, with the objective of detecting and identifying areas of mineralogical alteration - clays, iron oxides and carbonates, among others –, of soils and vegetation; of structural analysis, which allowed the identification of tectonic and structural patterns and geomorphological analysis through digital elevation model generated from radar images.

From the analysis and interpretation of the various products obtained of satellite images, both from the LandSat 8 satellite, the ASTER sensor of the Terra satellite and SRTM data, a number of areas were recognized of mining interest within the study area, mainly corresponding to three depositional models:

- Copper porphyries
- Copper in Sediments
- Skarns Polimetálicos

Once the areas of interest have been defined based on the satellite images, The spectral results obtained were integrated with the geological information collected in different publications, the geochemical information and the geological information available in the Argentine Mining Geological Service (SEGEMAR).

In the region studied, a total of eighty-six (86) were identified prospective areas:

- Twenty-six (26) targets with potential mineralization related to Copper porphyries,
- Twenty-eight (28) corresponding to Copper –associated with other elements- in Sediments and
- Thirty-two (32) sectors with potential mineralization associated with Skarns Polimetálicos.

Of this total of areas, considering the greater agreement of the spectral responses with the geology, structures and geochemistry of the outcrops in them, the following were prioritized:

- Eleven (11) of those corresponding to the Copper Porphyries,
- Twelve (12) to Copper in Sediments and
- Fourteen (14) to the Polymetallic Skarns.

Additionally, these selected areas were also categorized by their logistical conditions and their situation regarding their social license in the province.

All images and data obtained in the processing phases, analysis and interpretation were incorporated into a database in format GIS.

II. STUDY AREA

• LOCATION AND ACCESS

The work area is located in the south of the Province of Mendoza, in the department of Malargüe, mainly covers the sector west of Malargüe and extends following the contour of the southern limit of the department. Its surface is 21,068.81 km2 (Fig. II.1).

The most important population center is the city of Malargüe, which is 326 km from the capital city of Mendoza. Its population reaches 32,775 inhabitants and has the infrastructure and, to a large extent, the availability of the services necessary to develop a mining project in the region.

The department of Malargüe borders to the north with the department of San Rafael, also in the province of Mendoza. To the East with the Province of Pampas. To the south with the province of Neuquén and to the west it borders with the Republic of Chili. The Andes mountain range marks the natural border between Malargüe and Chile.

You can access the department of Malargüe through National Route 40, This is one of the main roads in Argentina that runs through the country of north to south, this route is used whether traveling from Mendoza capital by the north, or if you enter from the south from the city of Neuquén. another route common way to get to Malargüe is through National Route 144, which connects San Rafael with Malargüe. From the East you can enter Malargüe along the Route Provincial 186 which is land.

From Chile you can enter through the international crossing Pehuenche. From Talca in Chile, it is accessed via Route CH-115, which is becomes National Route 145 in Argentina.

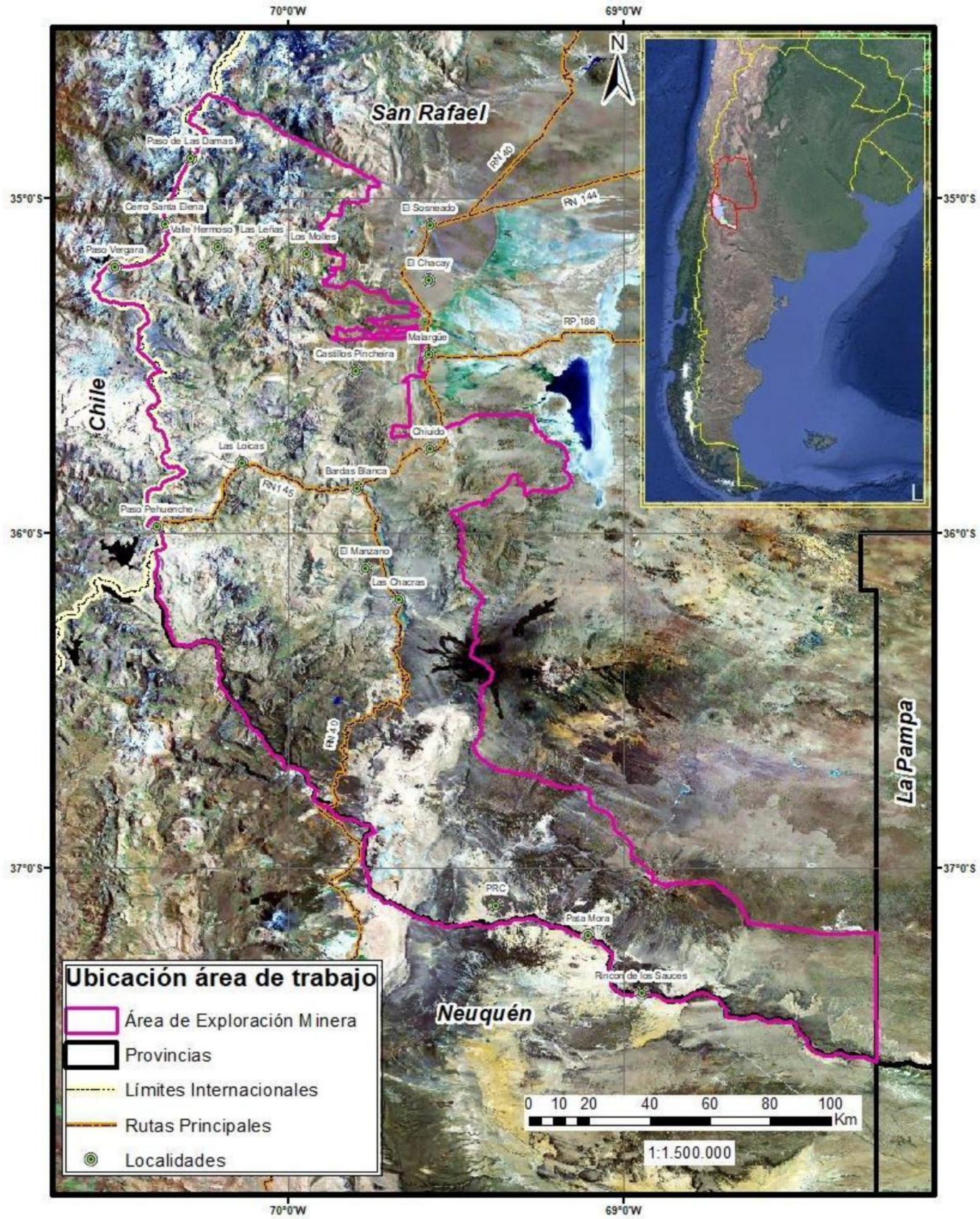


Figure II.1. Location of the work area.

III. Regional geology

III.1- Stratigraphy

The study area is covered by Geological Sheets 3569-I Maipo Volcano, Geological Sheet 3569-III Malargüe, Sheet 3569-IV El Reservoir Nihuil, Sheet 3769-I Barrancas, Sheet 3769-II Agua Escondida, Sheet 3769-III Chos Malal and 3769-IV Catriel. The geology of the area is complex and covers a large amount of lithological units, ranging from the Upper Paleozoic to the present, where active volcanism and important dynamics still develop erosive. The most important geological - geomorphological entity in the area selected is the Main Cordillera represented by the continuous and folded belt from Malargüe. Below will be a brief description of the main geological units present in the work area (Table III.1.).

Arroyo Mendino (Carboniferous- Permian 358 to 298 Ma.)

The oldest rocks known to date are the deposits metamorphics of the upper Paleozoic represented by the **Arroyo** formation **Mendino,** these outcrops are close to the Las Leñas ski complex, They are metasediments that are intruded by igneous rocks from the magmatism of the Choiyoi group, Permo - Triassic age. These metasediments would be the foundation of the entire region.

Choiyoi Group (Upper Permian-Lower Triassic. 286 to 247 Ma.)

The Choiyoi Group consists of bimodal (acid-basic) magmatism. extends from the south of the province of Neuquén to the center of the province of San Juan, in Malargüe, these igneous rocks are found along the entire the main mountain range and are usually found in the cores of anticlines, these Igneous Rocks are the basement of the entire Neuquén basin.

Mesozoic

During the Mesozoic, which lasted almost 185 million years and encompasses the Triassic-Jurassic and Cretaceous periods, the units were developed most important sedimentary deposits of Malargüe (from the point of view economic).

Tronquimalal-Arroyo Malo Group (Middle-Upper Triassic 247 to 203 And.)

This sequence begins with the continental sedimentary rocks of the **Tronquimalal-Arroyo Malo Group,** which rests discordantly on the rocks igneous rocks of Choiyoi and on the **Chihuido Formation,** these are conglomerates poorly selected with angular clasts that mainly correspond to the Choiyoi vulcanites, then transition to fluvial sandstones of the **Llantenes Training.** The Arroyo Malo Formation is a pelita bank laminated with sandstone intercalations that would be from a fluvial system deltaic becoming lacustrine, in a distensive tectonic environment.

Chihuido granite, this intrusive and its associated volcanic rocks They are of Upper Triassic age and their outcrops are scarce, but they are found from Las Leñas to Valle Noble, finding their best exponents on the Chihuido slope.

Cuyo Group (Jurassic 200 to 145 Ma.)

This group is made up of different Formations: Remoredo-El Freno, Sitio Araya, Tres Esquinas and Tábanos, which were called Cuyano Cycle (Groeber, 1947) and Cuyo Group or Cuyo Mesosequence. In the zone of study these rocks outcrop north of the Atuel River, immediately west of the Blanco stream and to the south, in the area where the Río Grande meets the stream Poti Malal, following the banks of the latter and in the La Vaina stream.

From here the geological formations will be described individually. given the importance that each one has in the stratigraphic table of Malargüe.

Remoredo – El Freno Formations (200 Ma.)

In the Lower Jurassic (200 million years) for the Malargüe sector powerful thicknesses of conglomerates began to accumulate with sandstone intercalations, these materials are represented by the Formations Remodeled – The Brake, both terms would be the same for these materials. These sequences that are the basis of the Cuyo group are supported by discordance on the materials of the Choiyoi Group and the Llantenes Formation.

Araya Post Formation (190 Ma.)

The materials of construction were deposited on the aforementioned deposits. the Sitio Araya Formation, these correspond to fine to coarse sandstones with intercalations of tuff banks and epiclastic materials, towards the top of the formation integrates fine materials from shallow marine coastal environment represented by dark shale. These materials emerge in the Valley of the Leñas, north of the Atuel River and in the Arroyo Blanco. This formation Post Araya It is also known in the literature as the Las Chilcas Formation or the El Cholo and in Neuquén with the Sierra Chacaicó Formation.

In the countryside the basal part of Sitio Araya is difficult to distinguish from the El Freno Training. Both units form large anticlines and synclines. From the paleo-environmental point of view, the first marine fossils appear (ammonites) that show the first entry of seawater into this basin.

Three Corners Formation (176 Ma)

The Tres Esquinas Formation is made up of dark shales with intercalations of gray-blue limestone, bearing ammonites. These materials were deposited in deep marine and shelf environments and have a high content of organic matter. Environmentally it represents an increase at sea level for this period.

Tábanos Formation (165 Ma)

This unit was defined by Stipanicic (1965), previously it was known as inferior plaster. The outcrops do not exceed 30 meters thick. They emerge at the elbow of the Blanco stream, on the Chivato hill and towards the south, in the La Vaina stream. The unit is composed mainly of plaster benches of grey-whitish color with intercalations of dark limestones that indicate a significant drop in mean sea level. In the area of Cerro Chivato small flaws are observed in the plaster, which cause intense fracturing and folding thereof. This unit is based accordingly on the Tres Esquinas Formation and is covered, in an erosive unconformity, by sandstones from the Lotena Formation. It was assigned a middle Callovian age, based on las stratigraphic relationships and ages with the infra and overlying units, since which has no fossils. With this unit the Cuyo group ends, environmentally shows a drop in sea level.

Group Lotena

This group is made up of three sedimentary units: Fm. Lotena, Fm. La Manga and the casts of the Fm. Auquilco. This group spans the boundary between the Middle Jurassic to the Late Jurassic 161.5 Ma.

Lotena Formation and La Manga Formation (165 to 154 Ma.)

These units are treated together since several authors consider the Lotena Formation as the basal part of the La Manga Formation, also in the field it is very difficult to differentiate them. These units emerge at the elbow of the Blanco stream and are best seen on Cerro Chivato near Hierro Indio, where the limits of both units can be recognized. At the base They find yellowish sandstones with parallel stratification and intercrossed that indicate a continental environment (Lotena Formation), and pass to the upper section that is made up of calcarenites, dark gray shales, small levels of chert and bluish-gray limestone known as “Limestone blue with Gryphaea fossils .”

The La Manga Formation presents a large number of marine fossils such as ammonites that indicate a change towards a purely marine environment of platform with shallow water. Due to the fossiliferous content and the stratigraphic relationships the Lotena-La Manga formations are assigned to the Middle to upper Jurassic.

Auquilco Formation (154.5 Ma.)

This unit is very well represented throughout the Main mountain range of Malargüe and almost the entire Mendoza mountain range. It is also known as "Main Gypsum", the Auquilco Formation composed mainly of gypsum, It is one of the most important formations since these plasters resolve most of the deformations of the mountain range and is the takeoff surface of several main faults that continue to elevate it. The main outcrops in Malargüe they are located on the east front of Cerro Chivato and at the elbow of the stream Blanco, to the south there are outcrops along the La Vaina stream and on the left bank of the Poti Malal stream. This unit has a thickness approximately 200 meters of almost pure whitish-grayish gypsum, which in some sectors are increased by tectonic duplication.

These deposits are characterized by a shallow marine environment and restricted that transitions to a continental environment. The age of Gypsum is Middle Jurassic and the underlying unit is the La Manga Formation. With the Auquilco plasters finish the Lotena group.

Mendoza Group

This Group is divided into four Formations: Tordillo, Vaca Muerta, Chachao and Agrio, in Mendoza is also known as the Mendocian Cycle. This group is one of the most important in the province, since it generates and houses hydrocarbons. This group has an age that includes from the Jurassic upper (Tordillo Formation) to the lower Cretaceous (Agrio Formation). It presents great lithological variations, which characterize from an environment continental (Tordillo Formation) to calm water marine, evidenced by the marine transgression of the Vaca Muerta Formation, and the calcareous rocks of the Chachao and Agrio Formations.

This group, in turn, is highly studied on the surface as well as in the subsoil. that the Vaca Muerta Formation presents great interest for being a generator of hydrocarbons.

Tordillo Formation (154.8 to 149.2 Ma.)

The Tordillo Formation is formed by alternating conglomerates, reddish-brown sandstones, with planar and cross-bedded stratification and some levels of greenish-yellowish claystones. The environment is clearly continental, with fluvial courses and alluvial fans connected to depressions beach-lake type . These sediments have a thickness that varies between 500 to 600 meters, they unconformably cover the gypsum of the Auquilco Formation and Above are the marine deposits of the Vaca Muerta Formation.

It was formerly designated as “Colored Sandstones and Malm Conglomerates”, the outcrops are distributed in a very wide, like elongated strips of north-south direction, are very tectonized, accompanying the detachments and deformations of the gypsum of the Auquilco Formation. This unit wedges towards the east and increases its thickness towards the west (Chile), where it interdigitates laterally with rocks of origin volcanic such as flows and breccias of basic to intermediate compositions, corresponding to the Río Damas Formation, with a distensive environment. In the area To the west of the Las Leñas valley, the outcrops slope gently to the west.

The age assigned to the Tordillo Formation by stratigraphic correlation is Late Jurassic (Kimmeridgian).

Vaca Muerta Formation (139 to 149 Ma.)

This unit is composed of a set of pelitic and limestone strata of dark colors carrying a rich fauna of ammonites, of wide areal distribution and together with the other formations that make up the Group Mendoza generate large synclines and anticlines structures. Main Outcrops in the area of interest focus on a north-facing belt. south to the north of the Atuel River, between the Blanco stream and the La Manga stream; south of Paulino stream, western sector of Cerro Chivato, along the Salado River and above the Cuesta del Chihuido. It is made up of gray-blue to black shales and micritic limestones that contain a great variety of marine fossils such as ammonites. The detailed study of these fossils has been very useful for determine the age of said formation as Upper Jurassic Lower Cretaceous. The depositional environment varies from a fluvial one, which is found to the east with facies proximal to a marine environment with periodic variations in the depth found to the west.

Chachao Formation (139.8 to 132.6 Ma.) Cretaceous

The calcareous banks with abundant coquinas and pelecypods, the type locality of this unit is found on the Chachao hill, south of the Chihuido hill, it also crops out in the near the Atuel River and west of Cerro Chivato. The general thickness of the Carbonate levels are 20 to 45 meters and become thinner towards the center of the basin. It is made up of yellowish-brown limestone and coquina. carriers of a wide fauna of bivalves *(Exogyra couloni)* and ammonites that They assign the unit Early Cretaceous age and denote a marine environment with little deep, low relative energy. The Chachao Formation supports concordance with the Vaca Muerta Formation and is covered by the Agrio Formation.

Some authors equate the Chachao Formation with the Quintuco and Mulichinco that are above Vaca Muerta in the basin neuquina.

Agrio Formation (132.6 to 125.7 Ma) Cretaceous

The Agrio Formation represents the culmination of marine sedimentation of the Mendoza Group. The outcrops have a distribution similar to those of the Vaca Muerta Formation, outcrop near the Atuel River, west of the hill Chivato and along the Salado River. It is made up of proximal facies and distal, are mainly siltstones, calcareous pelites and limestones that correspond to a shallow marine environment, with agitated waters for the facies proximal waters and a medium of calm waters with occasional variations in the depth for the distal ones (Legarreta *et al.* 1981). It is covered by unconformity for the Huitrín Formation and the assigned age is Hauterivian-Barremiano.

Rayoso Group

The Rayoso Group was divided into two units, Huitrín Formation and Rayoso Formation. This Group emerges in the Atuel River area, between the streams Blanco and La Manga, to the west of Cerro Chivato and in small glimpses along of the Salado River, its thickness increases towards Neuquén, its equivalents in the Neuquén basin is the Bajada del Agrio Group.

Huitrin Formation (125.7 to 113)

The Huitrín Formation was previously known as Huitrinian or “Yeso of Transition¨, later it was replaced by Huitrín Formation composed of three members: Chorreado, Troncoso and La Tosca.

This unit is made up of gypsum deposits and thin banks of limestones and calcareous sandstones that denote a shallow marine environment, with salinity abnormal that changes to a hypersaline to continental environment (Fig. 2.2.17) from Barremian-Aptian age.

Rayoso Formation (113 to 100.5 Ma.)

For its part, the Rayoso Formation is composed of siltstones and reddish sandstones, which represents the regression of the Mesozoic seas. Volkheimer (1978) chose to retain the name "Salas Formation" and assigns a thickness of 500 meters in the Paulino stream to the west of Cerro Chivato. The layers of the Rayoso Formation record a marked expansion of the basin towards the foreland and have an Albian age. The entire Group is discordant over sedimentites of the Mendoza Group and is covered by the layers red from the Diamante Formation.

Training. Diamond (100.5 to 72.1 Ma)

A set of continental sediments arranged in unconformity angular over the Huitrín-Rayoso Formation, was called “Diamantiano” and Other authors compare it with the Neuquén Group. The formal name was assigned by Dessanti (1973) in the geological sheet of Bardas Blancas in the south from Malargüe. In the north, they emerge south of the Laguna Amarga intrusive, between the La Manga and Blanco streams and on the southern bank of the Salado River, near Los Molles. These are reddish sandstones and conglomerates with great variety of structures that denote an alluvial environment. The age of this unit, established based on the ages determined for the units below and overlying, is located in the Upper Cretaceous.

Malargüe Group

A set of limestones and marls is called the Malargüe Formation. fossiliferous species widely distributed in southern Mendoza. The Malargüe Group It has four training units: Loncoche, Roca, Pircala and Coihueco. This group is well exposed in the Alquitrán hill area where it presents thicknesses of 280 m and in the Salado River (Los Molles). The most complete profiles They are found in the Laguna Amarga area and along the Las Aucas stream, on the northern bank of the Atuel River. The age of the Malargüe Group goes from Maastrichtian to Paleocene.

Loncoche Formation (72.1 Ma.)

The Loncoche Formation is made up of a grain sequence decreasing conglomeratic sandstones, greenish sandstones and silt claystones yellowish and reddish. The thickness of this unit measured south of the Cuchilla de La Tristeza is 150 meters. It is an alternating environment between systems river and lacustrine brackish waters.

Roca Formation (63 to 58 Ma.)

The Rock Formation is composed of skeletal limestone and siltstone. calcareous, has an abundant fossiliferous content rich in bivalves, corals, foraminifera, etc. The thickness of this unit in the Las Aucas stream area It is 30 meters and corresponds to an external carbonate platform developed on a passive margin. Based on the marine fauna and the dating of the volcanic material present in the upper part of the Rock Formation (63 to 58 Ma) was assigned an upper Maastrichtian-Danian age.

Pircala Formation and Coihueco Formation (from 61 to 41 Ma.)

This name is given to the Cenozoic layers above the Formation Malargüe. In general, both units are treated together since it is difficult recognize in the field a net limit between them. At present it study these units separately since there is pseudoconcordance between both units, which is why they separated them with different names. The Pircala formation is made up of siltstones and fine sandstones with great pyroclastic content and the Coihueco Formation is made up of marls and greenish silt claystones. Both units, together, have thicknesses of approximately 340 meters in the Las Aucas stream and only 50 meters in Three corners. The depositional environment is dominated by plains alluvial, floodplains and low to moderate river systems sinuosity that move to a higher energy regime as a consequence of the rise of the basins that fed said system. The Formations Pircala and Coihueco have a Paleocene age, because they are arranged above the Rock Formation and below the synorogenic prism, which is generated in the Eocene due to the beginning of the uplift of this sector mountain range.

Agua de la Piedra Formation (14.2–12.2 Ma.)

To the reddish sedimentary deposits found above the Malargüe Group and below the Loma Fiera Formation, are called ¨Strata of Stone Water¨. Good exposures of the Agua de Formation la Piedra are found in the areas of Laguna Amarga, Cerro Alquitrán and Los Vultures.

The unit begins at its base with shiny-looking conglomerates, which encompass polished and faceted clasts of variable sizes, known like ¨Lustrous Rolls¨. Continue with an increasing grain sequence of fine reddish sandstones that transition upwards to yellowish conglomerates supporting matrix with subangular to rounded andesitic and rock clasts sedimentary. This variation in grain size is well observed in the area de laguna Because.

The thicknesses of the Agua de la Piedra Formation are very variable probably due to erosion. The paleoenvironment is alluvial fans developed under a semi-arid climate associated with the rise of the Cordillera de los Andes, something important to mention is that these materials are contemporaneous with the Huincán Eruptive Cycle.

The synorogenic deposits of the Agua de la Piedra Formation are of Middle Miocene age (14.2–12.2 Ma.).

Neogene Volcanic Sequences (from 23 to 2.5 Ma.)

The evolution of the volcanic arc during the Neogene in southern Mendoza It is characterized by intense magmatic activity whose products correspond mainly to laccoliths, dikes, layered veins, porphyries and basaltic effusions of variable ages and compositions. According to radiometric ages, the activity had its first manifestations at 17 Ma, becoming more intense between 14 Ma and 5 Ma.

The first retroarc volcanic sequences are those of the Cycle Molle eruptive assigned to the Oligocene to Early Miocene. Later, during the Early Miocene to the Late Miocene-Pliocene, the activity of a volcanic arc superimposed on the structuring of the fold and thrust belt which was called the Huincán Eruptive Cycle.

Huincán Eruptive Cycle

In the study area, various subvolcanic bodies of composition mainly andesitic to basandesitic, with forms of dikes, cape veins and laccoliths that intrude into the Mesozoic sequence. Previously, several of these bodies were mapped as Mollelitense or Molle Group of upper Oligocene age. Subsequently, radiometric dating 40Ar/39Ar They gave ages from 13.94 Ma on Cerro Chivato, 10.56 Ma on Cerro Laguna Amarga, 10.42 Ma on Cerro Alquitrán and up to 5.97 Ma on Cerro La Pitch. Baldauf (1997) called the oldest suite Huincán I, the one that seems having been emplaced in the final phases of belt deformation folded and thrust between 13.88 and 12.47 Ma and Huincán II to the most intrusives young (from 10.56 to 5.58 Ma). Other authors propose that the Cycle Huincán Eruptive is made up of two magmatic pulses called Huincán Andesite (between 17 Ma to 10 Ma) and La Brea Andesite (10 to 4.5 Ma Ma) both separated by the Quechua orogenic cycle.

Andesite Huincán (between 13 and 7 Ma.)

The outcrops are distributed south of the Atuel River, crossing the river Salty until reaching the Rio Grande. One of the bodies belonging to these outcrops exhibits a subcircular, laccolithic shape, extending 2 kilometers wide by 4 kilometers long located on Cerro Chivato. HE It is a dacite with a serial texture, composed of amphibole phenocrysts, feldspar and quartz. A dike that emerges to the west of the central body, near the Paulino stream west of Hierro Indio, was dated 13.94 ± 0.08 Ma.

Another subvolcanic body belonging to this unit is the one that emerges in The Las Leñas Gendarmerie post is made up of rocks of andesitic composition, dark green to gray in color, with a large amount of plagioclase and hormblende. This body was initially described by Llambías and Palacios (1979) and was later dated by Baldauf (1993) who obtained a value of 12.4 ± 0.7 Ma.

The Huincán Andesite is temporally correlated with the deposits from the Agua de La Piedra Formation, that is, middle Miocene.

NEOGENE - QUATERNARY

Upper Coyocho Formation (2.5 to 2 Ma.)

It is called Fm. Coyocho Superior to basaltic flows and effusions of andesites and basadesites emitted by the Risco Plateado and Cerro El hills Sosneado, with upper Pliocene age. This unit, within the area of study, crops out in the northern part of the Cuchilla de la Tristeza and in proximity to Los Morros (Salado River). The volcanic deposits are supported through angular unconformity on the folded Mesozoic sequence and on the Huincán Andesite and is covered by fanglomerates of the Los Formation Inns.

Chapúa Formation (3.6 to 1.7 Ma.)

The Chapúa Formation is called a set of mantles and flows of basaltic composition with olivines, which emerge mainly in the area western Malargüe. The flows emerge in the so-called field of Llancanelo. They constitute volcanic cones, partly pyroclastic, on which multiple lava events are observed. The rocks that make up this unit are dark to dark gray in color, massive, with a marked joint that cuts the lava blanket in some exhibitions. Phenocrysts are observed plagioclase and olivine crystals. Vesicles are observed in some strains, filled with zeolites or a whitish powdery material.

QUATERNARY

El Puente Formation - Loma Seca Formation (0.77 to 0.15 Ma.)

The name El Puente Formation identifies a set of basaltic emissions. These are mantles and stratified flows of basaltic composition, black, dark gray and dark brown, in minor proportion. In some exposures, pyroclastic deposits of 2 to 4 m power, mainly ignimbritic. A typical rock from this unit shows porphyry texture and integranular paste composed of plagioclase, in part altered and small phenocrysts of clinopyroxene and olivines. The assigned age This Formation is Middle Pleistocene.

The Loma Seca Formation are volcanic Tuffs and Ignimbrites of a caldera complex and pyroclastic flows located in the Andean sector. From the Pehuenche pass in the south to the Fierro stream in the north, recognizing a sequence characterized by tuffs of basaltic composition at the base and a thicker upper one, composed of andesitic tuffs with tendency to dacitic, with abundant vitreous sections.

According to the radiometric dating determined by Hildreth et to the. (1984), the deposits of the Loma Seca Formation are associated with the effusions of the Calabozo caldera varying its between 0.8, 0.3 and 0.15 Ma, which allows place it in the Upper Pleistocene.

HOLOCENE

Cerro Campanario Basalt

Cerro Campanario is located to the south of the region, forming part of the international limit with the Republic of Chile. Flows come down from this hill basaltic rocks that are arranged peripherally to the mouth of the cone, which are assigned to this unit. The highest sectors are very eroded and part of the western sector of the cone is dismantled. For his morphology, these basalts are considered to have Holocene age, but it is not It has radiometric dating to confirm it.

Basalt Peter

The Peteroa volcano is located in the middle sector of the Leaf, on the limit international with Chile. In the highest part there is the volcanic cone or caldera, which has been in historical activity between 1660 - 1991 in 13 opportunities. On the eastern slope there are successive flows basaltic. Part of these have been mapped independently, observing distally, which sit on pyroclastites of the Loma Seca Formation. By Its geomorphological characteristics, the volcanic apparatus had different stages of activity. The youngest lavas, due to their appearance, can be assimilated to the Holocene, without radiometric dating available to confirm it.

Tromen Formation

This unit is characterized by basaltic coladas, slag, lapillis and volcanic ash, dark black or reddish in color. The accumulations are They appear almost as if they had just been produced. On the surface of the lava flows you can see the details of the flow, such as gas escapes, they observe clearly.

One of the most spectacular castings of this unit is the one that cut and He named the Salado River, east of the Los Molles area. There it is observed that there was the arrangement of a reflecting pool, which developed a system of terraces at west of the dedication, until finally it was able to cut its channel again. The Niña Encantada lagoon is associated with this lava phenomenon. Others flows of similar morphological characteristics are available in the sector eastern part of Malargüe, such as those of the cones of Piedras Blancas or those of the hill Jarilloso, a little further north. The surface is marked by intense roughness, which makes movement through it difficult. Is about coreaceous basalts, very porous and with tonsils filled with zeolites. The rock is dark gray to black, with abundant vesicles small, rounded or stretched by the weight of successive castings in the cooling time. The texture is porphyry, with pilotaxic paste hyalopilitic, with plagioclase slats, corroded and altered, with certain orientation. It has olivine, clinopyroxene and opaque phenocrysts.

Modern Deposits.

Moraine deposits of glacial origin have been observed in several mountain sectors, with thick fanglomerates mainly disposed to reworked lateral brunettes mode. They manifest mainly in the valley of the Cajón River and in the mountains south of the Manguira lagoon. Also They emerge in other mountain sectors, such as in the lateral terraces of the mouth of the Salado or Atuel rivers, where numerous grooved wheelsets.

In almost all cases they are characterized by little wheels. selected, subangular to rounded, composed of volcanic rocks among which those corresponding to the Huincán Eruptive Cycle prevail. In others Sometimes, in smaller valleys, such as the Montañes and the Montañesito, the accumulations are very small, and are preserved at the bottom of the ravines partly reworked by the subsequent fluvial action, which generates conglomerates and fluvial sandstones.

Above these materials we can find current wind deposits that form dunes and dunes. The materials that make up the dunes are sands of fine to very fine size, of great selection and high mobility. If of the dunes in the west of the region, a large part of the clasts are made up of volcanic glass, a product of historical volcanic emissions or of the reworking of the tubes or ignimbrites of the Loma Seca Formation.

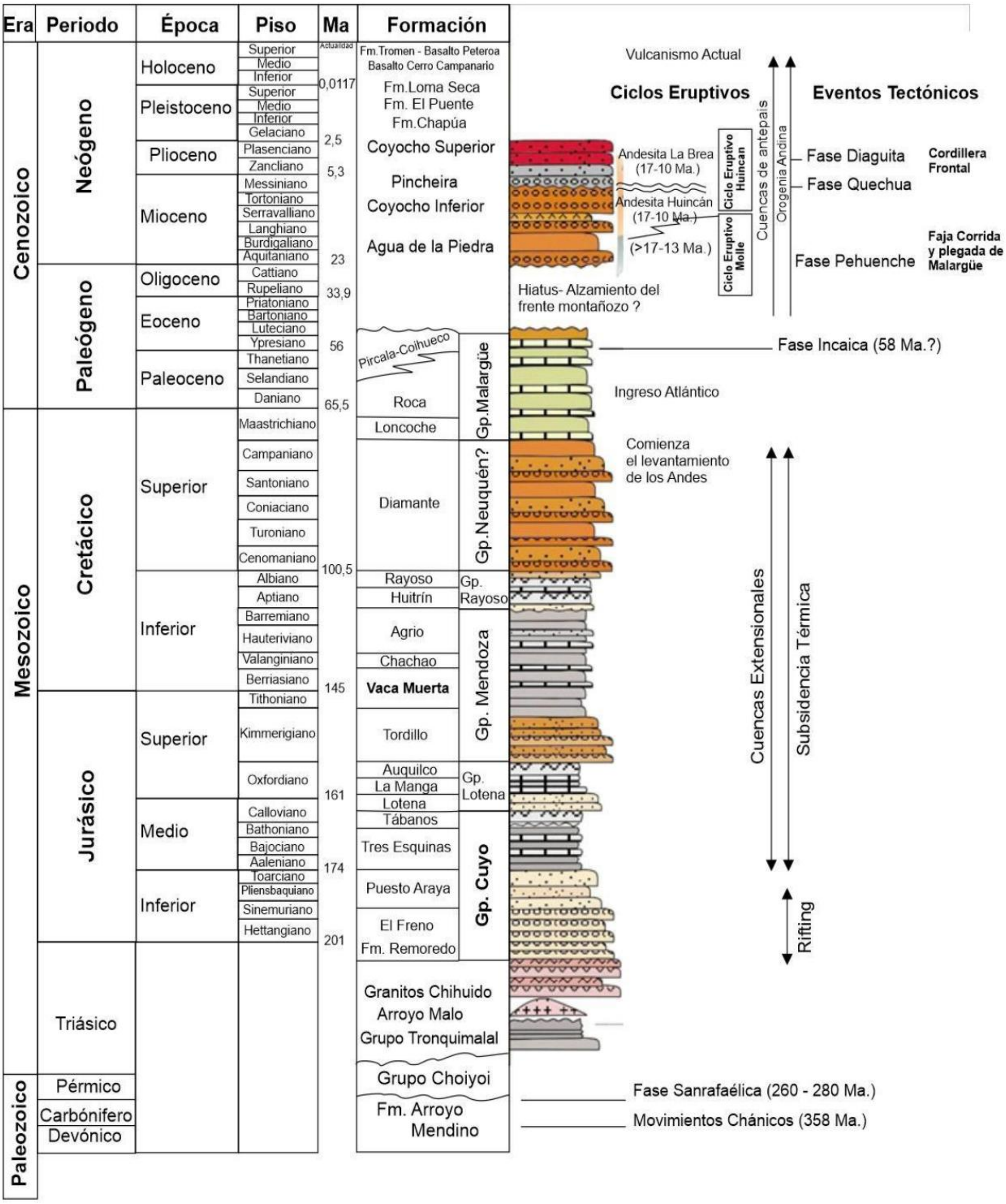


Table III.1. Stratigraphic table of the study area.

III.2 - Structural Geology and Geological Evolution

The post-Paleozoic geological history of the Cordillera Principal Mendoza recognizes two great events, the formation of a marine basin backarc during the Mesozoic and the development of the Andean cycle during the Cenozoic.

The retroarc basin, extended in the west of Neuquén and southwest of Mendoza, was associated with a western volcanic arc of island type (volcanic islands). The sedimentary fill of this marine basin covers almost the entire Mesozoic, from the upper Triassic to the upper Cretaceous, hard about 155 Ma. Throughout most of the Mesozoic the basin was subjected to global eustatic oscillations (rises and falls in the level of the sea), whose cyclical nature gave rise to an alternate succession of events transgressive and regressive and their associated sediments.

The oldest units correspond to the marine sedimentites of the Cuyo Group, the limestones of the La Manga Formation and the evaporitic deposits of the Auquilco Formation. Above are the river deposits of the Tordillo Formation, which make up a sequence made up of red sandstones and greenish conglomerates, with frequent intercalation of layer veins of the Río Damas Formation, which evidence the activity of a persistent volcanic arc to the west of the basin. These rocks constitute the lateral gear facies between the Tordillo Formation and the Río Formation Ladies. The local column culminates with marine sedimentites, with remains indeterminable ammonites, belonging to the Mendoza Group.

On a regional scale, the development of the Andean cycle is characterized by the structuring of the basement and the Mesozoic sequences, the accumulation of synorogenic deposits to the east and the emplacement of magmas calcalkaline linked to successive phases of orogenic deformation.

Beginning in the Miocene, evidence of the installation of a volcanic arc, which experienced migration and expansion during the last 20 million years.

In the study area, the stratigraphic units affected by the phase main deformation of the Mesozoic of the Neuquén Basin are crossed by two suites of intrusives. The oldest suite, called Huincán I, seems to have been emplaced in the final phases of the deformation of the folded and thrust belt between 13.88 and 12.47 Ma., based on Ar-Ar dating. The emplacement ages of the post-intrusives younger tectonics, called Huincán II suite, range from 10.56 to 5.58 Ma. These intrusives also cut the main structures of the phase main part of the Malargüe folded and continuous belt and its exposure suggests continued survey and exhumation of said area.

During the Neogene, successive magmatic events occur from of the evolution of the arch and retroarc, which can be divided into two eruptive cycles: Molle Eruptive Cycle (19 to 13 Ma.) and Huincán Eruptive Cycle (17 at 4.5 Ma.), the latter is made up of two magmatic pulses, the most ancient called Andesite Huincán, spans from 17 to 10 Ma., with greatest intensity in the 14 Ma. and the youngest, Andesita La Brea that It ranges from 10.7 to 4.5 Ma. The Molle Eruptive cycle is composed by rocks of basic composition (basalts), while the second, the Cycle Huincán Eruptive comprises rocks of compositions mainly andesitic.

From the last 5 Ma to the present, the volcanic arc has remained stable in its position and the volcanoes are active to this day, the rise of the Andes Mountains has not ceased during all this time some of its peaks reaching over 6,000 meters in height (Cerro Aconcagua 6,961 meters above sea level), this gap keeps the agents very active erosive mainly streams and rivers. sedimentary materials modern river and wind power interdigitate with deposits produced by the Volcanic eruptions.

IV- Models of Mineral Deposits

IV.1 Metalliferous Deposits in the Department of Malargüe

Malargüe has a favorable geological and tectonic environment for existence of mineral deposits of interest. The *flat* subduction environment variable *slab ,* post-arc distension zones, marine basins and continental, added to the bimodal magmatism located in limestone rocks and permeable red sandstones, create an environment conducive to the existence of hydrothermal deposits of high and low sulfidation, many related to copper porphyries, base metal deposits (Ag, Pb and Zn), skarn, copper in sandstones, fluorine deposits in veins, sulfur, barite, manganese, uranium and iron, nickel and cobalt ores. Furthermore in the Mesozoic marine basins there are deposits of potassium chloride, coal, gas and hydrocarbons.

IV.2 Copper Porphyries

The sector of the Principal mountain range of Malargüe, brings together very good conditions to host porphyry copper deposits, it has a powerful accumulation of Mesozoic sedimentary rocks that are deformed by the Andean tectonics and intruded by igneous bodies. Added to this, Starting at 23 Ma. a magmatic cycle called Malargüe begins. Molle - Huincan Eruptive Cycle, produced by the subduction zone of the Andes, already with a thickened continental crust, which favored the magmas in their ascent assimilate the box rocks and become enriched in metalliferous elements.

Copper porphyries are essentially low-grade mineral deposits. grade and large tonnage. They are called porphyries because they frequently, but not exclusively, they are associated with intrusive igneous rocks with phenocrysts of feldspar into a finer-grained crystalline groundmass.

The porphyry texture indicates that the magmas intruded and crystallized close to the surface and due to its relatively shallow nature called epizonal intrusives.

Porphyry deposits can be subdivided into different types considering its metallic content. These types include Cu-Mo, Cu-Au, Cu, Au and Mo. In general, porphyries rich in Cu or Au are associated with intrusives derived by fractional crystallization of mafic magmas originating in partial melting of the mantle in subduction zones (continental margins assets and island arcs). Molybdenum porphyries are associated with intrusions with a felsic chemical composition derived from magmas with a important component of recast continental crust.

In general, there are several bodies of intrusive rocks, located in several pulses and copper porphyries are frequently associated with swarms of dikes and breaches. Box rocks intruded by porphyries They can be of any type, but if they are calcareous they can generate deposits they tipo skarn.

IV.2.1. Miocene Metallogenetic Belt

In the Miocene, exceptional geological conditions occurred, which example in Chile, generated two mineralization belts, one in the Miocene Lower (23 to 17 Ma.) and another from the Middle Miocene to the Pliocene (17 to 4 Ma.). This period generated the majority of world-class deposits ever found in the Miocene Metallogenetic Belt, which includes the well-known strips of Maricunga and El Indio – Pascua in Chile. Main deposits of the Lower Miocene belt are: El Indio, Pascua-Lama, the porphyry auriferous Casale Hill, La Coipa, Caspiche, Pimenton and the Lobo- auriferous porphyry Mars. In Argentina there is the Veladero deposit associated with this belt.

The Upper Miocene metallogenetic belt, one of the most important In Chile, it is developed almost on the border with Argentina. It presents porphyries of World class Cu-Mo such as El Teniente, Los Bronces-Rio Blanco and The Pelambres. The ages of these deposits range from 13 to 10 Ma in Los Pelambres and later the deposits of El Teniente and Rio Blanco-Los Bronzes between 6.46 and 4.37 Ma. In Argentina this belt is associated with the project El Pachón in San Juan. All these deposits are located to the north of the area of study corresponding to the present work.

Many Chilean authors consider that these belts do not have continuity towards the south, mainly on the Chilean side, and others consider that economic porphyry copper is unlikely to be found towards the south of the strip on the Argentine side, below 35° latitude. However, the studies carried out by different companies from 2005 to date, show that there are different projects with characteristics of deposits of porphyritic copper in Malargüe, both in alteration and anomalies geochemistry and geophysics.

Unfortunately, almost none of the projects characterized as possible porphyry copper deposit has been able to be drilled, since the entire Prospecting and mining exploration stopped in the province of Mendoza as of of 2007, due to the unfavorable legislation for mining activity that was issued as of that year.

IV.3 Copper in Sediments

The geology of Malargüe favors the development of this type of deposits, since it has several sedimentary units in its stratigraphic column of different ages and characteristics and that in addition, many of them have carbonate cement that favors the precipitation of metallic minerals. Many of the Mesozoic age deposits are made up of continental conglomerates of the alluvial fans type and sandstones of different environments, predominating river, wind and beach environments.

There are several geological formations that present lithologies of sandstones and conglomerates. The main ones are: in the Triassic, the Fm. Tronquimalal, in the Lower Jurassic the Fm. Remoredo, El Freno and Sitio Araya of the Cuyo Group, are sedimentary materials that accumulated for a period of 27 Ma. In the Upper Jurassic the materials of the Fm. Lotena of the group of the same name and the sandstones and conglomerates of the Fm. Tordillo from the Mendoza Group. In the Upper Cretaceous, for 28 Ma. the materials of the Fm. Diamond equivalent to the group Neuquen.

These types of copper deposits are characterized by being housed in porous and permeable sedimentary rocks such as sandstones and conglomerates mainly with calcareous cement. These deposits are divided into two types; one called in the bibliography as Exotic Copper and others, as Copper Sedimentary.

IV.3.1 Genesis of the Copper Deposits housed in Sediments

IV.3.1.1 Exotic Coppers

The genesis of **Exotic Coppers** is directly related to the weathering, alteration and erosion of a porphyry copper, where the minerals copper are mainly sulfides, such as chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4), chalcosine (Cu_2S), covelin (CuS), etc. These sulfides, when interact with water and weather, they decompose, forming mainly copper oxides, sulfates and carbonates. The released sulfur helps to acidify the meteoric waters that infiltrate the subsoil, which favors that accelerates the alteration processes of more sulfides and helps maintain to copper in solution.

Copper is remobilized by these acidic meteoric waters and achieves migrate laterally through permeable sedimentary rocks. The distance that can migrate copper in solution is variable and according to the literature, does not exceed 10 kilometers from the source. If the sediments have cement carbonatic, this reacts with acidic water neutralizing its pH and precipitating the copper.

IV.3.1.2. Sedimentary Coppers

These are generated when hot, acidic, hydrothermal fluids brackish, with abundant dissolved copper, ascends through fractures and faults to find porous and permeable sedimentary rocks, which begin to impregnate slowly until the physical – chemical conditions are favorable for the deposition of copper minerals.

Other authors suggest that when there are red sandstones in a basin extensional sedimentary that acquires temperature by subsidence, when generate a tectonic inversion, the water present in the pores of the rocks is forced to migrate to areas of lower pressure. If the basin has rocks evaporitic, these waters will generate a hot brine that can remobilize elements such as copper, which will travel in solution until it finds favorable conditions for depositing.

IV.4. Iron Skarn

This type of mineralization is generated at the contact between molten rock (magma), in contact with very reactive carbonate rocks. The fluids hydrothermal compounds that form generate a chemical exchange called metasomatism, which alters rocks and precipitates minerals. In the case of the Malargüe deposits, the igneous rocks of the Huincán Group that intruded in the Middle Miocene, represented by dioritic rocks and andesitic, when these igneous materials are housed in carbonate rocks such as those of the Tres Esquinas geological formation of the Cuyo Group, Vaca Muerta, Chachao and Agrio of the Mendoza Group or carbonate rocks of the Group Malargüe, favorable conditions exist for generating a deposit of the Skarn type. These types of deposits can be iron or copper and iron.

V. REMOTE SENSORS

V.1 - Principles

When solar radiation reaches planet Earth, part of that energy electromagnetic radiation is reflected and some is absorbed (and can then be re-emitted). Remote sensors have the ability to measure this interaction between electromagnetic waves and the different materials on the Earth's surface, recording information with devices of different types. The energy captured by The sensor is converted into an electrical signal that is then digitized. If of a digital image, the signal is subdivided into discrete areas called pixels (from picture elements). Each pixel provides essential data to identify the materials existing within the surface it represents.

The interaction between radiation and the surface can be recorded various ways, according to the particular objective and scope of the study spectral. For example, satellite sensors, airborne o terrestres (Fig. V.1 & V.2).

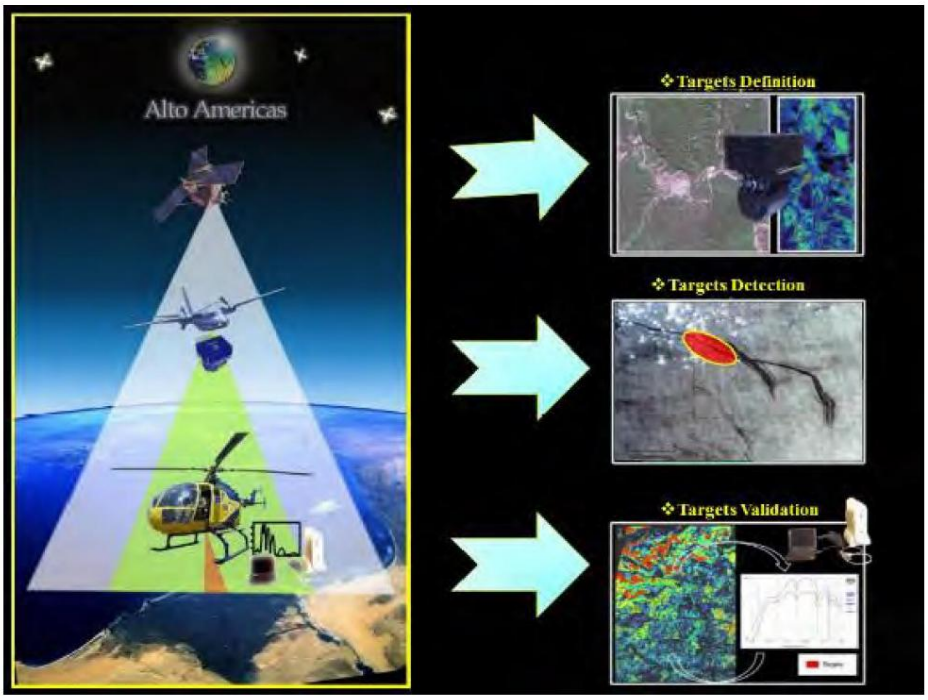


Figure V.1. Exploration with remote sensors.

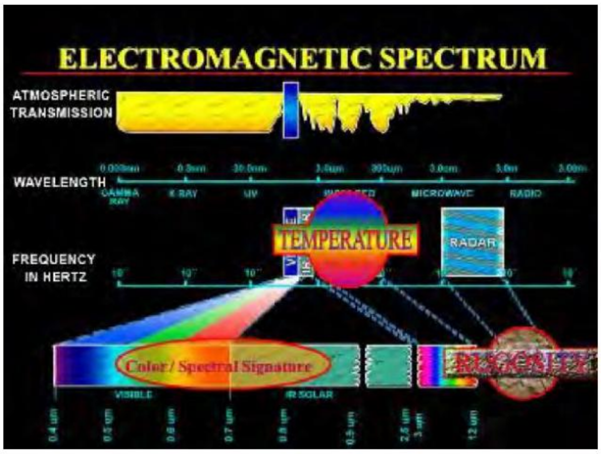


Figure V.2. Electromagnetic spectrum

In general, the amount of information that can be extracted from the Interpretation of digital images is limited by the characteristics specific to the instrument chosen for their acquisition.

These features are:

- **Spatial Resolution**

It is determined by the dimensions of the pixel. Defines the size of the elements that can be detected in the image. For example, if the pixel is 30 x 30 meters will not allow you to clearly distinguish objects much smaller than that distance. Figure V.3 shows the differences between an image with a spatial resolution of one meter and another with spatial resolution of thirty meters.

Figure V.3. Different resolutions.

Table V.1 shows the number of pixels that would provide information on an area equivalent to one hectare according to different resolutions space.

	Spatial resolution			
	30 m	15 m	4 m	1 m
1 ha	11 pixels	44 pixels	625 pixels	10000 pixels

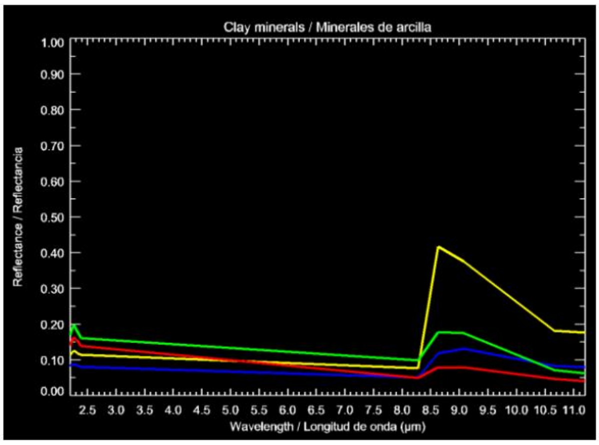
Table V.1. Number of pixels equivalent to one hectare in different resolutions.

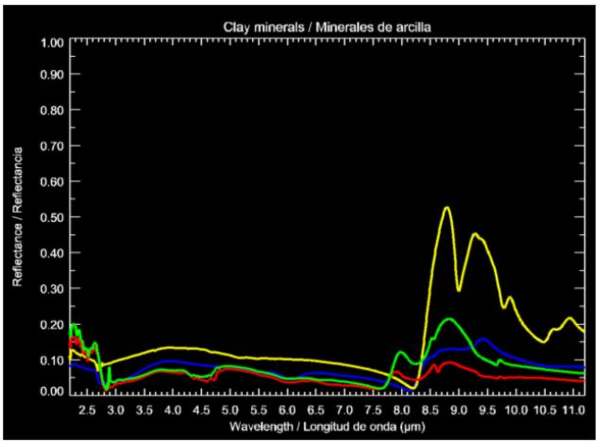
- **Spectral Resolution**

Spectral resolution refers to the number and width of the bands or channels collected by the sensor. Electromagnetic energy is captured in discrete segments of the electromagnetic spectrum. That is, a sensor records specific wavelengths, determined by the type and quantity of detectors that compose it. This property leads to the important distinction between multispectral and hyperspectral sensors. The first ones have generally between four and twenty wide channels, located in the spectrum of dispersed manner, while hyperspectrals have more than one hundred bands narrow ones located sequentially.

When the values that are recorded in the different channels are graphically expressed against their respective wavelengths, the form resulting is called a spectral signature. Every material on the earth's surface It has a distinctive spectral signature. This true fingerprint is presented with greater detail by increasing the spectral resolution.

In Figures V.4.a and V.4.b you can see the difference between signatures multispectral and hyperspectral, in this case for clay minerals typical.





Figures V.4.a and V.4.b. Comparison between multispectral (left) and hyperspectral (right) signatures.

- **Temporal Resolution**

It is defined as the period of time in which a sensor returns to record data about the same area.

For example, for a satellite that has a fixed orbit, it is the time it takes to pass over the same point on the earth's surface. Table V.2 shows the temporal resolution of several satellites.

Satellite	Revisit Time
Icons	3 days (*)
LandSat	16 days
QuickBird	7 days (*)
Spot	23 days
EARTH (ASTER)	16 days

Table V.2. Periods of different satellites

(* a 40 th latitude and with a capture angle of up to 26º).

- **Platform**

Another important parameter to take into account is the type of platform on which a sensor can be mounted. Basically, there are three types:

o **Satellite:**

The sensors are attached to satellites with polar synchronous orbits with respect to the Sun, generally between 400 km and 800 km altitude nominal.

o **Airborne:**

Sensors on board aircraft are called sensors airborne. They record information during a planned flight, Depending on its implementation on the existing weather conditions in the area to fly over.

o **Terrestrial:**

They are so-called portable terrestrial spectrometers; their Small dimensions allow for field surveys, recording data in the field with high spectral resolution (more of 1000 bands).

For this work, the acquisition of images obtained by two types of satellite sensors: LandSat-8 OLI and ASTER. Figure V.5 summarizes comparatively their basic characteristics.

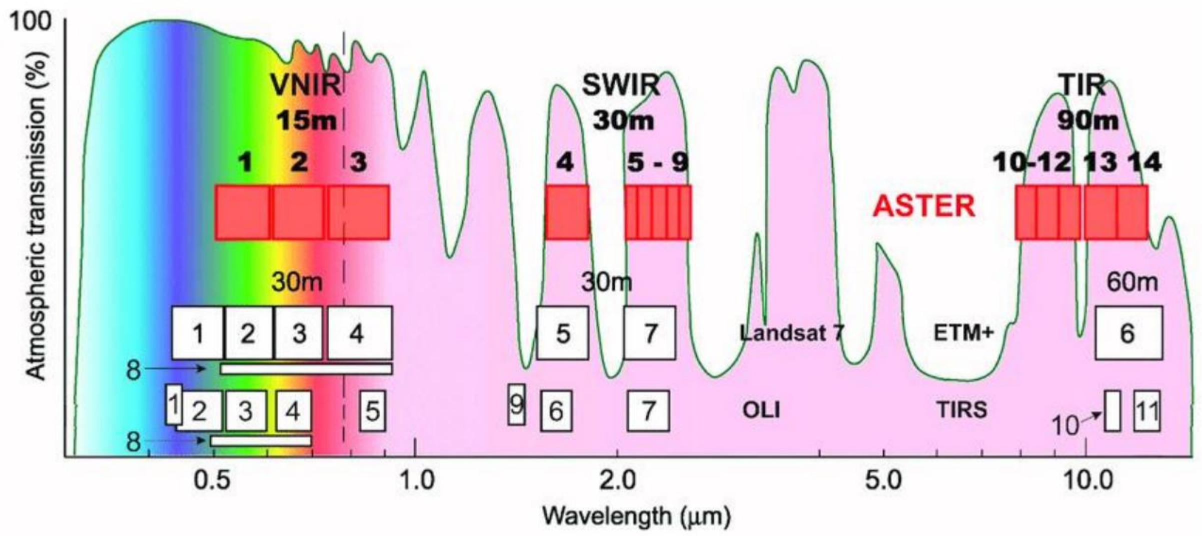


Figure V.5. Comparison between the basic characteristics of LandSat-8 and ASTER satellite sensors.

The LandSat sensor array has been acquiring images around in the world for more than 40 years. Of the aforementioned series, they are still operational LandSat-7 and LandSat-8. LandSat-8 added two new instruments: the Operational Land Imager (OLI) y el Thermal Infrared Sensor (TIRS).

LandSat-8 images consist of 9 bands with a resolution 30 meter special for Bands 1-7 & 9. The resolution of Band 8 (panchromatic) is 15 meters. Thermal bands 10 & 11 are useful for obtain more precise surface temperature data and have a resolution of 100 meters. (Table. V.3).

	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

Table V.3. LandSat 8 OLI Features

Each LandSat 8 image covers an area of 185 x 180 km. Nominal altitude It is 705 km. Mapping accuracy for LandSat 8 products is 12 m or better (including compensation for terrain effects). Because the LandSat 8 series includes additional bands, the combinations used for create the RGB compositions differ from the previous LandSat ones (Fig V.6)

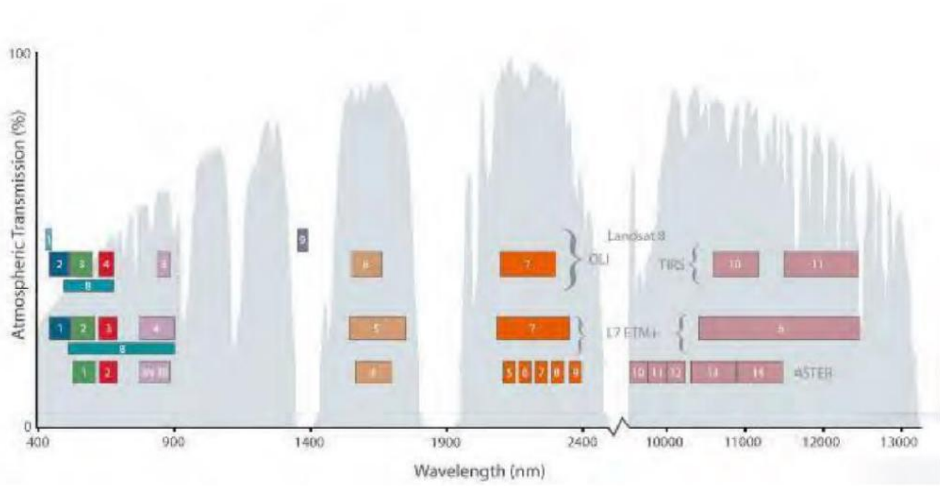


Figure V.6. Band comparison between LandSat 7, LandSat 8 and Aster

El sensor ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) was launched along with other instruments aboard the TERRA satellite satellite in late 1999. Since 2001, this data has been widely used for mining exploration. Maintaining the spatial resolution similar to that of the LandSat-7 ETM+ sensor, the 3 ASTER sensor subsystems produce higher spectral resolution information. Furthermore, the characteristics of the ASTER channels were specified taking into account geological studies and soils, which allows greater mineralogical discrimination. By For example, ASTER has bands on the absorption spectral segments characteristic of hydroxyls, to differentiate clay minerals and oxides of iron.

HytecAltoAmericas Hyperspectral Remote Sensing

Resolution Spectral	Region Electromagnetic		Center Band (nm)	Width of Band (nm)	Resolution Spatial (m)	Range Dynamic
Band 1	Visible	Green	0,556	0,09	15	8-bit
Band 2		Red	0,661	0,06		
Band 3N/B	Near infrared		0.807/0.804	0.10/0.11		
Band 4	Infrared shortwave		1.656	0,092	30	
Band 5			2.167	0,035		
Band 6			2.209	0,040		
Band 7			2.262	0,047		
Band 8			2.336	0,070		
Band 9			2.400	0,068		
Band 10	Infrared thermal		8.291	0,344	90	12-bit
Band 11			8.634	0,347		
Band 12			9.075	0,361		
Band 13			10.657	0,667		
Band 14			11.318	0,593		

Table V.4. Spatial and spectral resolution of the ASTER satellite

Additionally, the digital elevation data obtained were acquired by the Space Shuttle Endeavor Radar Survey Mission (SRTM) corresponding to the study area. This mission took off on February 11 2000, and used the same radar instruments as those of the SIR-C/X- mission. SAR, which traveled twice on the shuttle Endeavor in 1994 (Table V.5). The mission was designed to collect three-dimensional data from the surface land for which a 60-meter-long (200-foot) mast was added, a additional radar antenna in bands C and X, and other navigation systems high spatial precision.

SYSTEM		**FREQUENCY Ghz**	**LENGTH cm**	**RESOLUTION m**		**BROAD OF SWEPT Km**
				H	**IN**	
SRTM	**SIR- C**	5,3	5,8	30	16	225
	X-SAR	9,6	5,7	30	16	50

Table V.5. SRTM System Detail

V.2 SELECTION AND ACQUISITION OF SATELLITE IMAGES

V.2.1. LANDSAT 8 OLI

The entire Project area is spatially covered with three (3) images. However, for the final selection of the optimal ones, evaluated a large number of images obtained in various years, due to the degree of cloudiness present in the region. It is between 30% and 50%. After inspecting extensive databases, such as belonging to the USGS and the ESDI, the images with the best spectral quality. (Fig. V.7) (Table V.6)

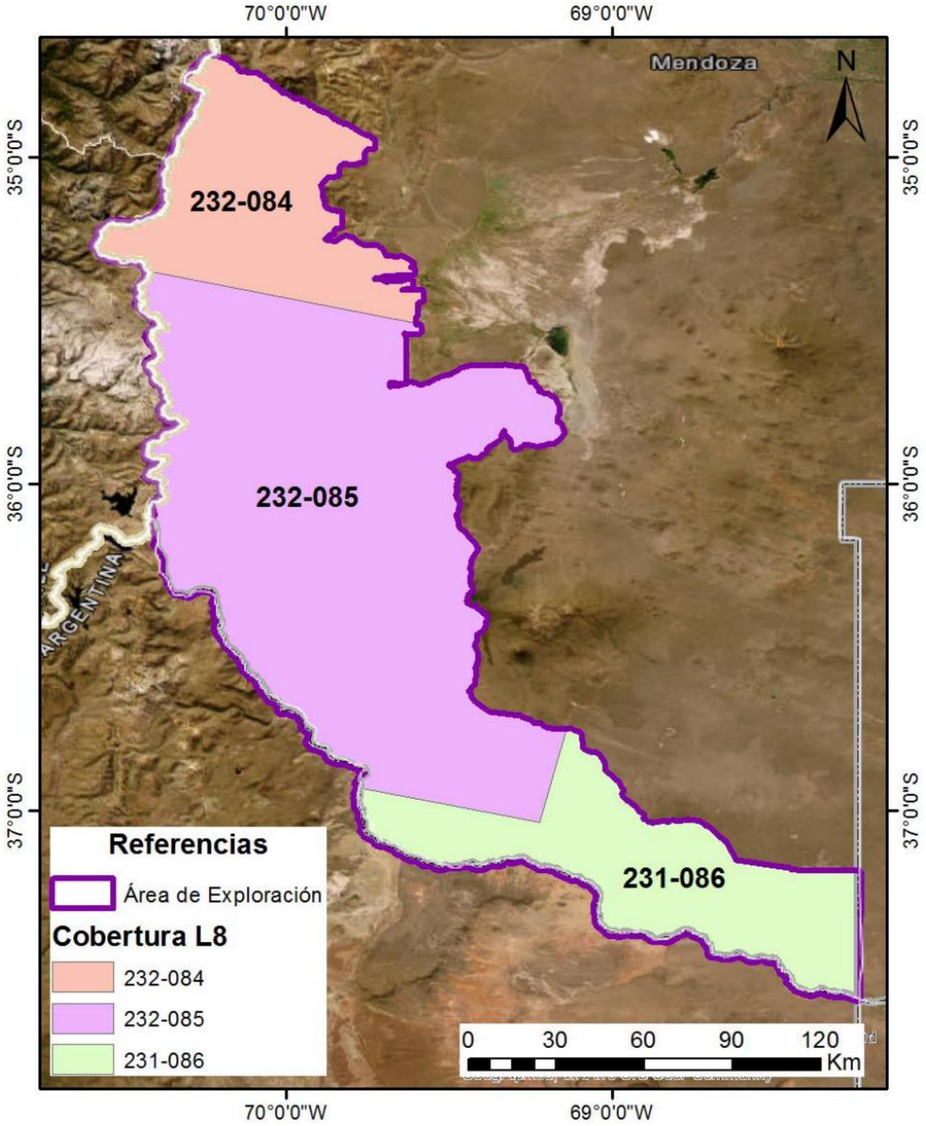


Figure V.7. Cobertura LandSat 8

LandSat 8 COVERAGE			
ID	Path	Row	Date Acquisition
LC08_L2SP_231086_20230221_20230228_02_T1	231	86	21/02/2023
LC08_L2SP_232084_20230228_20230315_02_T1	232	84	28/02/2023
LC08_L2SP_232085_20230228_20230315_02_T1	232	85	28/02/2023

Table V.6. ID LandSat 8

V.2.2. ASTER

For the Project Area, an information collection window was defined between the first day of January 2000 and the last day of December 2006. This date in 2006 corresponds to the last month in which the SWIR subsystem it worked correctly. In July 2008, NASA issued a report in which communicated a change in the status of the ASTER SWIR system. In it It was also detailed that since April 2008, the bands corresponding to said subsystem presented anomalous values, resulting in products of lower spectral quality. Later, it was reported that this error was also presented in the data acquired during 2007. The area is covered with sixteen (16) images. (Fig V.8) (Table V.7)

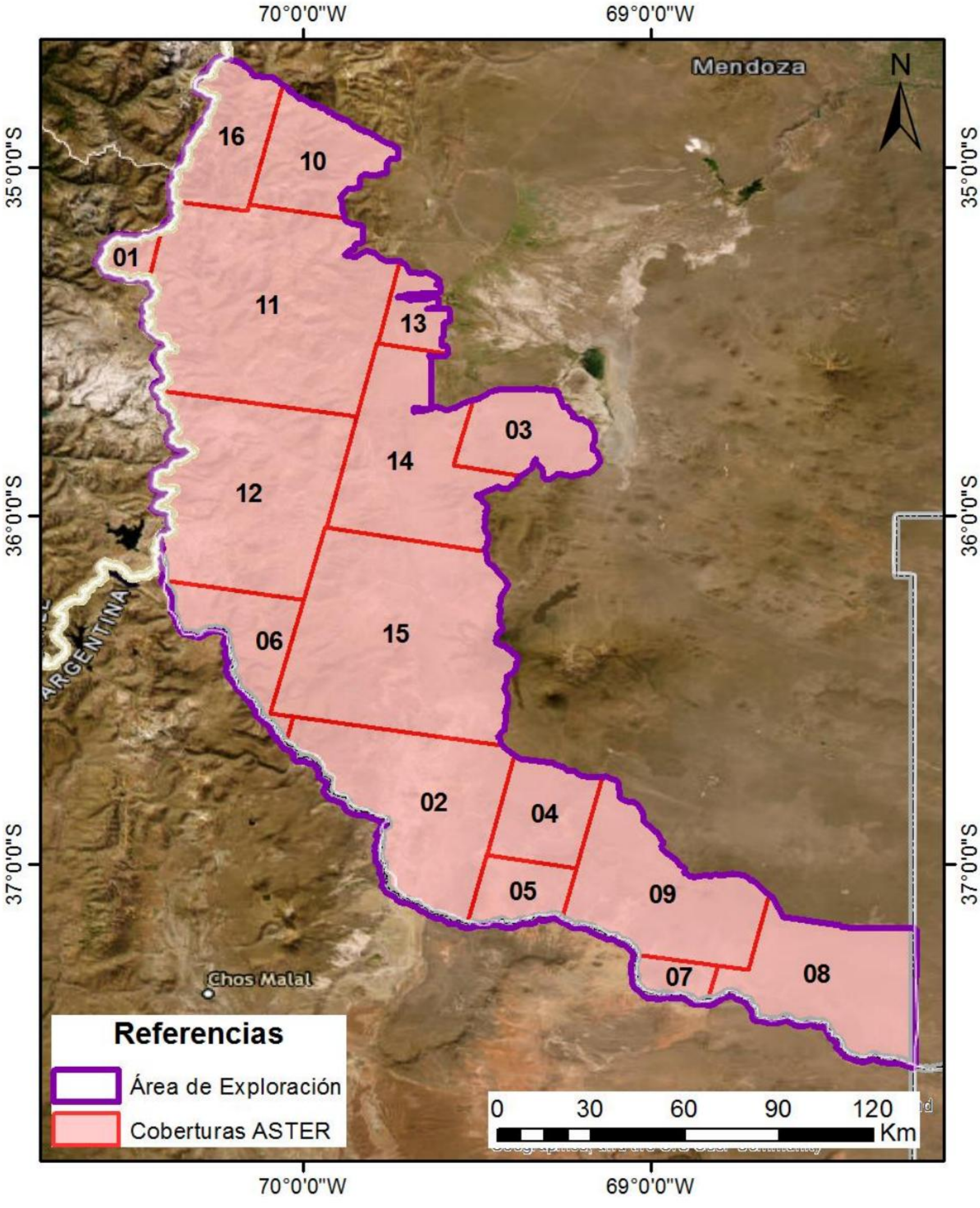


Figure V.8. ASTER Coverage

ASTER COVERAGE		
Id	Name	acquisition date
AST_L1T_00304092003145220_20150427232834_24808	1	09/04/2003
AST_L1T_00301062001145818_20150414032653_118127	2	06/01/2001
AST_L1T_00302012007143940_20150518025255_61278	3	01/02/2006
AST_L1T_00302042008143952_20150522215810_51138	4	04/02/2006
AST_L1T_00302042008144000_20150522230432_53792	5	04/02/2006
AST_L1T_00303052008145153_20150523044834_7408	6	05/03/2006
AST_L1T_00303102003144031_20150427142537_106187	7	10/03/2003
AST_L1T_00310152007143954_20150521155616_28308	8	15/10/2006
AST_L1T_00312052000145819_20150413101127_110105	9	05/12/2000
AST_L1T_00312162007145131_20150522100146_6266	10	16/12/2006
AST_L1T_00312162007145140_20150522100203_8761	11	16/12/2006
AST_L1T_00312162007145149_20150522100146_6268	12	16/12/2006
AST_L1T_00312272002144643_20150426125932_24464	13	27/12/2002
AST_L1T_00312272002144651_20150426125929_54453	14	27/12/2002
AST_L1T_00312272002144700_20150426125933_86578	15	27/12/2002
AST_L1T_00302232004145209_20150503085655_59242	16	23/02/2004

Table V.7. ID ASTER

V.2.3. SRTM data

The topographic information used for the Project area was acquired by the Radar Topographic Mission flown on the Space Shuttle Endeavour. The study area is covered by a total of nine (9) SRTM DEM images in HGT format. (Fig V.9) (Table V.8)

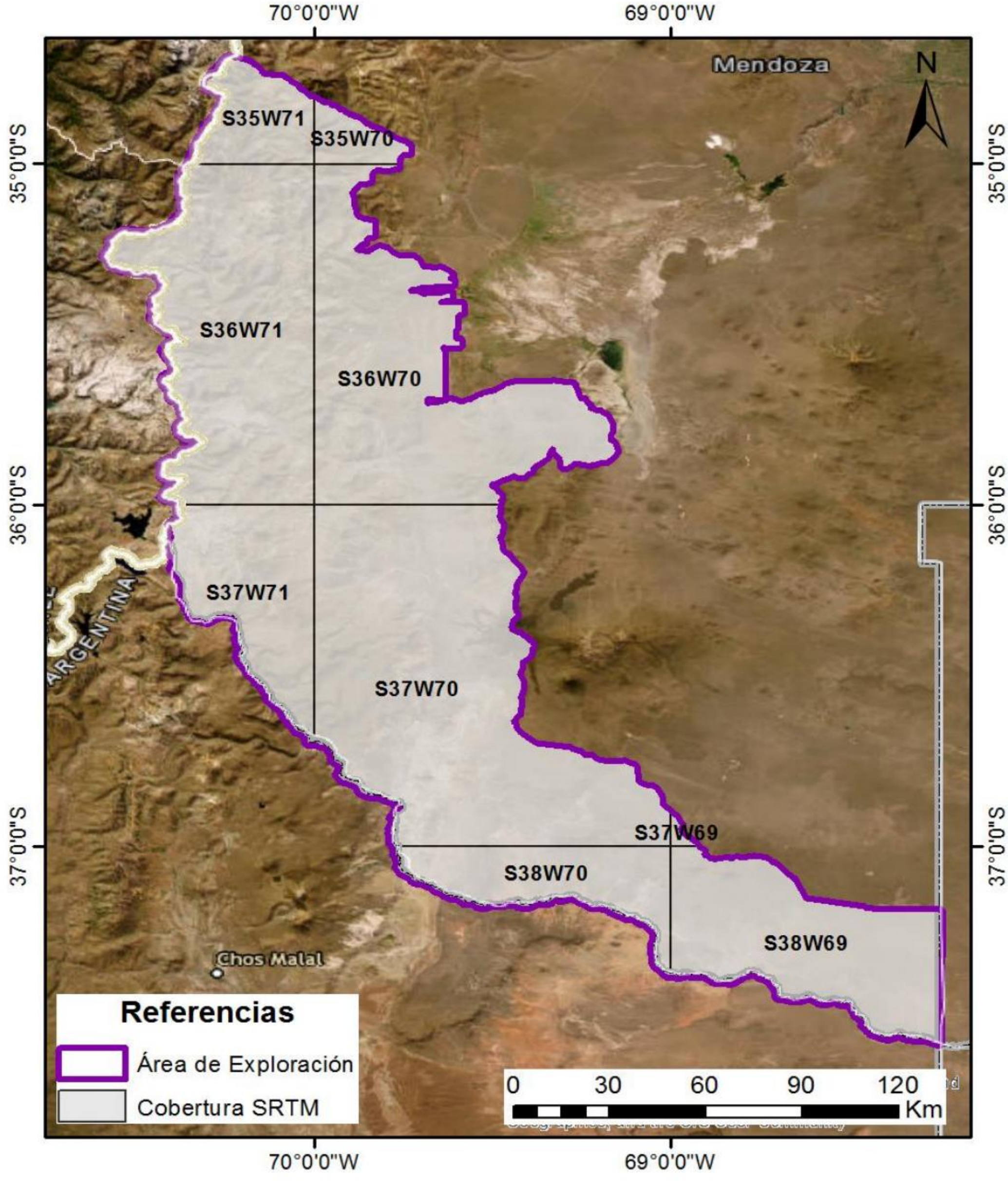


Figure V.9. Cobertura SRTM

Raw	Name
s38_w070_1arc_v3.tif	s38w70
s38_w069_1arc_v3.tif	s38w69
s37_w071_1arc_v3.tif	s37w71
s37_w070_1arc_v3.tif	s37w70
s37_w069_1arc_v3.tif	s37w69
s36_w071_1arc_v3.tif	s36w71
s36_w070_1arc_v3.tif	s36w0
s35_w071_1arc_v3.tif	s35w71
s35_w070_1arc_v3.tif	s35w70

Table V.8. RAW SRTM

V.3 PRE-PROCESSING AND DATA PROCESSING

V.3.1 DATA PRE-PROCESSING

Passive Sensors

This section of the study corresponds to the pre-processing stage and actual processing of the acquired satellite data, in which is applied to them, a series of corrections, adjustments and processes that They allow the generation of products to be interpreted.

LandSat 8 images

The pre-processing of the LandSat 8 images consisted of the application of the following radiometric corrections and geometric adjustments:

- Orthorectification
- Georeferencing
- Radiometric Calibration
- Atmospheric Correction
- Reprojection
- Scene Cut
- Mask Making
- Mosaic

The images were obtained, georeferenced and orthorectified with a geolocation error less than one pixel (30 meters). The original data of the image in digital numbers (DNs) were converted to radiance values in the sensor, using the available LANDSAT gain and offset parameters in the header files. The values were expressed in W / (m2 x st-rad x µm). The reflective bands were then corrected to exo-atmospheric reflectance (reflectance measured at the top of the atmosphere) using the tool DOS1 of QGIS.

This application uses astronomical data (solar azimuth and angle of elevation), telescopic parameters (acquisition angle) extracted from the LANDSAT satellite ephemeris and atmospheric data obtained from models of advanced mathematical aerosols (MODTRAN 4), as well as climate statistics corresponding to the geographical area, and to the date and time of acquisition.

Images are acquired in plane coordinate system and UTM projection, so it is subsequently necessary to reproject them to geographic coordinates with Datum WGS-84.

Masking removes low-quality spectral information, which is mainly due to high cloudiness or atmospheric humidity that prevails throughout the region.

Figure V.10 indicates the flowchart for LandSat 8 images.

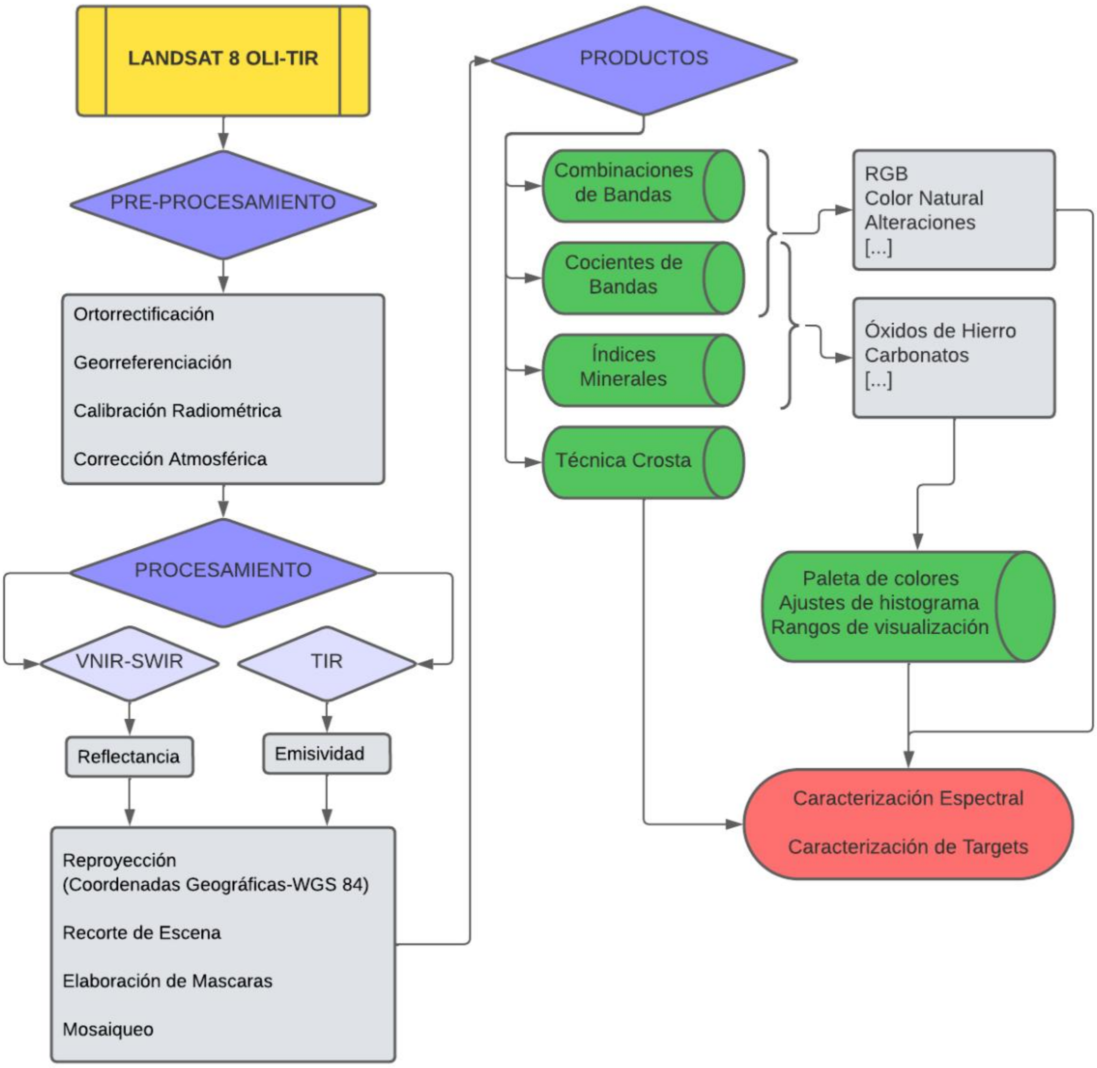


Figure V.10. Flowchart. LandSat images.

ASTER Images

The level of ASTER data used was L1B, that is, already in units of radiance. All scenes were reviewed in order to identify possible band alignment errors – a recurring problem in images ASTER-. When this defect was detected, it was corrected to achieve the spatial coincidence of all bands, for each pixel of each scene. The ASTER images were orthorectified using a digital elevation model coarse and the corresponding data from the TERRA satellite ephemeris. The output projection is UTM in plane coordinate system, so later it is necessary to reproject them to geographic coordinates with Date WGS-84.

Each original ASTER image was split into two data sets, one with the bands in the visible (V), near infrared (NIR) and shortwave regions (SWIR) and another with the thermal infrared (TIR) bands. The SWIR bands were taken from a pixel of 30 m to a pixel of 15 m with the purpose of being compatible with VNIR bands. Band 3B (designed for processing stereoscopic) was discarded. The “nearest” resampling method was used. neighbor”.

Mosaics were constructed according to the selected images. All mosaics have all VNIR and SWIR bands. The method of The resampling adopted was that of nearest neighbor and the smoothing was limited to 20 pixels.

As with LandSat images, masking eliminates low quality spectral information, which is mainly due to the high cloudiness or atmospheric humidity that prevails throughout the region.

Figure V.11 indicates the flowchart for ASTER images.

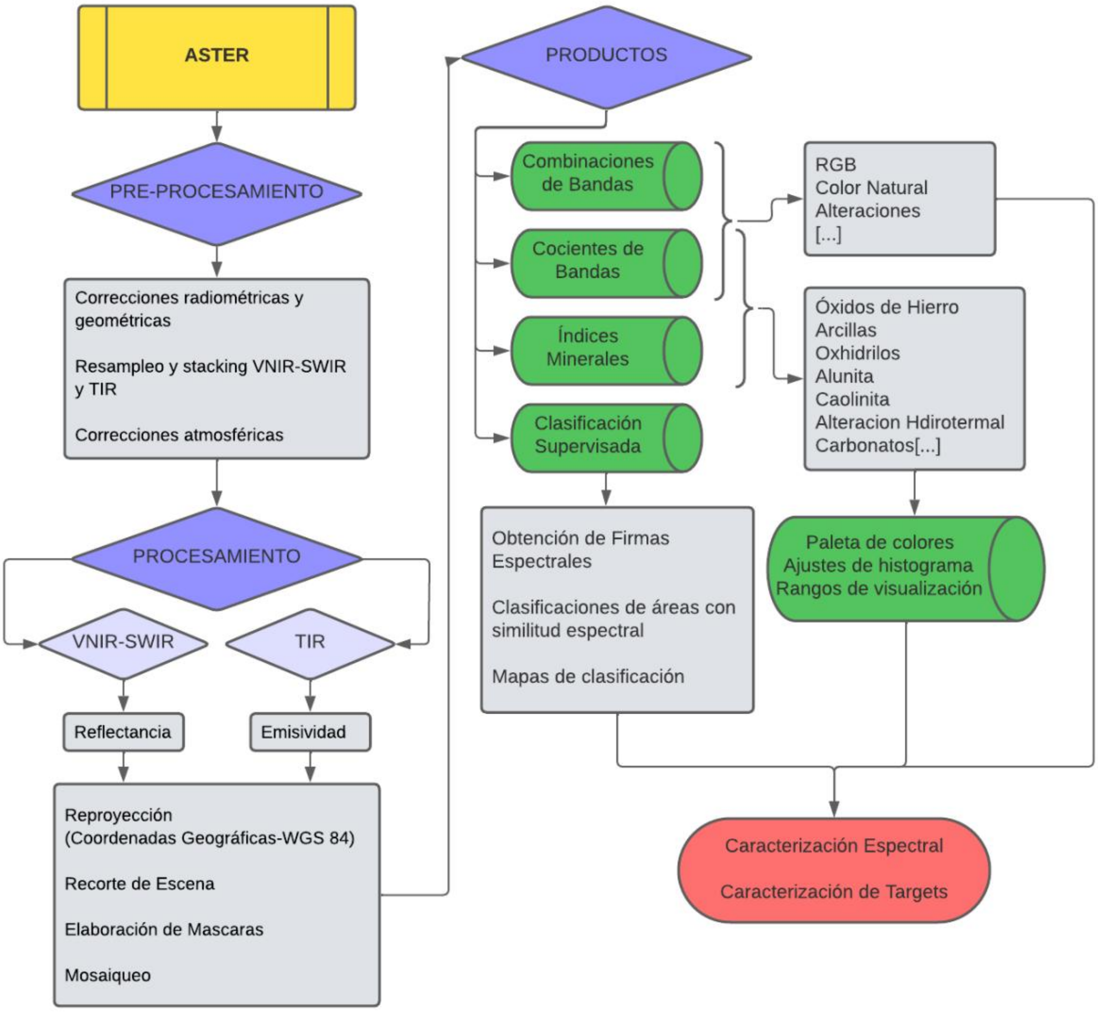


Figure V.11. Flowchart. ASTER Images

Active Sensors

SRTM Data

SRTM data were acquired in "RAW" format (without headers), 16 integer bits, the elevation expressed in meters above sea level and "Geographical" projection (latitude and longitude). The area is of 3-arc-seconds and los files contain 1,201 columns and 1,201 rows of data, whose total size 2.884.802 bytes.

The SRTM mission, like any SAR survey, has pixels of "NO DATA" type. During pre-processing, these pixels (< 0.2% of the total of the image) are corrected through the interpolation process.

The procedure for opening Radar data is detailed below. SRTM using the example of a compressed file:

In the first instance, the files must be unzipped and renamed with the coordinates of the lower left corner of the image, since when opening the image in the ENVI software, the program interprets that the hgt extension directly references an SRTM image (Fig. V.12).

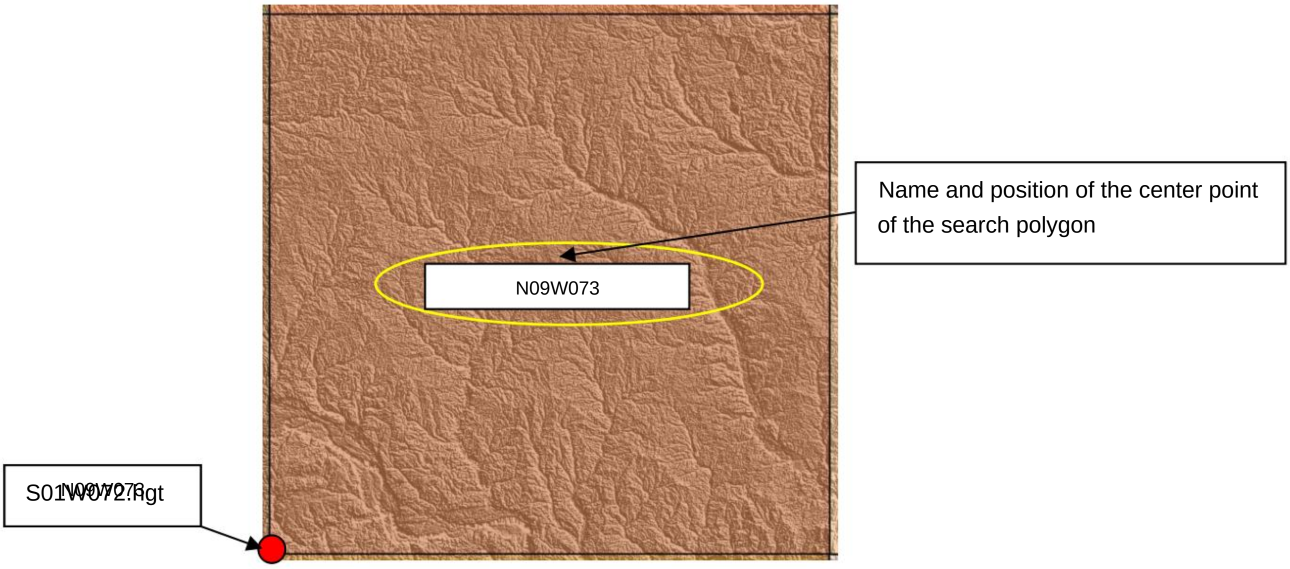


Figure V.12. Data SRTM

In this way, the N09W073.ZIP file when decompressed and renamed, it will be N09W073.hdr, which is the geo-information. location that will be read in the process of opening the SRTM image (Figure V.13).

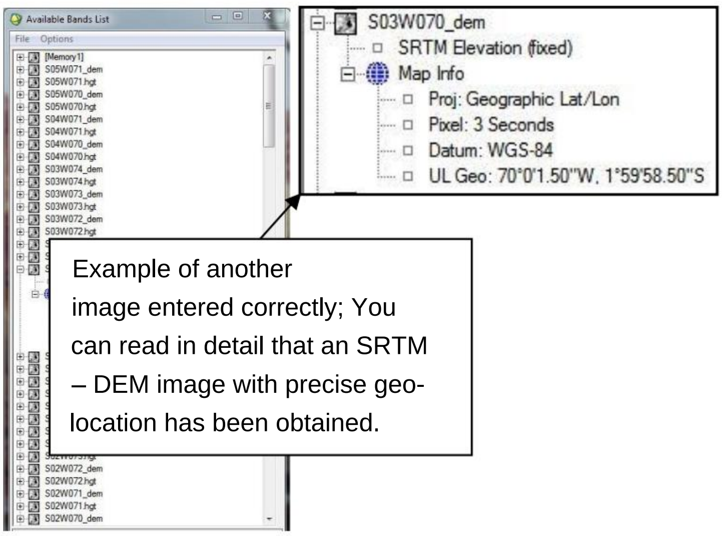


Figure V.13. Example SRTM – DEM with precise geo-location.

V.4 DATA INTEGRATION AND INTERPRETATION

PRODUCTS

- **SRTM**

SRTM Sensor Final Products Involve Elevation Models Digital (DEM), and all topographical extracts that are generated from it. Such products include both raster products as vectors (Fig. V.14):

- **Vector Products**

o Surface runoff o Contour lines o River channels o Water micro-basins

- **Raster Products**

o Shading map o Slope direction maps o Slope intensity maps

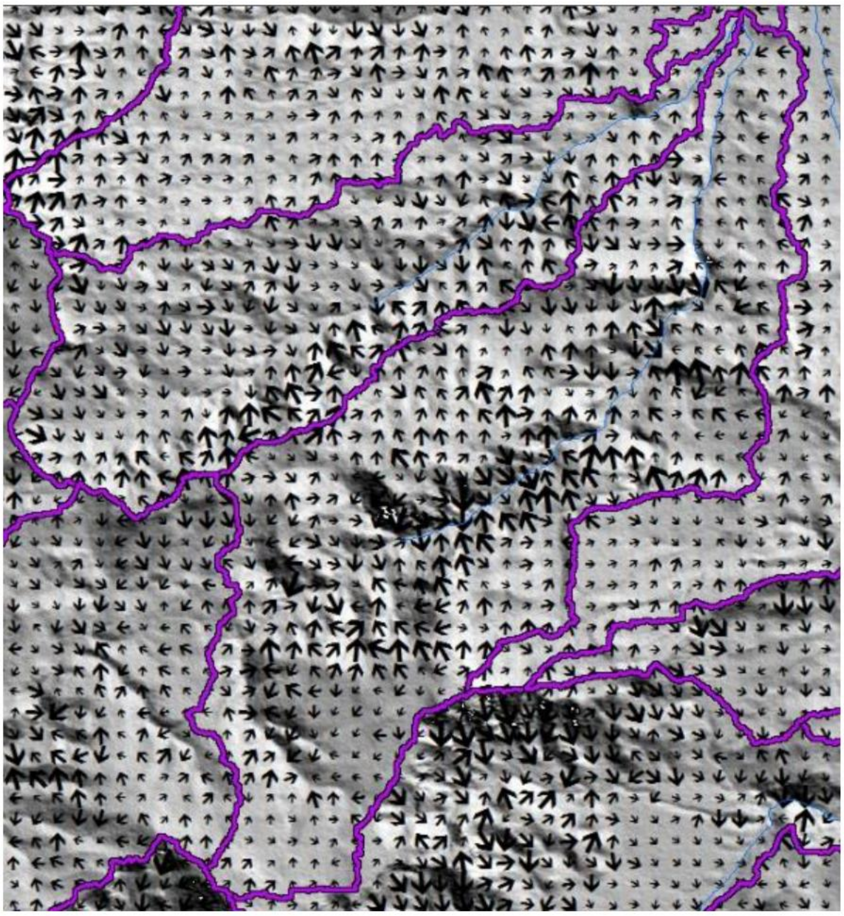


Figure V.14. Example of delimitation of microbasins with surface runoff points and river channels with shaded relief base map.

- **LANDSAT 8**

LandSat 8 image processing deliverables include various types of rasters, between band combinations and indices. These products have been extensively researched and there are various repositories thereof. One of the reference repositories that was used in this project is found in the following link: **https://custom-scripts.sentinel-hub.com/custom-scripts/LandSat-8/indexdb/**

Mineral Indices

Involve quotients and band algebra to highlight patterns or peaks absorption characteristics of certain minerals, mineral groups or types of alterations. The name of the index is indicated below and in parentheses its band algebra formula:

- Ferric Oxide (B4/B3)
- Óxido Ferroso (B7/B5 + B3/B4)
- Gossan (B6/B4)
- Laterita (B6/B7)
- Carbonates (B10/B11)

Crust Technique

The principal component transformation is a statistical technique multivariate that selects uncorrelated linear combinations (eigenvectors) of variables such that each linear combination extracted successively, or principal component (PC), has a lower variance. He main objective of CPs analysis is to eliminate redundancy in data multispectral. Principal component analysis is widely used to map alteration in metallogenic provinces (Ranjbar *et al.,* 2003).

The Crosta technique is also known as component selection main oriented to spectral characteristics. Through the analysis of the eigenvectors and eigenvalues allow us to identify the main components that contain spectral information about specific minerals, as well as the contribution of each of the original bands to the components in relation with the spectral response of the materials of interest.

Minerals containing hydroxyls constitute the product of more widespread alteration. The abundance of clays, which contain minerals and hydroxides containing Al-OH- and Mg-OH- in the alteration zones, implies that absorption bands in the range of 2.1 to 2.4 µm (Band 7) due to processes of molecular vibration become very prominent. Iron oxide is also a fairly common component of alteration zones associated with hydrothermal sulfide deposits. Minerals containing iron oxide can be detected by the ratio of the CP of B4. This relationship would give values very high for areas containing iron oxide.

Band combinations (Rx-Gx-Bx)

It corresponds to the generation of color rasters, where in each red channel (red, "R"), green (green, "G"), and blue (blue, "B") a band or index is assigned in particular to highlight areas of interest in different colors. Below is indicate the bands or indices used in each channel R, G and B: (Fig. V.15).

- Color natural (B4-B3-B2)
- Infrared (B5-B4-B3)
- Falso Color (B7-B6-B2)
- Alteración (B4/B2 - B6/B7 - B10)

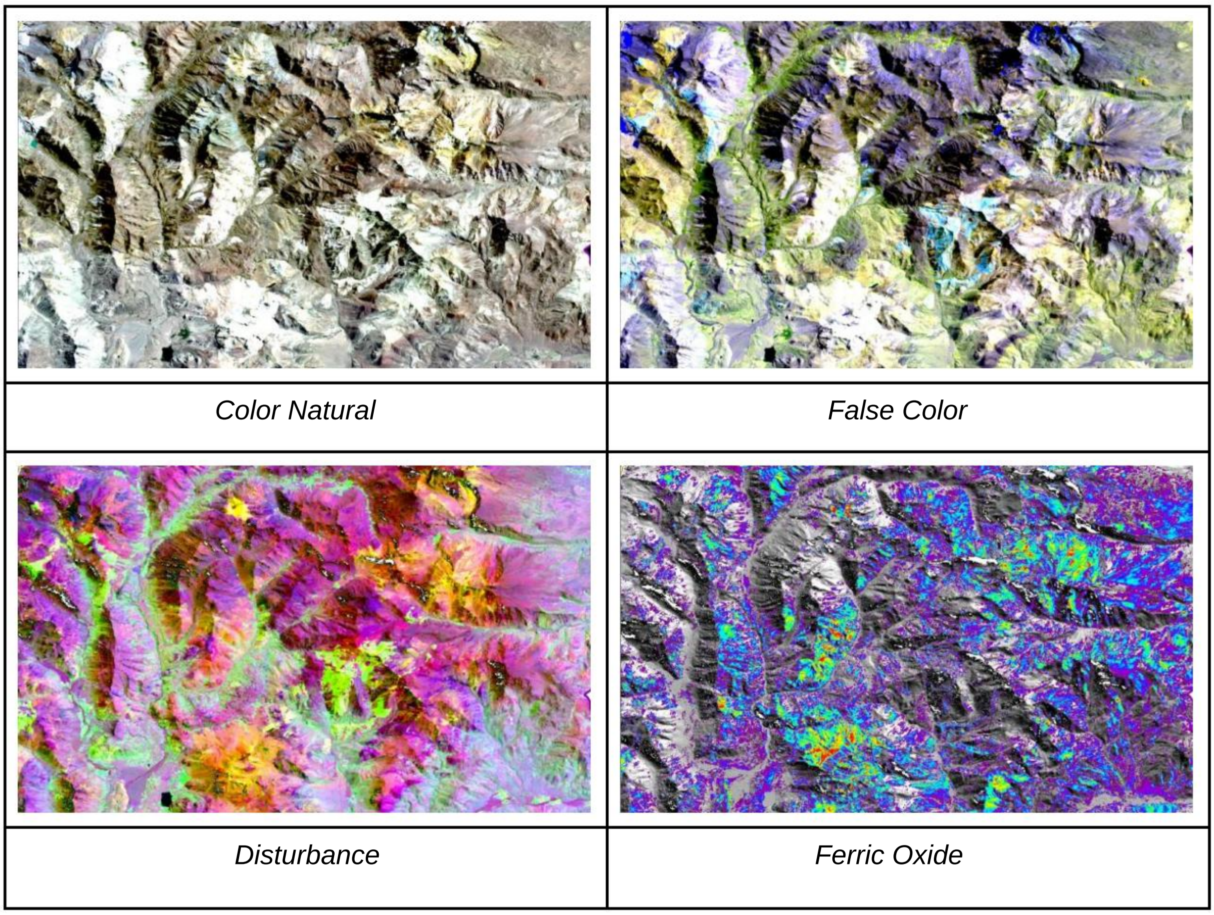


Figure. V.15. LandSat 8 Products

- **ASTER**

The end products of ASTER image processing include various types of rasters, between band combinations and indices. These products have been extensively researched and there are various repositories of the same, ASTER products being the reference for the mapping of mineral alterations and mining prospecting worldwide. One of the reference repositories and that was used in this project is located in the following link:

https://www.scribd.com/document/535228885/IMP-GA7833?utm_medium=cpc&utm_source=google_search&utm_campaign=3Q_Google_DSA_NB_RoW_P1_UGC&utm_adgroup=Documents&utm_term=&utm_matchtype=&utm_device=c&utm_network=g&gclid=CjwKCAjw1t2pBhAFEiwA_-A-NG8WUDy9uuRH88ScF5vOK6v5zSVaL7zMsn2cP44iRbDND--7FvsoXxoCZasQAvD_BwE

Particularly, the Ninomiya indices (Pérez *et al.* 2007) have been Wide application in hydrothermal alteration detection and quantification qualitative clay minerals.

Mineral Indices

Involve quotients and band algebra to highlight patterns or peaks absorption characteristics of certain minerals, mineral groups or types of alterations. The name of the index is indicated below and in parentheses its band algebra formula:

- Alunite/Kaolinite/Pyrophilite: (B4+B6)/B5
- Oxhydrilos: B4/B5
- Alunita - B: (B4+B7)/B5
- Alunita - AL: (B7*B7)/(B5*B8)
- OHIa: (B4*B7)/(B6*B6)
- OHIb: (B4*B7)/(B5*B5)
- Biotita/Clorita/Anfibolita: B5/B4
- Kaolinite: (B4+B7)/B6
- Oxido Ferroso: B5/B3 + B1/B2
- Ferric Oxide: B2/B1
- Muscovita: B7/B6
- Carbonato/Clorita/Epidoto: (B7+B9)/B8
- Arcillas (5): (B5*B7)/(B6*B6)
- Arcillas (6): B4/B6
- Fengita: B5/B6
- Sericita/Muscovite/Illita/Esmectita: (B5+B7)/B6
- Epidoto/Clorita/Anfibolita: (B6+B9)/(B7+B8)

To view them, these indices are edited by adjusting the histograms. In this way, from a certain threshold the most important values are highlighted. highs of each one, and leaving transparent all the values below said threshold. Thus, the entire rainbow palette is distributed in the values representative, and the rest remains transparent.

Band combinations (Rx-Gx-Bx)

It corresponds to the generation of color rasters, where in each red channel (red, “R”), green (green, “G”), and blue (blue, “B”) a band or index is assigned in particular to highlight areas of interest in different colors. Below is indicate the bands or indices used in each channel R, G and B: (Fig. V.16).

- Pseudo Color Natural (B3 - B2 - B1)
- Argílica (Fengita - Muscovita - Caolinita)
- Hidrothermal A ((B4+B7)/B5 - (B4+B7)/B6 - (B5+B7)/B8)
- Hidrothermal B (B4/B5 - B4/B6 - B4/B7)
- Hydrotermal - Ninomiya (OHIa - OHIb - ALI)
- Skarn Iron (Ferric - Ferrous - Carbonates/Chlorite/Epidote)

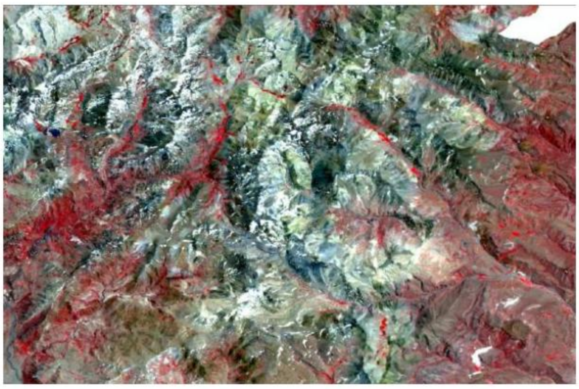
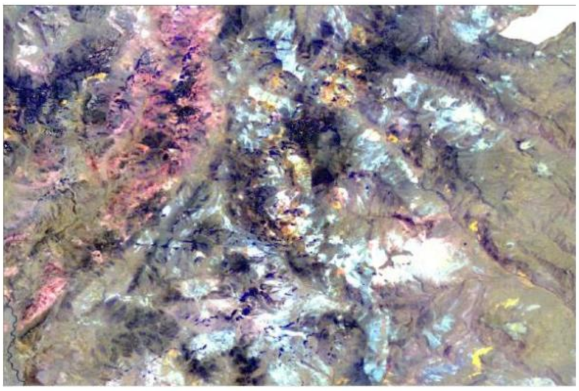
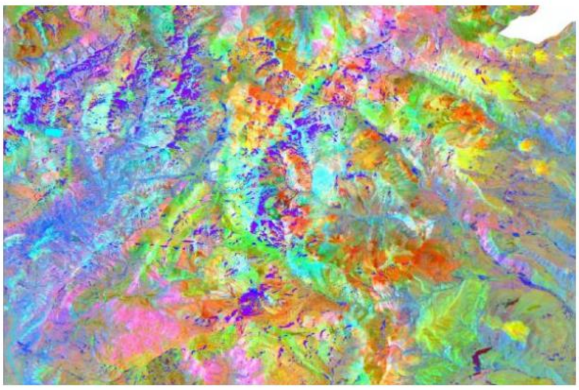
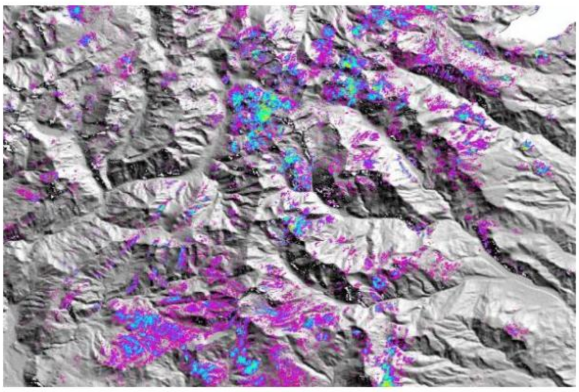
	
Pseudo Color Natural	*Hydrothermal - Ninomiya*
	
Iron Skarn	*Ferric Oxide*

Figure. V.16. ASTER Products

At the same time, there are areas of known mining potential close to the area. investigated in the neighboring country of Chile. These include various porphyry zones copper, copper-molybdenum, etc. (Fig. V.17).

Based on this known information, the spectral signatures were extracted of 3 of them (Vista (copper), Romeral Norte (copper), and Pellejo Norte (copper and molybdenum) and were used as end members for classifications supervised using the Spectral Angle Mapper technique. This method searches detect within each image pixels with a spectral signature similar to that of each end member, and thus find with the same characteristics as the zone of reference.

Figure. V.17. Known projects in the Chilean sector. Those used in this project were Vista, Romeral Norte and Pellejo Norte.

VI - IDENTIFICATION OF AREAS OF INTEREST WITH POTENTIAL MINER

• Areas of Mining Interest

From the analysis of the various products obtained from images satellites, both from the LandSat 8 satellite, the ASTER sensor on the Terra satellite and SRTM data, three types of objectives of mining interest were recognized:

- Copper porphyries
- Copper in Sediments
- Skarns Polimetálicos

Once the areas of interest have been defined based on the satellite images, The spectral results obtained were integrated with the geological information collected in different publications, the geochemical information and the geological information available in the Argentine Mining Geological Service (SEGEMAR).

In the region studied, a total of eighty-six (86) were identified prospective areas:

- Twenty-six (26) targets with potential mineralization related to Copper porphyries,
- Twenty-eight (28) corresponding to Copper – associated with other elements- in Sediments and
- Thirty-two (32) sectors with potential associated mineralization to Polymetallic Skarns.

The areas of interest were grouped according to the Geological Sheets defined by SEGEMAR corresponding to the region studied, from north to on:

- Maipo Volcano,
- Malargüe,
- Barrancas Sheet and
- Chos Malal.

• Areas with Copper Porphyry Potential

These areas of interest were identified mainly by interpreting the products "Ferric Oxide" and "Crosta Technique" obtained from the information of the LandSat 8 satellite and the products "Alunite-Kaolinite-Pyrophyllite", "Kaolinite", "Clays", "Muscovites", "Alunite-Kaolinite-Sericite", "Hydrothermal – Ninomiya", "CS-Cu Porphyry", "Ferric Oxide" and "Phengite" from the ASTER sensor of the Terra satellite (Table VI.1) .

Products that highlight clay minerals, added to the products that show ferric oxides, allow good recognition precision the possible zones with porphyry copper type mineralization. These products presented a concordance with the information provided by the obtained from the application of the Crosta Technique, the Hydrothermal – Ninomiya and CS-Cu Porphyry for the same type of mineralization.

SATELLITE PRODUCTS	
LandSat 8	**ASTER**
Ferric Oxide	Molten-Kaolinite-Pyrophilic
Crust Technique	Kaolinite
	Clays
	Muscovite
	Alunite-Kaolinite-Sericite
	Hydrothermal - Ninomiya
	CS- Cu Porphyries

Table VI.1. Satellite products used in the identification of areas with potential porphyry copper deposits.

A total of twenty-six (26) areas of interest were identified with possible porphyry copper mineralization:

- Six (6) on the Maipo Volcano Leaf,
- Fifteen (15) on the Malargüe Sheet and
- Five (5) on the Barrancas Sheet.

The parameters applied to the recognition of these areas of interest are They are detailed in Annex 1.

Of the total of these areas, eleven (11) were prioritized, considering the greatest agreement of the spectral responses with the geology, structures and geochemistry of the outcrops therein. Additionally, these areas selected were categorized by their geological and logistical advantages and their situation regarding their social license (Table VI.2.).

COPPER PORPHYDS - PRIORITIZED AREAS OF INTEREST				
Leaves Geological	**Area Name**	**Logistics**	**Geology**	**License Social**
Volcano Leaf Maipo	Florida	Green	Red	Green
	The Choicas	Green	Green	Green
Malargüe Leaf	Yellow Hill	Green	Yellow	Green
	Insurance	Green	Red	Green
	Trolon Pass	Green	Red	Green
	Turbid Stream	Green	Red	Green
	Cerro Belfry	Green	Yellow	Green
	Cerro Chacaico	Green	Yellow	Green
Barrancas Leaf	Rucamileo	Green	Red	Green
	Mary	Green	Red	Green
	Mayan	Green	Red	Green

Table VI.2. Prioritized Areas of Interest: Green, optimal condition; Yellow, intermediate; Red: unfavorable.

• Areas with Potential Copper Deposits in Sediments

These areas of interest were identified mainly by interpreting the products "Ferric Oxide", "Crosta Technique", "Hydrothermal Alteration" and "Oxide".
Ferrous" obtained from the information from the LandSat 8 satellite and the products "Clays- 5", "Hydrothermal- B", "Iron Skarn", "Ferric Oxide" from the
ASTER sensor of the Terra satellite (Table VI.3.).

SATELLITE PRODUCTS	
LandSat 8	**ASTER**
Ferric Oxide	Clays (5)
Crust Technique	Iron Skarn
Hydrothermal Alteration	Hydrothermal B
Ferrous Oxide	Ferric Oxide

Table VI.3. Satellite products used to define potential copper deposits in sediments.

A total of twenty-eight (28) areas of interest were identified with possible copper mineralization in sediments:

- One (1) on the Maipo Volcano Leaf,
- Six (6) on the Malargüe Sheet,
- Eighteen (18) in the Barrancas Sheet and
- Three (3) on the Chos Malal Sheet.

The parameters applied to the recognition of these areas of interest are They are detailed in Annex 1.

Of the total of these areas, twelve (12) were prioritized, considering the greatest agreement of the spectral responses with the geology, structures and geochemistry of the outcrops therein. Additionally, these areas selected were categorized by their geological and logistical advantages and their situation regarding their social license (Table VI.4).

COPPER IN SEDIMENTS - PRIORITIZED AREAS OF INTEREST				
Leaves Geological	**Area name**	**Logistics**	**Geology**	**License Social**
Volcano Leaf Maipo	The Donkey			
Malargüe Leaf	Huemul			
	Mirano			
	Yellow Pampas			
Barrancas Leaf	The Apple tree			
	Mechanquil			
	Calmuco			
	The island			
	The Huincals			
	El Relincho Post North			
	El Relincho Post On			
	San Romeleo			

Table VI.4. Prioritized Areas of Interest: Green, optimal condition; Yellow, intermediate; Red: unfavorable.

• Areas with Potential Polymetallic Skarn Deposits

These areas of interest were identified mainly by interpreting the products "Ferric Oxide", "Carbonates", "Hydrothermal Alteration" and "Oxide".

Ferrous" obtained from the information from the LandSat 8 satellite and the products "Clays", "Hydrothermal – B", "Iron Skarn", "Ferric Oxide" and "Hydrothermal – Ninomiya" from the ASTER sensor of the Terra satellite (Table VI .5).

SATELLITE PRODUCTS	
LandSat 8	**ASTER**
Ferric Oxide	Clays
Carbonates	Iron Skarn
	Hydrothermal - B
	Ferric Oxide
	Hydrothermal - Ninomiya

Table VI.5. Satellite products used to define Polymetallic Skarns.

A total of thirty-two (32) areas of interest were identified with possible mineralization of polymetallic skarns:

- Five (5) on the Maipo Volcano Sheet,
- Twenty-five (25) on the Malargüe Sheet and
- Two (2) in the Barrancas Sheet.

The parameters applied to the recognition of these areas of interest are They are detailed in Annex 1.

Of the total of these areas, fourteen (14) were prioritized, considering the greatest agreement of the spectral responses with the geology, structures and geochemistry of the outcrops therein. Additionally, these areas selected were categorized by their geological and logistical advantages and their situation regarding their social license (Table VI.6.).

POLYMETALLIC SKARNS - PRIORITIZED AREAS OF INTEREST				
Leaves Geological	**Name of the area**	**Geology**	**Logistics**	**License Social**
Volcano Leaf Maipo	Choicas On	Green	Green	Green
	Indian Iron	Green	Green	Green
	Felipe Stream	Green	Yellow	Green
Malargüe Leaf	Iron Corner	Green	Yellow	Yellow
	Cerro Los Whites	Green	Green	Yellow
	Drawer Tears	Green	Yellow	Yellow
	Small Drawer	Green	Yellow	Green
	Rio Montañez	Green	Green	Green
	Header of And so	Green	Red	Green
	Los Angeles Creek	Green	Red	Green
	Large Drawer	Green	Red	Green
	Cerro Station	Green	Yellow	Green
	Chacayco	Green	Red	Green
Leaf Barrancas	Stone Stop	Green	Red	Green

Table VI.6. Prioritized Areas of Interest: Green, optimal condition; Yellow, intermediate; Red: unfavorable.

BIBLIOGRAPHY - CONSULTED MATERIAL

- ANDRADA DE PALOMERA R. P., 2003. Application of remote sensing and geographic information system for mineral predictive mapping, Deseado Massif, Southern Argentina. Thesis, International Institute for Geo-Information Science and Earth Observation. Netherlands.

- ANGELELLI V. (1950). Mineral Resources of the Argentine Republic. Magazine of the National Institute of Natural Sciences, Geological Sciences II. Buenos Aires.

- ANGELELLI V., FERNANDEZ LIMA JC, HERRERA A. and ARISTARAIN L. (1970). Description of the metallogenetic map of the Argentine Republic. Metalliferous minerals. SEM, annals XV. Buenos Aires.

- ANGELELLI V., SCHALAMUK IB and FERNANDEZ R. (1980). The deposits of non-metalliferous minerals and application rocks of the Central-Cuyo region. SEM, Anales XIX. Buenos Aires.

- ANGELELLI V., BRODTKORB MK, GORDILLO CE and GAY HD (1983). The mineral species of the Argentine Republic. SSM, Serv. Min. Nac., Special publication. Buenos Aires.

- ANGELELLI V. (1984). Metalliferous Deposits of the Argentine Republic. CIC. At payment.

- BOLOKI M. y POORMIRZAEE R., 2009. Using ASTER Image Processing for Hydrothermal Alteration and Key Alteration Minerals Mapping in Siyahrud area, IRAN. International Journal of Geology, Issue 2, Volume 3.

- BONHAM-CARTER, G.F., ROGERS, P.J. Y WRIGHT D.F. 1988. Integration of Geological Datasets for Gold Exploration in Nova Scotia. Photogrammetric Engineering and Remote sensing, v. 54, n 77, pp. 1585-1592

- CAMUS, F. 2003. Geology of porphyry systems in the Andes of Chile. National Geology and Mining Service: 267 p.Chile.

- CARPIO F., MALLIMACCI H., RUBINSTEIN N., SALVARREDI J., SEPÚLVEDA E., FUSARI C., CENTENO R., ROSAS M. and VARGAS D. (2001). Metalology of the San Rafael Block, Mendoza. Technical Contributions Series. Mineral Resources 20. Institute of Geology and Mineral Resources. SEGEMAR.

Buenos Aires.

- CENTENO R., ROSAS M. and RUBINSTEIN N. (2009). Metallogenetic Mining Letter 3569-IV. El Nihuil Reservoir. Province of Mendoza. Institute of Geology and Mineral Resources, Argentine Mining Geological Service. Bulletin 299, 71 p. Buenos Aires.

- CRÓSTA AP, SOUZA FILHO CR, AZEVEDO F. and BRODIE C., 2003.
Targeting key alteration minerals in epithermal deposits in Patagonia, Argentina, using ASTER imagery and principal components analysis. International Journal of Remote Sensing 24 (21): 4233-4240.

- CROSTA S. and PALACIO M. de B. (2015). Mining-Metallogenetic Letter 3569-III, Malargüe. Province of Mendoza. Institute of Geology and Mineral Resources, Argentine Mining Geological Service. Bulletin 407: 89 pp. Buenos Aires.

- CROSTA S. (2015). Mining-Metallogenetic Letter 3769-I, Barrancas. Provinces of Mendoza and Neuquén. Institute of Geology and Mineral Resources, Argentine Mining Geological Service. Bulletin 406: 47pp. Buenos Aires.

- DESSANTI RN (1956). Geological description of Sheet 27c, Cerro Diamante, Province of Mendoza. National Mining Directorate, Bulletin 85. Buenos Aires.

- DESSANTI RN (1973). Geological description of Sheet 29b, Bardas Blancas, Province of Mendoza, SSM, National Geology and Mining Service, Bulletin 139, Buenos Aires.

- DESSANTI RN (1978). Geological description of sheet 28b, Malargüe, Province of Mendoza. SEM, Bulletin 149, Buenos Aires.

- EKNELIGODA T. C. y HENKEL H. 2010. Interactive spatial analysis of lineaments. Computers & Geosciences 36: 1081-1090.

- FERPOZZI L. and TUREL A., 1998. Geochemical Charter of the Argentine Republic: A Support Instrument for Mining Exploration. In: Aerial Geophysics and Geochemistry Symposium in Geological-Mining Prospecting – X Latin American Congress of Geology VI National Congress of Economic Geology, pp 171-183. Buenos Aires.

- FERPOZZI L., TUREL A., CENTENO R., ROSAS M., JARA A., SIEHANKIEWICZ D. and VARGAS D., 2000a. Multielement geochemical data and location of stream sediments. Sheet 3569-IV, El Nihuil Mendoza Reservoir. Republic
Argentina. Technical Contributions Series. Geochemistry No. 26. Institute of Geology and Mineral Resources. SEGEMAR. Buenos Aires.

- FERPOZZI L., TUREL A., CENTENO R., ROSAS M., JARA A., SIEHANKIEWCZ D. and VARGAS D., 2000b. Multielement geochemical data and location of stream sediment sampling sites. Sheet 3769-II Agua Escondida, Mendoza,
Argentinian republic. Technical Contributions Series 28, Geochemistry. Argentine Mining Geological Service. 74 page Buenos Aires.

- FERPOZZI L., TUREL A., VARGAS D., BUTRÓN ASCONA F., JARA A., SIEHANKIEWSKI D. and CASA A., 2001a. Multi-element geochemical data and location of Los Planes stream sediment sampling sites

Mountain Range and Drillings. Sheet 3769-I Barrancas, provinces of Neuquén and Mendoza, Argentine Republic. IGRM, SEGEMAR. Geochemical Technical Contributions Series 50/D. Buenos Aires.

- FERPOZZI L., TUREL A., VARGAS D., BUTRÓN ASCONA F., JARA A., SIEHANKIEWICZ D. and CASA A., 2001b. Multielement Geochemical Data and Location of Stream Sediment Sampling Sites from the Cordilleran Plans and Drillings. Sheet 3769-III Chos Malal. Provinces of Neuquén and Mendoza. Argentinian republic. Technical Contributions Series; Geochemistry 54.

Argentine Mining Geological Service. Institute of geology and mineral resources.
Buenos Aires.

- FERPOZZI L., TUREL A., VARGAS D., BUTRÓN ASCONA F., JARA A., SIEHANKIEWICZ D., CASA A., 2001c. Cu, Pb and Zn Geochemical Data and Location of Stream Sediment Sampling Sites from the Cordilleran Plans and Drillings, Sheet 3769-III Chos Malal, Provinces of Neuquén and Mendoza. Argentinian republic. Technical Contributions Series; Geochemistry 53.

Argentine Mining Geological Service. Institute of geology and mineral resources.
Buenos Aires.

- FERPOZZI L., TUREL A., VARGAS D., BUTRÓN ASCONA F., JARA A., SIEHANKIEWICZ D., CASA A., 2001d. Cu, Pb and Zn Geochemical Data and Location of Stream Sediment Sampling Sites from the Cordilleran Plans and Drillings, Sheet 3769-I Barrancas, Provinces of Neuquén and Mendoza. Argentinian republic. Technical Contributions Series; Geochemistry 49.

Argentine Mining Geological Service. Institute of geology and mineral resources.
Buenos Aires.

-FRANCHINI , MB , DE NEIGHBORHOOD , RE , RIVERS , FJ , SCHALAMUK , IB , LANFRANCHINI , M. , PONS , MJ2 Petrology, mineral chemistry and paragenesis of the Indian Iron deposit, Mendoza. Guides to the exploration of Faith. In Cabaleri N.,Cingolani , CA, Linares, E., Lopez de Luchi,MG ., Oyster AND and Panarello, HO(eds.) 15th Argentine Geological Congress, Proceedings 2: 303-310.

- METALOGENIC STRIPES OF THE CENTRAL ANDES: key targets for mining exploration - Directorate of Studies and public policies - Chilean Copper Commission - DEPP 05/2016.

- GALARZA, BJ, ZAMORA VALCARCE, G., FOLGUERA, A. and BOTTESI, GL, 2009. Geology and tectonic evolution of the mountain front at 36º30'S: Yihuin-Huaca and Puntilla de Huincán blocks. Mendoza. Association Magazine
Geologic Argentina, 65 (1): 171-191.

-ARGENTINE GEOLOGY -Undersecretariat of Mining of the Nation Argentine Mining Geological Service Institute of Geology and Mineral Resources - Buenos Aires – 1999.

- GIAMBIAGI L., MESCUA J., BECHIS. F., TASSARA A. y HOKE, G., 2012. Thrust belts of the southern Central Andes: Alongstrike variations in shortening, topography, crustal geometry, and denudation. Geological Society of America Bulletin 124 (7-8): 1339-1351.

- GIAMBIAGI L., MESCUA J., BECHIS F., HOKE G., SURIANO J., SPAGNOTTO S., MOREIRAS SM, LOSSADA A., MAZZITELLI M., TOURAL DAPOZA R., FOLGUERA A., MARDONEZ D. and PAGANO DS, 2016. Cenozoic Orogenic Evolution of the Southern Central Andes (32o-36o S). In: A. Folguera *et al.* (eds.), Growth of the Southern Andes, Springer Earth System Sciences: 63-99.

- GILLESPIE A.R., 1985. Lithologic mapping of silicate rocks using TIMS, The TIMS Data User's Workshop, JPL Pub. 86-38, pp. 29-44.

- GIUSIANO A., FRANCHINI M., IMPICCIN, A. and O'LEARY S., 2006. Cu mineralization associated with bitumen in Cretaceous sandstones, Barda González prospect, Neuquén, Argentina. XI Chilean Geological Congress, Actas 2: 255-258.

- GIUSIANO A., FRANCHINI MB, IMPICCINI A. and PONS MJ, 2008. Cu mineralization in Mesozoic sedimentites of the Neuquén Group and hydrocarbon habitat in the Huincul Ridge, Neuquén. XVII Argentine Geological Congress, Actas 2: 769-770. San Salvador de Jujuy.

- GONZALEZ DÍAZ E. (1972). Geological description of Sheet 30d, Payún Matrú. Province of Mendoza. SEM, National Directorate of Geology and Mining, Bulletin 130. Buenos Aires.

- GUSTARSONL, B., 1978, Some major factors of porphyry copper genesis: ECONOMIC GEOLOGY, v. 73, p. 600-607.

- GUSTAFSONL, B., AND HUNT, J.P., 1975, The porphyry copper deposit at El Salvador,Chile: ECONOMIC GEOLOGY, v. 70, p. 875-912.

- HEDENQUIST J.W., AND SHINOHARA, H., 1997, K-silicate to sericite-stage transition in porphyry Cu deposits: Collapse of magmatic plume, or overprint by meteoric water? [abs.]: Geological Society of America, Abstracts with Programs, v. 29, A-359.

- LITVAK VD, POMA S., JONES RE, FERNANDEZ PAZ L., IANELLI SB, SPAGNUOLO M., KIRSTEIN LA, FOLGUERA A. and RAMOS VA, 37o S).

En: Folguera *et al.* (eds.) The Evolution of the Chilean-Argentinean Andes. Springer Earth System Sciences: 503-536.

-LLAMBÍAS, EJ, 2003. Geology of igneous bodies. Argentine Geological Association, Series B, Didactic and Complementary No. 27, Higher Institute of Geological Correlation, Geological Correlation Series 15: 182 pp., Buenos Aires.

- LLAMBÍAS EJ, BERTOTTO GW, RISSO C. and HERNANDO I., 2010. Quaternary volcanism in the Payenia backarc: a review. Magazine of the Argentine Geological Association 67(2): 278-300.

- MALLIMACCI H., CARPIO F. and RUBINSTEIN N. (2010). Mining Letter Metallogenetics 3769-II Hidden Water. Provinces of Mendoza and La Pampa.
Institute of Geology and Mineral Resources, Argentine Mining Geological Service.
Bulletin 387, 57 p. Buenos Aires.

- MARCHANT FATHER N. (2014). NI 43-101 Technical Report on the Yellow Hill Project, Mendoza Province, Argentina. Meryllion Resources Co. 188 p. http://meryllionresources.com.

- MENDEZ V., ZANETTINI JC and ZAPPETTINI EO (1995). Geology and Metallogenesis of the Central Andean Orogen. National Geological Survey Directorate, Annals 23: 190 pp. Buenos Aires.

- WOLF MUGAS AC, MARQUEZ-ZAVALIA MF, GALLISKI MA and WÄLLE M.
(2018). The Permian-Triassic low sulfidation epithermal Au deposit of Don Sixto, Mendoza. Magazine of the Argentine Geological Association 75 (3): 441-456.

- UNITED NATIONS (1970). Research on porphyry copper ore in the Provinces of Mendoza, Neuquén and San Juan, Argentina. NY.

- NARCISO V., SANTAMARÍA G. and ZANETTINI J. (2001). Geological Sheet 3769-I, Barrancas. Provinces of Mendoza and Neuquén. Institute of Geology and Mineral Resources, Argentine Mining Geological Service. Bulletin 253. Buenos Aires.

- NULLO FE, STEPHENS G., COMBINA A., DIMIERI L., BALDAUF P., BOUZA P. and ZANETTINI JCM (2005). Geological Sheet 3569-III/IV, Malargüe, Mendoza province, Argentine Geological Mining Service. Institute of Geology and Mineral Resources. Bulletin 346, 85p. Buenos Aires.

-PEREZ, DJ; AZCURRA, D.; D ÿODORICO, P.; SEQUEIRA, N. “Mapping of hydrothermal alteration with ASTER data, in the La Coipa region, Cordillera Frontal (31°45 ÿS), San Juan Province, Argentina”. Brazilian Remote Sensing Symposium, Florianópolis. 21-26 April 2007.

- RABBIA OM, HERNÁNDEZ LB, TOWNLEY B, KING RW, AYERS JC (2003)
Anatase-b earing veins in the El Teniente Cu-Mo porphyry system. Special Symposium on Supergiant Andean Porphyry Copper Deposits. 10° Congreso
Chilean Geological. October 6-10, Conception.

-RANJBAR, H.; HONARMAND, M.; MOEZIFAR, Z. "Application of the Crosta technique for porphyry copper alteration mapping, using ETM+ data in the southern part of the Iranian volcanic sedimentary belt". Journal of Asian Earth Sciences. 2003.

-MINERAL RESOURCES OF THE ARGENTINE REPUBLIC – Volume 1 and 2 – Undersecretariat of Mining of the Nation-Argentine Mining Geological Service – Institute of Geology and Mineral Resources – Bs. As. 1999.

- SARUDIANSKI R. and DEL CARRIL FC (1984). The barite and celestine deposits of the Province of Mendoza. IX Argentine Geological Congress, Minutes V: 452-472. San Carlos de Bariloche.

- SEGEMAR, 1995. National Program of Geological and Thematic Charts of the Argentine Republic. Regulations for Mining-Metallogenetic charts of the Argentine Republic. 92 pp. Buenos Aires.

- SEGEMAR, 1997. Magnetic survey of the Cordillera Principal area, province of Mendoza.

- SEGEMAR, 1998. Magnetic and gamma spectrometric survey of the San Rafael area, provinces of Mendoza and La Pampa.

-SEGEMAR - Geological Sheet 3569-III/3572-IV Malargüe - Francisco E. Nullo, George Stephens, Ana Combina, Luis Dimieri, Paul Baldauf and Paul Bouza –

- SEPÚLVEDA E., BERMÚDEZ A., BORDONARO O. and DELPINO D., 2007. Geological Sheet 3569 IV El Nihuil Reservoir, province of Mendoza. Institute of Geology and Natural Resources, Argentine Mining Geological Service, Bulletin 2689: 52pp., Buenos Aires.

- SIGISMONDI ME, 2015. Study of the geodynamics of the Neuquén Basin from geophysical observations. In: SA Casadío *et al.* (eds.) Geology of the Neuquén Basin and its petroleum systems: an integrative view from the outcrops to the subsoil. CABA, YPF Foundation; Viedma, National University of Río Negro. pp: 36-47.

- SILLITOE, R.H., 1993, Gold-rich porphyry copper deposits: Geological model and exploration implications, in Kirkham, R.V., Sinclair, W.D., Thorpe, R.I., and Duke, J.M., eds., Mineral deposit modeling: Geological Association of Canada, Special Paper 40, p. 465-478.

- SILLITOE, R.H., 1994, Erosion and collapse of volcanoes: Causes of telescoping in intrusion-centered ore deposits: Geology, v. 22, p. 945-948.

-SILLITOE, R.H., 1995, Exploration of porphyry copper lithocaps, in Mauk, J.L., and St. George, J.D., eds., Proceedings Pan American Conference on Research
on Fluid Inclusions Congress 1995: Australasian Institute of Mining and Metallurgy, Publication Series No. 9/95, p. 527-532.

- SILLITOE, R.H., AND HEDENQUIST, J.W., 2003, Linkages between volcanotectonic settings, ore-fluid compositions, and epithermal precious metal deposits, in Simmons, S.F., and Graham, I.,eds., Volcanic, geothermal, and ore-forming fluids: Rulers and witnesses of processes within the Earth: Society of Economic Geologists Special Publication 10, p. 315–343.

- SILLITOE, R.H. y PERELLÓ, J., 2005, Andean copper province: Tectonomagmatic settings, deposit types, metallogeny, exploration, and
discovery. Economic Geology 100th Anniversary Volume, p. 845–890.

- MINING GEOENVIRONMENTAL INFORMATION SYSTEM (SIGAM) (2018). Mineral deposits database. Argentine Mining Geological Service. Buenos Aires. https://sigam.segemar.gov.ar/.

- SPAGNUOLO M.G., FOLGUERA A., LITVAK V., ROJAS VERA E.A. y RAMOS V.A., 2012a. Late Cretaceous arc rocks in the Andean retroarc region at 36.5ºS: Evidence supporting a Late Cretaceous slab shallowing. Journal of South American Earth Sciences, 38: 44-56.

- SPAGNUOLO, MG, LITVAK, VD, FOLGUERA, A., BOTTESI, G. and RAMOS, VA, 2012b. Neogene magmatic expansion and mountain building processes in the southern Central Andes, 36-37oS, Argentina. Journal of Geodynamics, 53: 81-81.
94.

- SRUOGA P., ETCHEVERRIA M., FOLGUERA A. and REPOL D., 2005. Geological Sheet 3569 I Maipo Volcano, Mendoza Province. Institute of Geology and Natural Resources, Argentine Mining Geological Service, Bulletin 290: 116 pp., Buenos Aires.

- SRUOGA P., RUBINSTEIN NA, ETCHEVERRIA MP and BLIND M.
Neogene volcanism and associated mineralization, Cordillera Principal, Mendoza (35ºS). Proceedings of the 12th Geological Congress of Chile: p 4. Santiago de Chile.

-VANESA ARAUJO, 2013- Doctoral Thesis. Location of Cenozoic igneous bodies in the mountain front of the Cordillera Principal: mechanisms and spatial-temporal relationship with Andean tectonic structures. NATIONAL UNIVERSITY OF THE SOUTH.

- VIVALLO WP, ZANETTINIJ.CM, GARDEWEG, MC, MARQUEZ MJ, TASSARA AH AND GONZALEZ RA (1999). Map of mineral resources of the Argentine-Chilean border area between 34o and 56oS. National Geology and Mining Service, Multinational Geological Publication, No. 1, 62 p., 1 scale map

1:1000000 on 2 sheets. Santiago de Chile.

- ZANETTINI JC AND CAROTTI M. (1993). Metalliferous deposits and metallogenesis. In: VA Ramos (ed.), Geology and natural resources of Mendoza, Report of the XII Argentine Geological Congress and II Hydrocarbon Exploration Congress, Proceedings IV (1): 485-504. Mendoza.

- ZAPPETTINI, EO, 1999a. Geotectonic evolution and metallogenesis of Argentina. In: Mineral Resources of the Argentine Republic (Ed. EO Zappettini), Institute of Geology and Mineral Resources SEGEMAR, Anales 35: 51-73, Buenos Aires.

- ZAPPETTINI EO, CROSTA S., RUBINSTEIN N. and SEGAL, S., 2015. Review of mineralization models associated with rifting; Metallogenetic implications related to Mesozoic rifting in Argentina. Argentine Mining Geological Service, Buenos Aires.

- ZAPPETTINI EO, RUBINSTEIN N., CROSTA S. y SEGAL SJ, 2017. Intracontinental rift-related deposits: A review of key models. Ore Geology Reviews 89: 594-608.

Potential in Malargüe Distrito Minero Occidental (Malargüe Western Mining District)