DIRECTION OF MINERAL AND ENERGY RESOURCES

"Potential Evaluation of the Mineral Deposits in the Western Cordillera of the Ancash Region"

The Pierina deposit.

METALLOGENY AREA REPORT

Prepared by:

Humberto CHIRIF RIVERA

Metallogenic Team

Raymond RIVERA CORNEJO
Alexander SANTISTEBAN ANGELDONIS
Eder VILLARREAL JARAMILLO

Lima – Peru

November, 2008

INDEX

ABSTRACT

The Geological survey of Peru (INGEMMET) in agreement with Geological survey of Korea (KIGAM) carried out the study to evaluate mining potential in the Ancash region. The area is located between: 9º00'-10º30' South Latitude and 77º00'-78º00' West Longitude.

Three field trips were realized where 9 mineral deposits and 4 prospects were recognized: Pierina, Pachapaqui, Huinac, Santo Toribio, Pashpap, Antamina, Pucarrajo, Contonga and Huanzala (mines); Cajabamba, Ocros, Tuco Chira and Aija Ticapampa (prospects). During the field work geologic structures, lithology units, hydrothermal alterations were recognized. A total of 136 samples of hosted rocks and ore were collected for microscopy studies and geochemical analysis.

There are 2 main sedimentary basins in the study are: Casma (west) and Santa (east) basin, that controlled the sedimentation in the study area.

Finally, the mineralization in metallogenic belt was controlled by 5 regional fault system: Tapacocha, Huacllan-Churin, Huaraz- Recuay, Cordillera Blanca Batholith and Chonta.

1. GENERALITIES

1.1. Introduction

The Ancash region is characterized by its intense mining activity and to harbor different types of deposits like Au-Ag epithermal, polymetallic skarns and Cu-W and Cu-Mo porphyries. In this region two of the biggest deposits in the Peruvian territory are located and they are Pierina (Au-Ag epithermal) and the Antamina skarn (Pb, Zn, Cu). There are also different projects with median and great mining such mines as Contonga mine (Ag, Pb, Zn); Pucarrajo (Pb, Zn); Huanzalá (Pb, Zn); Pachapaqui (Pb, Zn,) and the project San Luis (Au, Ag); Jacabamba (MB); Shulus (Au, Ag), etc.

The study was carried out with the purpose of evaluating the potential of the mineral deposits distributed in Ancash region between of scientific cooperation of KIGAM (Institute of Geosciences and Mineral Resources of Korea) with INGEMMET (Institute Geologic Miner and Metallurgist of Peru).

The area is located in the northwest of the peruvian territory and it have 6 National Geologic Sheets (Carhuaz 19h, Huari 19i, Huaraz 20h, Recuay 20i, Huayllopampa 21h y Chiquián 21i), to scale 1:250000.

Exist inside the area important geologic structures as Cordillera Blanca Batholith which emplacement has been controlled by the fault of the same name and numerous sub-volcanic stocks associated to Au-Cu mineralization.

But the Ancash region is important also for its tourist potential such as snowy of Cordillera Blanca, the Chavín de Huántar archaeological center, and the numerous lagoons formed in the inferior parts of the glaciers.

1.2. Location and access

The present study is located in the Occidental Cordillera of the Ancash Region; it includes the towns of Carhuaz, Huaylas, Yungay in the north part; Aija, Recuay and ticapampa in the central part, San Marcos, Ocros and Chiquián toward the south part (Figure 1.1).

The geographical coordinates are:

09º 00’ 00” – 10º 30’ 00” LS

77º 00’ 00” – 78º 00’ 00” LW

To access to the interested areas we can go by terrestrial way. There is asphalted ways that they arrive to the Huaraz city (Panamerican highway) and connect to several land ways toward to small villages of the region.

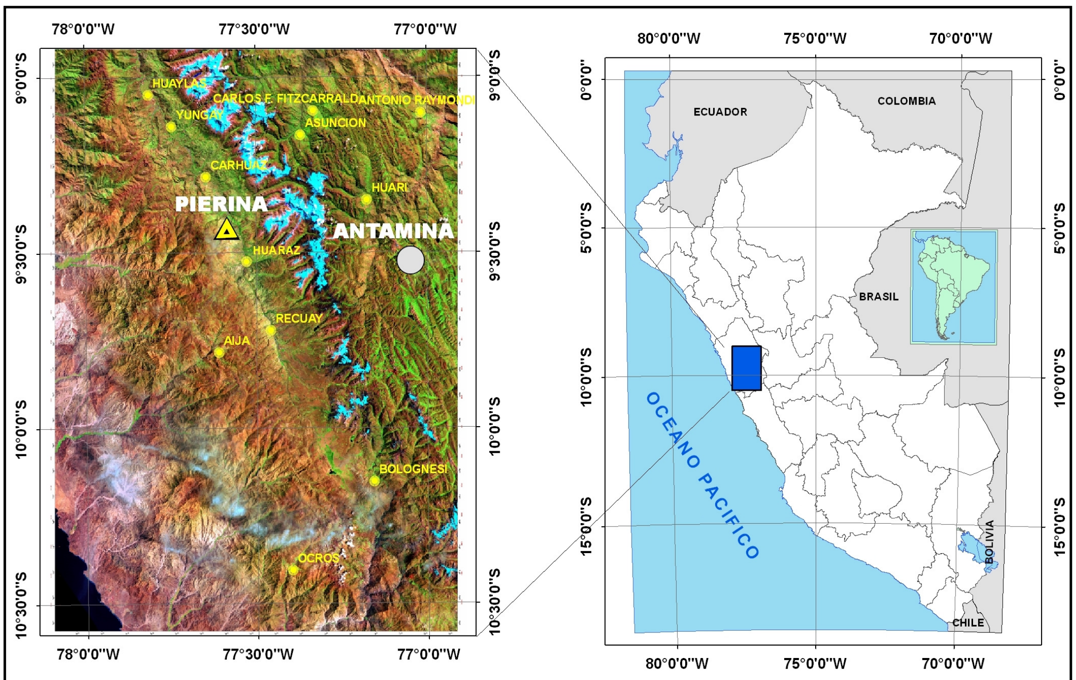


Fig. 1.1 Location of study zone

1.3. Previous studies

Numerous reports and many geologic articles were realized by different mining companies that operate inside the studied area, such as Antamina, Pierina, Pachapaqui, etc.

Among the studies of regional character we can mention that of Atherton et.al. (1979) "The geochemical character of the segmented peruvian coastal batholith and associated volcanics"; Núñez H. (1997) "The bedded deposits (Pb-Zn) hosted in the inferior sequence of the cretaceous Chavín basin (center and north of the Peru) "; Bodenlos, A. (1955) "Lead-zinc deposits of Cordillera Blanca and Northern Cordillera Huayhuash, Peru".

Studies realized by Norman and Landis (1993) based on Sr isotopes define a mantel source of the Cordillera Blanca granite related with the mineralization of Cu-W in Pasto Bueno.

INGEMMET in 2006 realized stream sediment sampling among 9 and 10 south Latitude; determining important anomalies of Au in the area of Pira, and anomalies of metals base along the Cordillera Negra what defines the polymetallic character of this area.

Rivera in 2003 defines a volcanic structure (possible cauldron) in the area of Ocros, which is associated with some anomalies and prospects Cu-Mo.

1.4. Mining Properties

The project has 1'685,400 hectares approximately; 40% has already been occupied by mining companies and the artesian miners. The 35% correspond to the national park of the Huascarán which is restricted to any mining activity.

The chart Nº 01 and the figure 1.2 and 1.3 show the cities with bigger area concession as Huaraz with 21%, Recuay with 14%, Huari, Bolognesi with 13% and Yungay with 10%.

Chart Nº 01.- Mining concessions of the main cities of the Ancash region

Province	Área (Has)
AIJA	24185
ANTONIO RAYMONDI	11430
ASUNCION	3151
BOLOGNESI	78348
CARHUAZ	32964
CARLOS F.FITZCARRALD	5500
CASMA	5261
HUARAZ	130024
HUARI	78477
HUARMEY	40141
HUAYLAS	39088
OCROS	21333
RECUAY	88242
YUNGAY	61298

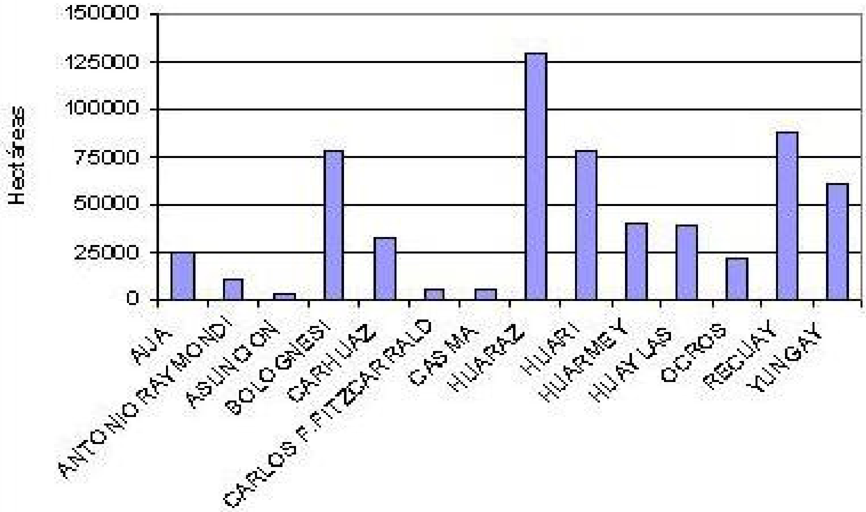


Fig. 1.2 Mining concessions of the main cities of the Ancash.

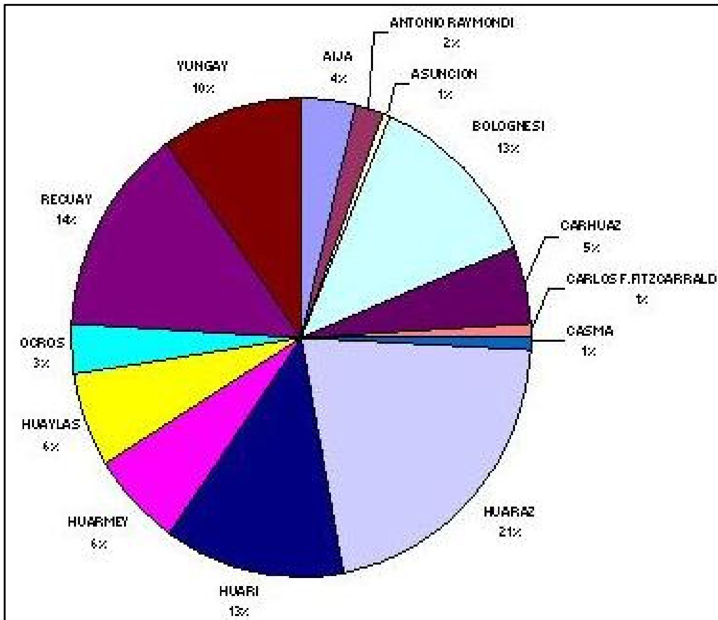


Fig. 1.3 Mining concessions of the main cities.

In the map of mining properties (See appendix) are shown the distribution of the different concessions given by the National Institute of Concessions and Mining Cadastre (INACC).

2. GEOLOGY SETTING

2.1 Introduction

The project area is between regional faults systems with main direction NW-SE which are cut by traverse faults to the Andean system (SW-NE direction). These fault systems have allowed defining tectonic domains that limit the Miocene epithermal Au-Ag belt of the Miocene porphyries Cu-Mo belt. The oldest rocks outcrop in the oriental side and they correspond to metamorphic rocks called The Marañon Complex; it continues an alternation of shale, sandstones and limestones of Paleozoico. The Mesozoic is represented by a potent sedimentary sequence that has like base the gray shales of the Fm. Chicama. Later on in the Lower Cretaceous a silicoclastic sequence called Goyllarisquizga Group. The Cenozoic is represented by volcanic rocks (Calipuy Group and Casma Group) composed by sequences of lavas and piroclastics interbedded with sedimentary horizons and pillow lavas respectively.

Intrusive rocks affected the stratigraphic sequence of the area and they are related to the mineralization processes. They belong to the Upper Cretacic to Paleogene Andean Batholith (Coast Batholith) and to the Cordillera Blanca Batholith (late Miocene).

2.2 Estratigraphy and Magmatic Evolution

Most of the early work on Andean geology concentrated on establishing the continuity along strike of specific features, whether they be Mesozoic palaeotectonic features, stratigraphic units or Andean structural units. It is now possible, however, to recognize discontinuities along strike within the major geologic components. Moreover, the discontinuities established in the Late Jurassic or Neocomian continued to be reflected in the structures generated by the initial phases of the Andean orogeny. The initial segmentation continued to influence the geologic development of the region until at least the Eocene.

The study area is inside the central segment of WPTB (Wilson, 2002) and more exactly in the Santa sub basin. Cobbing et al., 1981 would have named as two basins (Santa and Chavin). Romero (2008) it proposes a jurassic - cretacic basin named Chicama - Goyllarisquisga of very similar dimensions to the basin Santa and that it would be partly the equivalent of the Fm Santa.

2.2.1 Stratigraphy

BENAVIDES (1956) and WILSON (1963) showed that the upper Jurassic-Cretaceous sedimentary sequences of Northern and Central Peru were deposited in contrasting basin/platform areas denominated as the West Peruvian Sedimentary Basin and the Marañon Geanticline (MGA). It is now clear that the basinal sediments were deposited in a series of interconnecting depressions, each of which was characterized by specific facies development. The individual depressions are here named as the Cajamarca, Santa and Churin basins (Fig. 2.1).

The characteristic stratigraphy of the individual areas is summarized in Figs. 2.1 and 2.2.

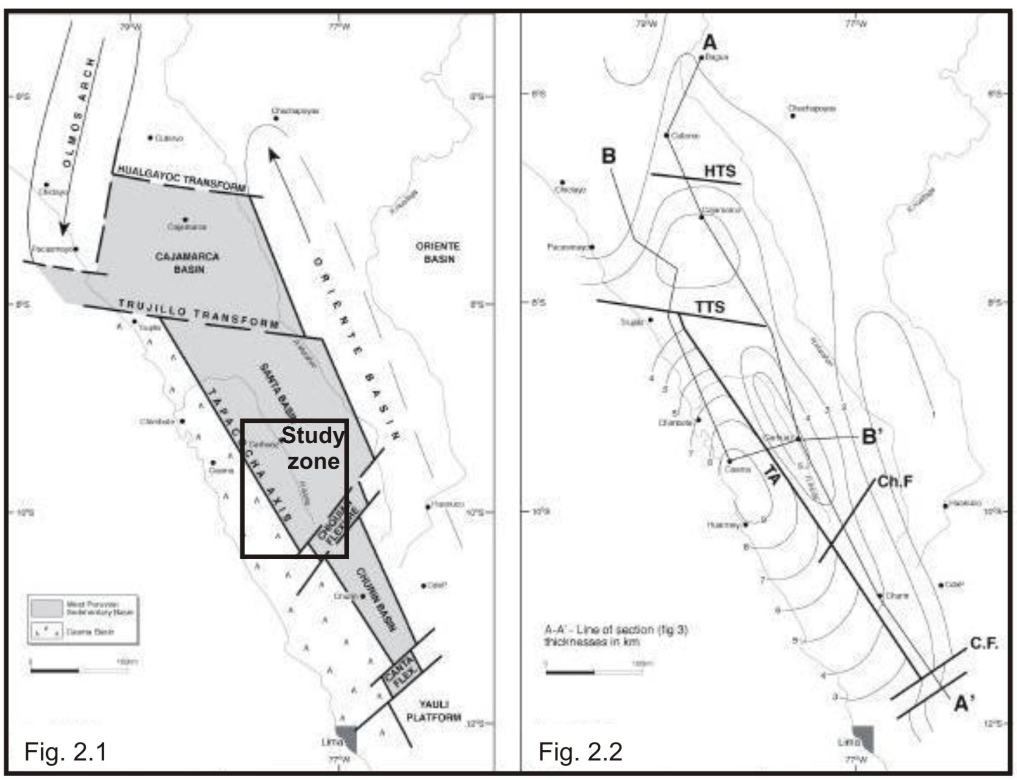


Fig. 2.1 structural development Schematic; Fig. 2.2 Upper Jurassic/ Cretaceous Isopachs (Wilson 2002)

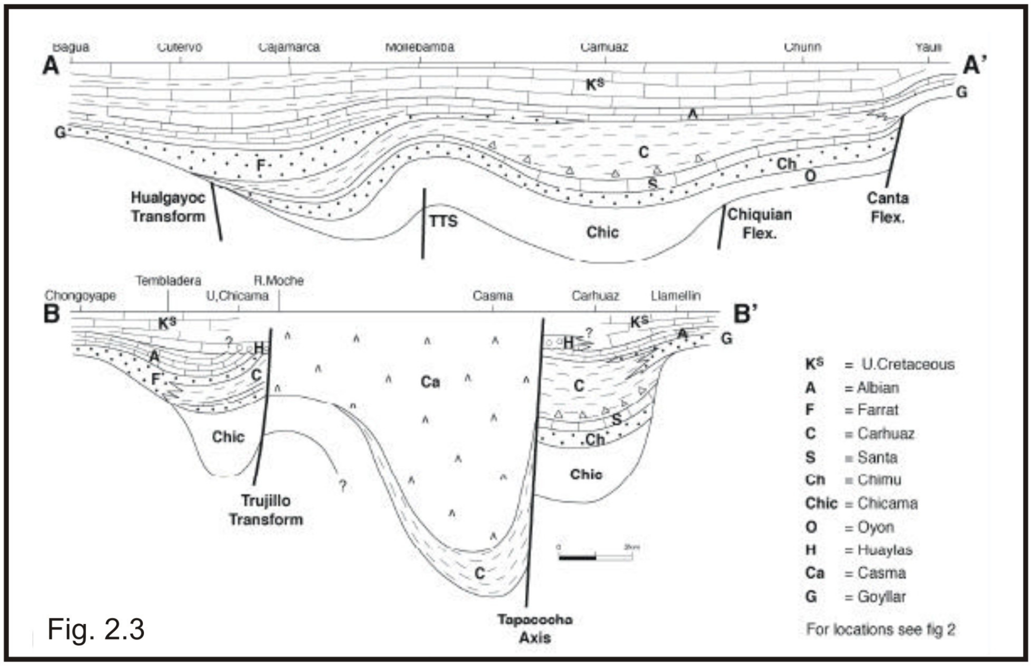


Fig. 2.3 Stratigraphic Cross section (North Peru) (Wilson, 2002)

MYERS (1974) subsequently identified the Tapacocha Axis as the boundary between the mainly sedimentary sequence to the east and the predominantly volcanic units to the west, which accumulated in the Casma basin (ATHERTON et al., 1983; ATHERTON et al., 1985). Finally, COBBING et al. (1981) recognised the NNE trending Olmos Arch as constituting the western limit of the sedimentary basin in northern Peru.

A) West Peruvian Sedimentary Basin (WPSB)

The WPSB was originally perceived by BENAVIDES (1956) and WILSON (1963) as a single NW-SE depression filled with U.Jurassic-Cretaceous sediments which showed changes in thickness and facies along the basin. It is now clear that the basin comprised a number of segments each with their own characteristic stratigraphy and here named the Cajamarca, Santa and Churin basins. The individual depressions are postulated to have been separated by major palaeotectonic features. While WILSON (1963) postulated that the NE limit of the basin was an essentially straight and continuous feature (West Peruvian Hinge Line), it now appears that the hinge itself was also probably segmented.

The situation is represented schematically in Fig. 2.1, which is based on the following considerations:

a) The Western Cordillera Fold Belt (WCFB) represents a dramatic NE-SW shortening which, though difficult to quantify, probably amounted to some tens of kms.

b) While there was compression from the SW, much of the shortening was the result of underthrusting from the NE.

c) It follows that the WPSB originally extended some distance beyond the present outcrop of basinal sediments.

d) It is assumed that the greater the amount of tectonic shortening, the more the basinal sediments originally extended beyond their present outcrop.

e) As the greatest apparent shortening occurred in the Santa Basin area, it is postulated that the contrast between original and current extent of basinal sediments was greatest there.

f) The effect is further heightened by the fact that the current outcrop of basinal sediments bulges NE in the area of greatest tectonic shortening.

A.1) Cajamarca Basin

The basin is bounded to the E and W respectively by the Marañon Geanticline (MGA) and the Olmos Arch (OA). The northern boundary is placed where the basinal Cretaceous wedges out along an approximately ESE trend

here named the Hualgayoc Transform System (HTS). The southern limit lies near 8o S at a feature here denominated as the Trujillo Transform System (TTS), which coincides with important stratigraphic

changes, as follows:

i) The Chimu Fm is thicker in the Cajamarca than in the Santa Basin.

ii) The Santa Fm is represented in the Cajamarca Basin by shales. it occurs mainly in a marine limestone facies.

iii) While the Carhuaz/Farrat Fms have a similar combined thickness in the Cajamarca and Santa basins, the Farrat quartzites undergo a dramatic thinning over the TTS. Thus while the Farrat Fm averages 500m in the Cajamarca Basin, it is only about 50m thick even in the northern part of the Santa basin.

iv) The ferruginous sands and shales of the Inca Fm are restricted to the Cajamarca basin and are abruptly replaced south of 8 S by the shelf carbonates of the Pariahuanca Fm.

v) While the Chulec/Pariatambo Fms are essentially uniform throughout the WPSB, the U. Cretaceous of the Cajamarca Basin is distinctive, consisting of 1500m of well differentiated limestones, marls, shales and calcareous sandstones. These are replaced abruptly at about 8 S by the Jumasha Fm, consisting of less than 1000m of clean limestones and dolomites.

vi) In the present coastal region the sedimentary sequence of the Cajamarca Basin is abruptly juxtaposed across the TTS with the largely volcanic assemblage of the Casma basin.

The Cajamarca Basin thus constituted a distinct palaeotectonic and stratigraphic entity in the Cretaceous, the separation from the rest of WPSB being brought about by apparently positive movements associated with the TTS.

A.2) Santa Basin

The Santa Basin as here defined includes both the Santa and Chavin Basins of COBBING et al. (1981). The characteristics of the basin can be appreciated by reference to Figs. 2.1, 2.2 and 2.3 which show it to contain the thickest Tithonian-Cretaceous sequence in the WPSB.It is bounded to the SW by the Tapacocha Axis, recognized by MYERS (1974) as the limit between the volcanic and sedimentary Cretaceous sequences (Fig. 2.3). The basin is limited to the NE by the MGA, and for the reasons stated above is believed to have extended beyond the present limit of the basinal facies. The northern and southern limits of the Santa Basin are formed respectively by the (Trujillo Transform System (TTS) and the Chiquian Flexure at 10o-10o 30’ S. The stratigraphic changes marking the TTS have already been mentioned. The main effect of the Chiquian Flexure was probably the sudden southward narrowing of the WPSB and the simultaneous reduction in thickness of the sedimentary infill.

A.3) Casma Basin

WILSON (1963) established that the thick volcanic sequence along the coast north of Lima was at least partly of Albian age. Cossio and Jaen (1967) mapped correlative volcanics south of Trujillo. MYERS (1974) named the sequence the Casma Group, confirmed its general Albian age and suggested that it had accumulated in a down faulted basin bounded on the east by the Tapacocha Axis (Fig.1). ATHERTON et al. (1983, 1985) went on to propose that the volcanics had accumulated ina marginal basin associated with extreme crustal thinning, and linked to the presence in the immediate offshore area of a shallow body of high density material recognized by JONES (1981). This high-density material has not been found north of Trujillo, but extends along the offshore area to the latitude of Ica (WILSON, 1985). It is therefore suggested hat the Casma Basin was initiated in the Tithonian as a back-arc basin, but which by mid-Albian had evolved into a marginal basin, possibly even with the generation of oceanic crust in some areas. The marginal basin, along with its volcanics and associated crustal thinning or pull-apart, was terminated by the Trujillo Transform.

The infill of the Casma Basin generally begins with Tithonian sediments and intercalated volcanics as seen south of Trujillo (COSSIO AND JAEN, 1967) and in the Lima area (VELA, 1997). In the central sector lower Cretaceous shales, siltstones, cherts and quartzites occur (SANCHEZ, 1995), reaching a total thickness of about 2000 m and representing the distal equivalents of the units of the WPSB.

Major volcanism was initiated in the Middle Albian with a dramatic outpouring of pillow lavas and associated breccias and tuffs of basaltic and andesitic compositions. The volcanics reached a maximum thickness of 6- 9 km in the Chimbote-Huarmey area (ATHERTON et al., 1985) but thin and have more terrestrial affinities to the east (COBBING et al., 1981). The late Albian-Cenomanian Mochica orogeny (MEGARD, 1984) was sufficiently intensive within the basin that in some areas units as old as Tithonian were exposed and subsequently covered by late stage volcanics of the Casma Gp. (COSSIO AND JAEN, 1967).

B) Structure and Stratigraphy of the Chicama – Goyllarisquizga Basin

The termed deposits Chicama Group (Middle-Upper Jurassic) and Goyllarisquizga Group (Berriasian-Aptian), define the termed Jurassic-Cretaceous Chicama-Goyllarisquizga basin in central and southern Peru. This basin is part of the Western Cordillera and to be more precise corresponds to the Cordillera Negra and Blanca. In the north the basin surrounds the Pallasca, Corongo and Huaylas areas, central the

Huaraz, Recuay and Aija areas (study zone), and south the Cajatambo, Oyon and Churin areas. The basin basement has not been possible determinate. However, in the Aija and Churin area, along the anticline core has been observed ignimbrites intercalated with volcanic breccias, probably corresponding to the Oyotun Formation of Lower Jurassic age.

In the central-northern Peru (8° 30' a 10° 30'), we divided the zone in three stratigraphic basins (Figure 2.4): of the west to east 1)The Cretaceous volcano-sedimentary Casma basin (KVSCB), 2) the Jurassic-Cretaceous Chicama-Goyllarisquizga basin, and 3) the Permian-Triassic Mitu-Pucara basin.

The Jurassic-Cretaceous Chicama-Goyllarisquizga basin to the west is limited with the volcano-sedimentary basin by the Tapacocha fault system (TFS) and to the east is limited with the Permian-Triassic Mitu-Pucara basin by the Chonta fault systems (CHFS) (Fig. 2.4).

The Jurassic-Cretaceous Chicama-Goyllarisquizga basin is characterized by ignimbrites and volcanic breccias of the Oyotun Formation (Lower Jurassic), sandstone sequences intercalated with mudstone to the top and bottom of the Chicama Formation (Middle Upper Jurassic). Those follow by the deposits of the Goyllarisquizga Group (Berriasian-Aptian) characterized by sandstones intercalated with mudstones and limestones, changing to quartz rich sandstones of the Chimú Formation, limestones with mudstones of the Santa Formation, developing to quartz rich sandstones, grauwacas intercalated with gray-red-green mudstones of the Carhuaz Formation, ending in white quartz rich sandstones of the Farrat Formation. Finally, we observe the carbonate sequence (Albian-Campanian) characterize by the Parihuanca, Chúlec, Pariatambo, Jumasha and Celendín units.

The Cretaceous volcano-sedimentary Casma basin is localized to the west of the study area and the boundary with the Chicama-Goyllarisquizga basin correspond to the Tapacocha fault system (Fig. 2.4). This basin is characterized by mudstones intercalated with chert, ignimbrites and limestones of the Cochapunta Formation (Albian-Cenomanian).

The Permian-Triassic Mitu-Pucara basin is limited to the west with the Chicama-Goyllarisquizga basin by the Chonta fault (Fig. 2.4). In this basin the Paleozoic-Precámbriam basement overlap with unconformity the sandstones and conglomerates, red mudstones intercalation of Mitu Group (Upper Permic-Middle Triassic), limestones of Pucara Group (Upper Triassic-Lower Jurassic) on the top of this deposits and with erosional angular unconformity are the red mudstones and sandstones intercalations that developed from white quartz rich sandstones to conglomerates of the Goyllarisquizga Formation (Berrisian-Aptian?) and to the end we observe limestones sequences of the Chulec-Pariatambo Formation (Albian).

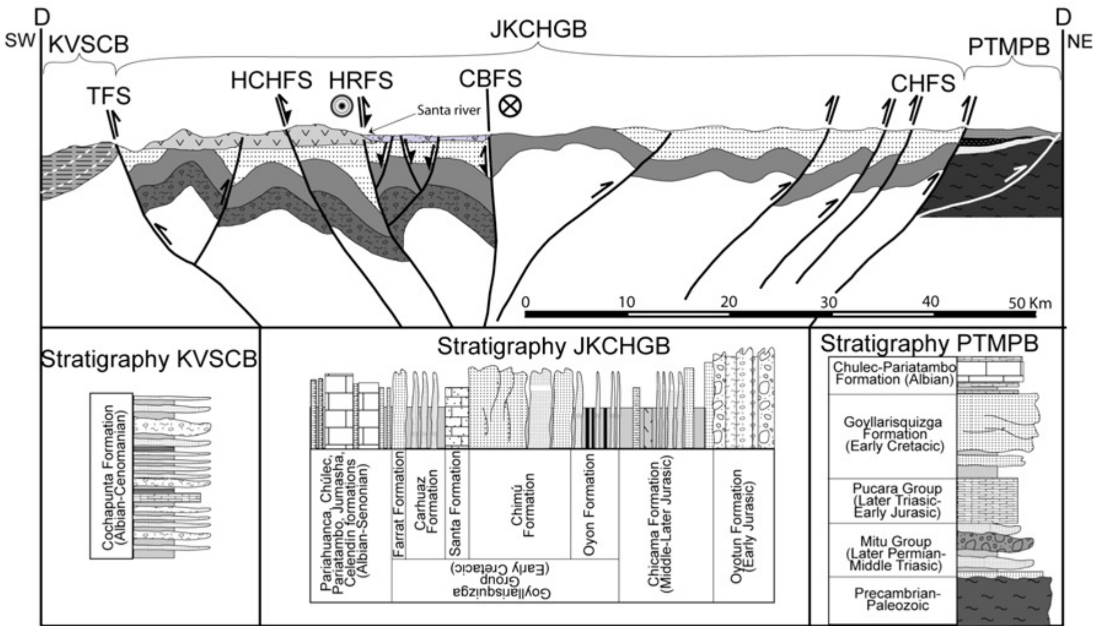


Fig. 2.4. Structural section D-D', showing the three Stratigraphic basins. Reference Fig. 2.7 (Romero, 2008)

2.2.2 Magmatic Evolution

The magmatism in the study zone is not very understand, exist a migration of west to east. We will analyze the plutonism and the volcanism trying to see the relationships that can have both.

A) Plutonism

The abundance of the plutonic rocks constitutes one of the essential characteristics of the chain of the Andes. The rocks cover a great composition range, presenting from leucogranite until gabbros. Almost the entirety of the Andean plutonism, corresponds to a calc-alkaline series. The main characteristic and the most spectacular in the Andean plutonism in the study area are the great Andean Batholith (Coast Batholith) that border the Pacific coast of south to north Peru and the Cordillera Blanca Batholith that border the oriental flank of the river Santa.

A.1) Coast Batholith

This forms an enormous outcrop parallely elongated to the Pacific coast, it has a long of 1600 km and a width from 50 to 80 Km. In the two ends extreme this batholith finishes with small individual stocks series. The nature of the rocks is varied, they go from gabbros to potassic granites. The surface occupied by the basic rocks is bigger than that of the true granites (Cobbing and Pitcher, 1972), the most frequent are the tonalite rocks.

Gabbro y diorite :15.9%

Tonalite : 57.9%

monzogranite : 25.6%

Granite :0.6%

The geometry of the intrusive rocks that constitute the Andean batholith has been emplacement in a regular order that goes from the most basic to the acidic rock. The order of location of the different intrusive rocks influences on its geometry. (Megard, 1973). The most basic lands (gabbros and diorite) form massive rocks without defined form, where the outcrop surface doesn't surpass the 100 square Kms. The tonalite, granodiorite rocks and certain monzogranitos rocks form massive body that can have 100 km long and 10 to 20 Km wide, elongated parallely to the batholith. The contact with the regional rock is vertical.

The rest of the monzogranite and granites rocks form annul structure (Cobbing and Pitcher, 1972). Cartographically they are arched, frequently concentric intrusions that clip their regional rocks vertically. (ring dykes)

The coast batholith (central segment) it was divided in several units and the geochronology of events it was the following:

Unit	Composition	Age (Ma)

Patap	Gabbro	95-105
Paccho	Diorite – Tonalite	93
Santa Rosa	Diorite. tonalite-granodiorite-monzogranite	93 – 84
La mina	Tonalite	66
Puscao	Granodiorite - Monzogranite	65 – 61
San Jerónimo	Monzogranite	65 - 61
Pativilca Sayán	Monzogranite porphyry	34

it has not still been possible to establish the cause the jump among 61 to 34 Ma, is possible corresponds to an interruption in the emission of the magmas or to lack in the taking of samples.

The mineralogical characteristics indicate a location of high temperature. The mineralogical characteristics indicate the ownership from these rocks to a calc-alkaline series.

A.2) Cordillera Blanca Batholith

The Cordillera Blanca Batholith is a mainly Mid- Late Miocene complex about 200 km in length and lying completely within the Santa Basin of the WPSB. It is limited to the north by the TTS, while its southern limit coincides approximately with the Chiquian Flexure (Fig. 2.1). Although there is a long time gap between the earlier structures and the emplacement of the batholith, the spatial relationships are very close. The Cordillera Blanca Batholith is located close to the area of maximum deposition/maximum crustal thinning in the WPSB, and also coincides with the area of greatest underthrusting and shortening in the WCFB. Although Petford et al., (1996) argue on compositional grounds that the Cordillera Blanca Batholith does not show crustal contamination, it seems possible that the location of the batholith is related in some way to the paleotectonic features with which it is spatially associated.

The main type of rock of the south part of Cordillera Blanca batholith are leucogranite that denominated Cojup granodiorite. They also observed a marginal contamination to Tonalite and diorite and the presence of a small late stock of granodiorite. The cahuish Stocks in the south extreme of the study zone are granodiorite + horblende and it is different to the granodiorite + biotite of the main body. Dikes and small stocks of quartz porphyry cut to the main granodiorite. The pegmatite are more abundant in the marginal areas.

The batholith this located mainly in shale the Chicama Formation (upper Jurassic). The folds in the shale of the Chicama Formation are cut by the intrusive rocks that is clearly post-tectonic (Wilson et al., 1967). The emplacement age seems to be still with little accuracy, existing a range of ages among 13 to 2 Ma with a grouping of 9 Ma. The determinations were made by the K-Ar method, that which would indicate an age of the upper Miocene for the Cordillera Blanca batholith.

A number of stocks lies toward the south along of the batholith and it is very possible that some are related with him. The lithology of the Cordillera Blanca rocks is very characteristic, they are leucocrates rocks and of grain more large that the rocks of the Coast Batholith. Some of these stocks have those characteristics and it is considered that the stocks of Aquia, Llaclla, Cajatambo and Churín are representative of the Cordillera Blanca batholith.

A.3) High Level Stocks

This group of intrusions is generally presented in the south part of the Cordillera Blanca Batholit and in general it is found to altitude over 4000 msnm. This rocks in general are emplacement in areas of cretacic silts, it is observed that some cut the Calipuy Group volcanic sequences. These intrusions are generally presented in form of stocks and also as dikes. The stocks is in general have 4 square Km of area, sometimes until of 10 square Km. One of the features more highlight of these stocks is that they are very similar in hand sample. Exists certain doubt that these stocks are the main responsible for the mineralization in the Western Cordillera, where most of the well-known deposits is related with this type of intrusions.

The location of these stocks was carried out mainly along main faults, in general these stocks are so small and they are located in the area of structural control. It doesn't present space problems as the batholith big.

Some examples of these stocks are those that we have in the area of Ocros – Ticapampa (study zone).

B) Volcanism

The volcanism in the study zone is characterized by two very defined sequences. The differences are related with respect to the origin of the volcanism, geochronology and geochemistry compositions. According to this in our study area have the Casma Group the Calipuy Group.

B.1) Mesozoic Volcanism

the east part of study zone this characterized by the Casma Group, which has been interpreted as a marine volcanism, emplacement in the border of the continent. It is compound essentially for andesite, basalts, dacite intercalate with marine silts. The submarine emplacement is frequently as pillow lavas.

B.2) Cenozoic Volcanism

The central part of the study zone this characterized by the Calipuy Group, which is generally interpreted as a continental volcanism, emplacement in the Cordillera Negra axis. These volcanic rocks were emplacement during effusive and explosive periods and in time range generally wide (Eocene - Miocene). it is believe that the centers of emission of these volcanic rocks are related to structures type caldera (example: Ocros, San Luis, Aija-Ticapampa). it is represented generally for andesite, dacite and riolite rocks.

Independent of the age both volcanism types have a composition geochemistry calc-alkaline, that which relates closely to the subduction area, being lightly more acid toward the continent.

2.3.- Regional Structural Control

The structural control in the study area is very complex. First, We will be speaking of a regional structural control, After to pass to describe some structural elements at local level, which can control the location of the different deposits type.

2.3.1.- Structural Pattern

That Study zone under discussion comprises the following major structural components (Fig. 2.5):

- Casma Province
- Western Cordillera Fold Belt
- Fault Block Province

A) Casma Province (CP)

The CP corresponds to the coastal belt plus the lower slopes of the Western Cordillera southwards from about 8° S and largely comprises the Cretaceous volcanics and underlying sediments of the Casma Basin, unconformably overlain by gently deformed Paleogene volcanics, and intruded by the Coastal Batholith. The CP is bounded to the north by the TTS and to the NE by the Tapacocha Axis. Its westward extension beyond the shoreline is poorly known though it may reach beyond the positive gravity anomaly found at shallow depth from Trujillo to the latitude of Ica .

The Casma Province is mainly characterized by broad open simple folds striking NW-SE. It also contains steeply hading faults, mainly on NW-SE, and associated with locally intense shearing. It has been established (MYERS, 1974; COBBING et al., 1981) that the tectonism which gave rise to the Casma Province occurred in the late Albian-Cenomanian.

The CP is terminated abruptly NW by the TTS (Fig. 5.4). The Cretaceous volcanics do not extend beyond the TTS where a conventional Cajamarca basin sequence is found. There is a similarly abrupt structural change well demonstrated by the mapping of COSSIO AND JAEN (1967), the NW-SE striking structures of the Casma Province being truncated by the TTS, north of which are found the WNW striking structures of the Chimu Andes or Cajamarca deflexion. There is no gradual swing in strike, but rather an abrupt change in stratigraphy, along with structural strike and style.

B) Western Cordillera Fold Belt (WCFB)

The WCFB consists of linear folds and thrusts developed in the U. Jurassic-Cretaceous sediments deposited in the WPSB and on the flank of the MGA. The main characteristics have been described by HARRISON and WILSON (1960), WILSON et al (1967), COBBING (1973), and COBBING et al. (1981) and can be briefly summarised as follows:

a) Deformation in the sediments of the WPSB occurred mainly by decollement in the shales of the Chicama and Oyon Fms.

b) Typical structures are steep sided folds 50-100km in length and commonly bounded by thrust faults.

c) The folds are generally asymmetric to the NE in eastern areas and to the SW in the western sectors.

d) The deformation is most intense along the NE and SW edges of the fold belt. The SW limit is marked by the development of a steep cleavage along the Tapacocha Axis and its extensions. The NE limit is characterized, particurlary in the Sihuas and Chimu sectors, by a dramatic tectonic juxtaposition of basinal and shelf facies indicative of substantial NE-SW shortening and associated with the development of a thin skin imbricate fan system on the flank of the MGA.

e) The deformation occurred in one or more phases of Incaic orogeny, after deposition of the Casapalca red beds and their equivalents.

Sihuas Sector.-

The Sihuas Sector corresponds to that part of the W. Cordillera between approximately 8° - 10° S. It is limited to the north and south by the TTS and the Chiquian Flexure respectively and thus has a distribution similar to that of the Santa Basin.

The particular structural characteristics of the Sihuas Sector can be summarized as follows:

1) The Sihuas Sector is a 80-90 km wide belt of variably deformed sediments, characterized by large NW-SE trending folds 50-100 km in length and cored by commonly contorted Chicama shale

2) The intensity of deformation increases to the NE, where bedding plane thrusts hading SW at 25o – 35o (WILSON et al., 1967) separate sheets of basinal sediments.

3) The NE limit coincides with an imbricate fan system composed of Cretaceous sediments deposited on the flank of the MGA.

4) The SW portion of the Sihuas Sector , near the Tapacocha Axis, is characterized by strong deformation and the development of cleavage.

5) The intermediate area, e.g. along the Santa valley, has less intense deformation.

The amount of shortening across the Sihuas Sector cannot be calculated from the available data, but probably amounts to some tens of kilometers.

B) Fault Block Province (FBP)

The Fault Block Province forms a long, relatively narrow belt striking NW-SE (Fig. 2.5) and characterized by commonly large vertical displacements along high angle reversed basement faults (WILSON et al., 1967). The faulting is younger than the movements which gave rise to the WCFB as it affects the thin skinned thrusts of the WCFB in some areas.

The axis of the FBP lies beyond the NE boundary of the WCFB, though the boundaries of the FBP itself can be difficult to define.

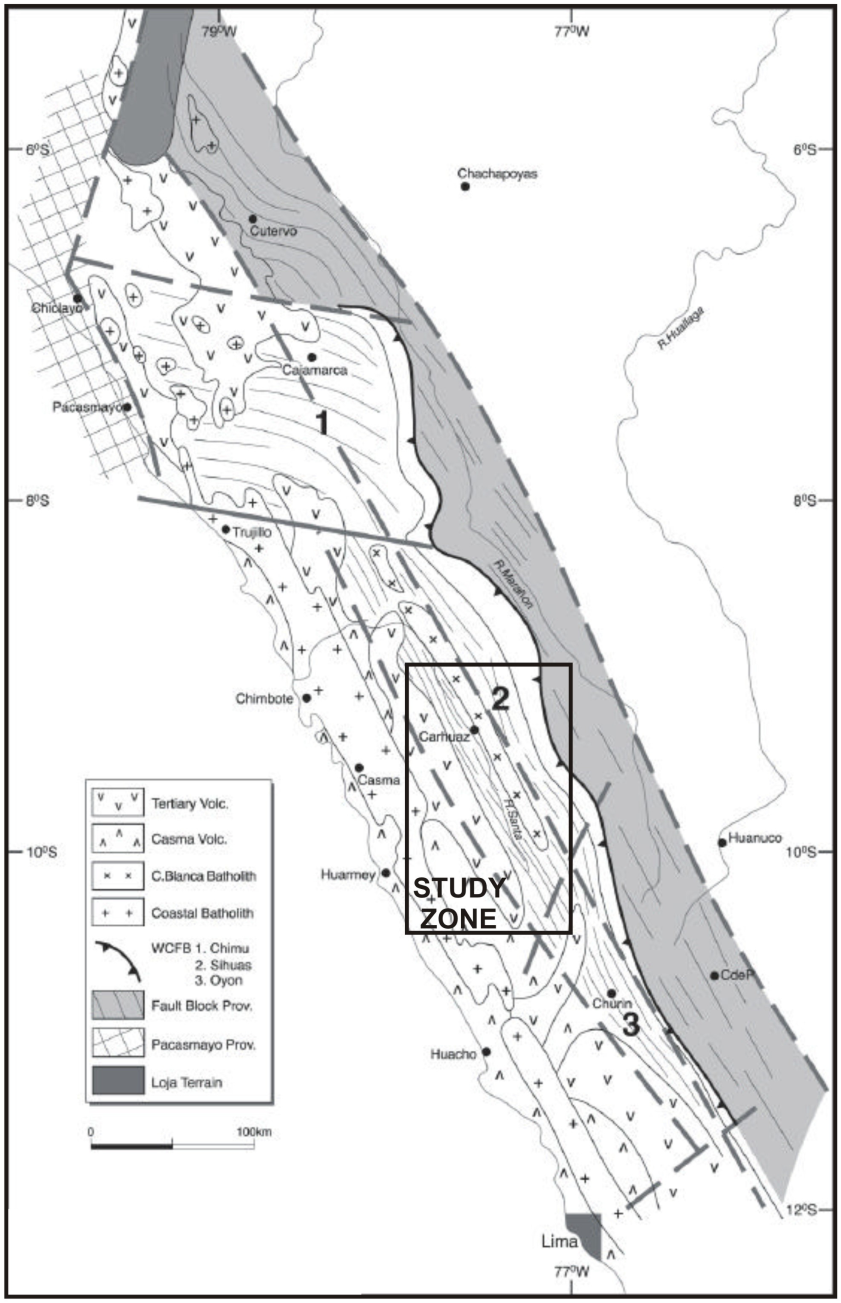


Fig. 2.5 Mains Structural Division of North Peru (Wilson, 2002).

2.3.2 Structural controls of the Jurassic-Cretaceous Chicama-Goyllarisquizga basin. (JKCHGB)

This basin is limited to the west by three reverse fault systems with vergence to west: 1) Tapacocha, 2)Huacllan-Churín, and 3) Huaraz-Recuay faults systems; and to east is limited by two reverse fault systems with vergence to east: 1) Cordillera Blanca and Chonta fault systems (Fig. 2.6) We will now describe the structural sections that cross the Cordillera Blanca fault system (Fig. 2.7))

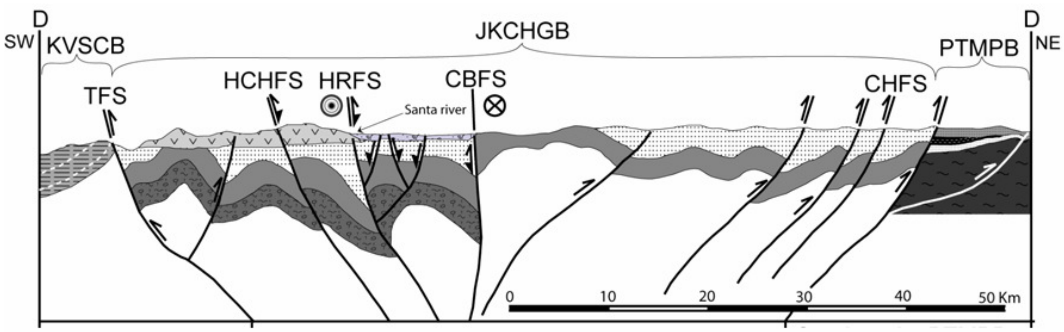


Fig. 2.6 Structural section D-D´, reference Fig. 2.7. (Romero, 2008)

The section A-A' (fig. 2.7) is located to the northern, has E to W direction, between Cabana and Pallasca towns. We observe the Huaraz-Recuay reverse fault systems with east dip, outcropping the Goyllarisquizga Group rocks and overlying the Tablacacha sequence (Upper Cretaceous-Paleocene, Navarro *et al*., in preparation). The sediment deformation of the Tablachaca sequence corresponds to folds with east dip. In this area the fold has NE-SW direction and the Huaraz Recuay fault system has NNE-SSO direction, thus indicate a reverse sinistral motion for the Huaraz Recuay fault system.

The structural section B-B' (fig. 2.7) is located in the central southern part of Cordillera Blanca fault system near Recuay town, from NE to SO direction, here we observe the Huaraz Recuay fault system as reverse with east dip and the Cordillera Blanca fault system as reverse with west dip, which due tectonic inversion actually show sinistral motion with normal component and generating a Plio-Qauternary basin with horst and graben showing NW to SE direction.

The section C-C' (Fig. 2.7) is located to the south, has NE to SW direction, near to Cajatambo town. Here we can observe the three western fault systems of the JKCHGB, corresponding reverse faults with east dip, affecting Jurassic rocks and the volcano-sedimentary sequence of Upper Cretaceous. This section is very important because we can observe in the HCH fault system a positive flower structure by tectonic inversion.

The section D-D’ (Fig. 2.6) located in the central-southern part of Jurassic-Cretaceous Chicama-Goyllarisquizga basin, has a NE to SO direction, between Chiquian and Recuay towns. This section is more regional, cross the three stratigraphic basins and all fault systems that controlled the JKChGB.

To the southwest we observe the Cochapunta Formation (Albian-Cenomanian) of the KVSCB basin and limited by the TFS. In the central part we observe the Jurassic-Cretaceous sediments controlled to the west by the Tapacocha, Huacllan-Churin, Huaraz Recuay fault systems, and to the east controlled by the Chonta fault system.

These fault systems show clear distensive tectonic inversion to compressive. However, between the Huaraz-Recuay and Cordillera Blanca fault systems we observe sinistral motion with normal component that affect Plio-Quaternary deposits.

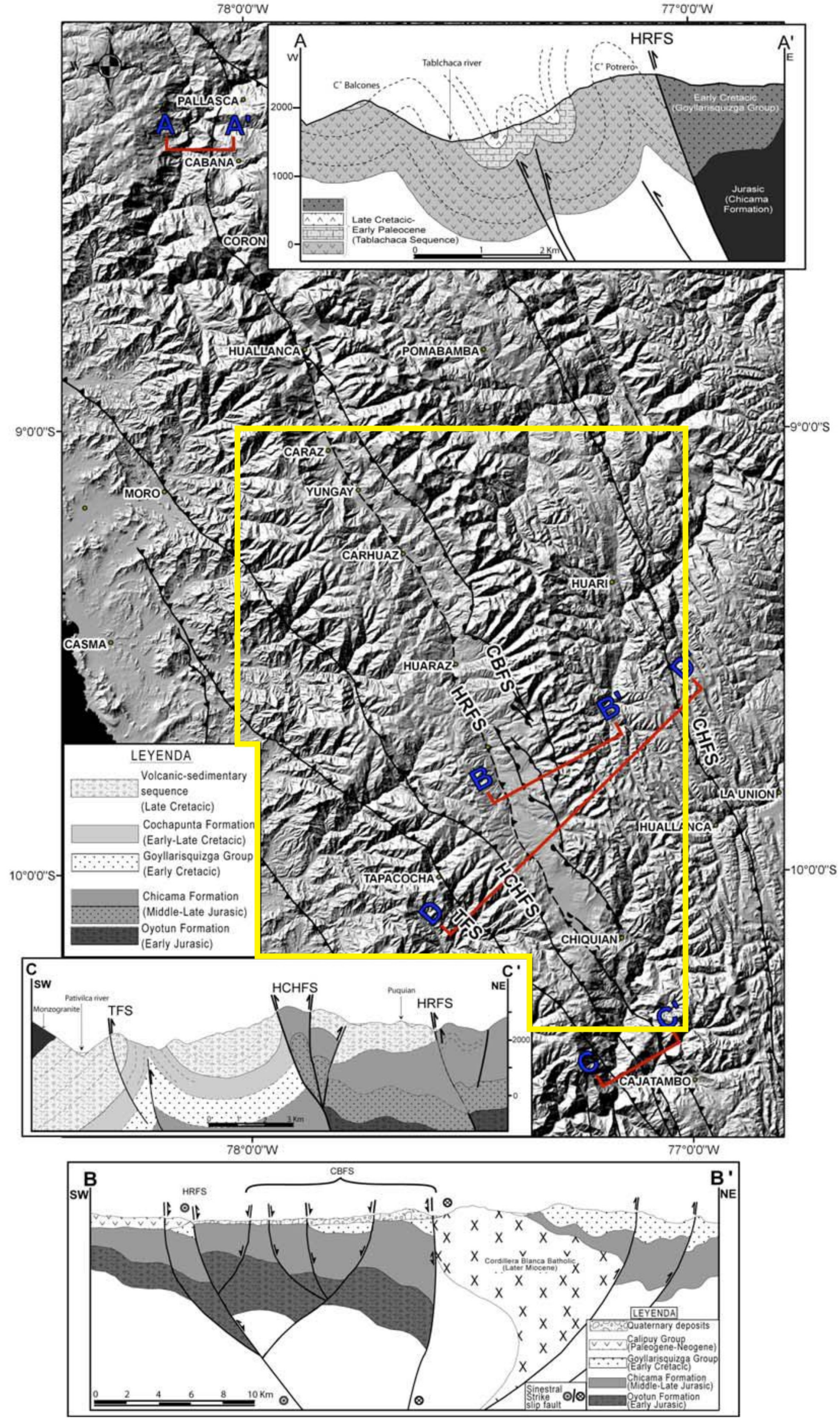


Fig. 2.7 Structural Schematic of the faults system (Romero, 2008).

2.3.3 Main Structures Related to the Mineralization

In the study area are varied the structures that are related to the mineralization. Most of they are linear or semicircular kilometric structures that correspond in general to strike slip faults and subvolcanic structures type caldera, respectively.

The semicircular structures related to caldera, are recognizable from satellite images and although most of they have high erosion grade you can still recognize their borders and their alteration zones. Among the structure main of this type we have: Ocros, Aija-Ticampampa and San Luis structure, all them emplacement in the Calipuy Group (Fig. 2.8, 2.9 and 2.10).

The mineral deposits associated to this structure are varied type, existing from porphyries, low sulphidation epithermal (veins), etc. These kilometric structures have been interpreted as the focuses of emission of the continental volcanism that originate to the Calipuy Group.

The Ocros structure has approximately 17 x 14 km (Fig.2.9), while the Aija – Ticapampa structure has approximately 3 x 4 Km (Fig. 2.10) and the San Luis structure has approximately 3.5 x 2.8 Km (Fig. 2.8). These structure is emplacement in the highest part of the Cordillera Negra, following a clear orientation NW, parallel to the main structures that controlled the different sedimentary basins.

At the moment the subvolcanic structure more studied is the Aija - ticapampa. TRURNIT P. et al. (1984) gave some reaches on a Neogene caldera emplacement in the northeast of the Aija - Ticapampa mining district. the main types of deposits are veins that dip among 70° at 85° toward the center of the caldera. The main mineralization is Pb, Ag and Zn. the Caldera this associated with a plutonism and volcanism of Neogene age.

The Ocros and San Luis subvolcanic structures has not been strongly studied, but they have a very similar mineralization to the Aija-Ticampampa structure. Something that characterizes to the Ocros and San Luis structures is the evidence of porphyry systems in depth many times with potassic alterations and tourmaline breccia outcrops (Fig. 2.8 and 2.9)

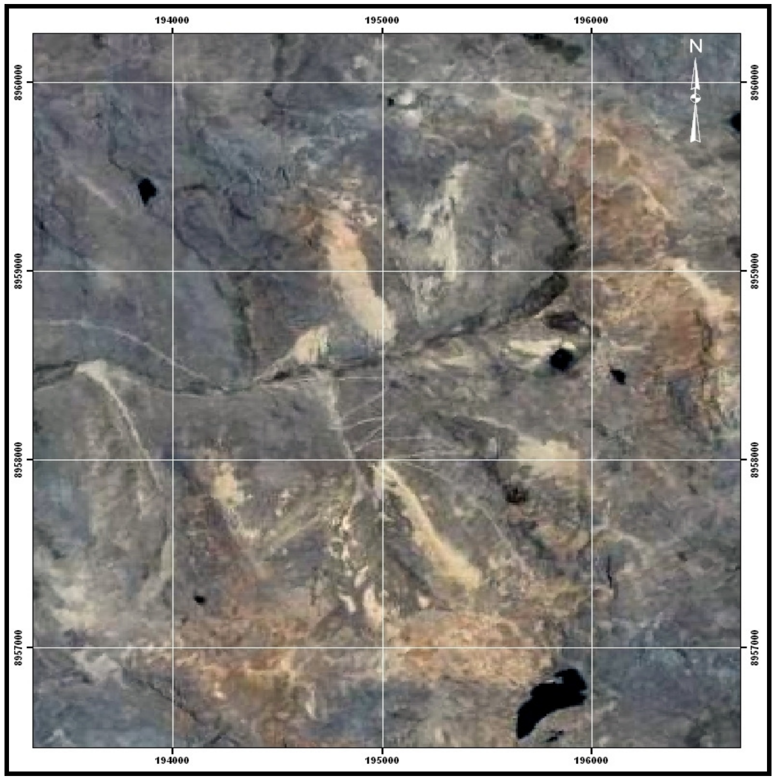


Fig. 2.8 San Luis subvolcanic structure

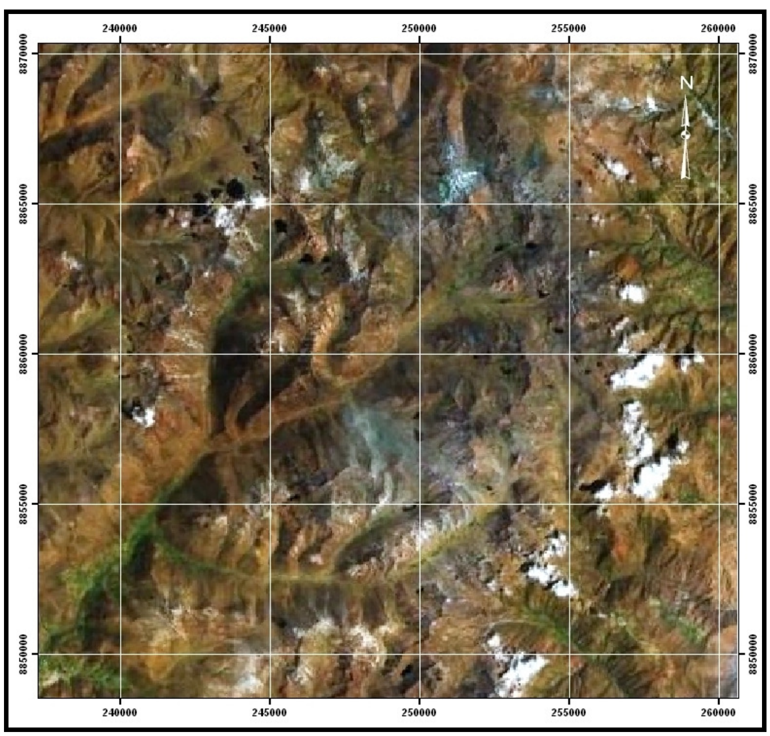


Fig. 2.9 Ocros subvolcanic structure

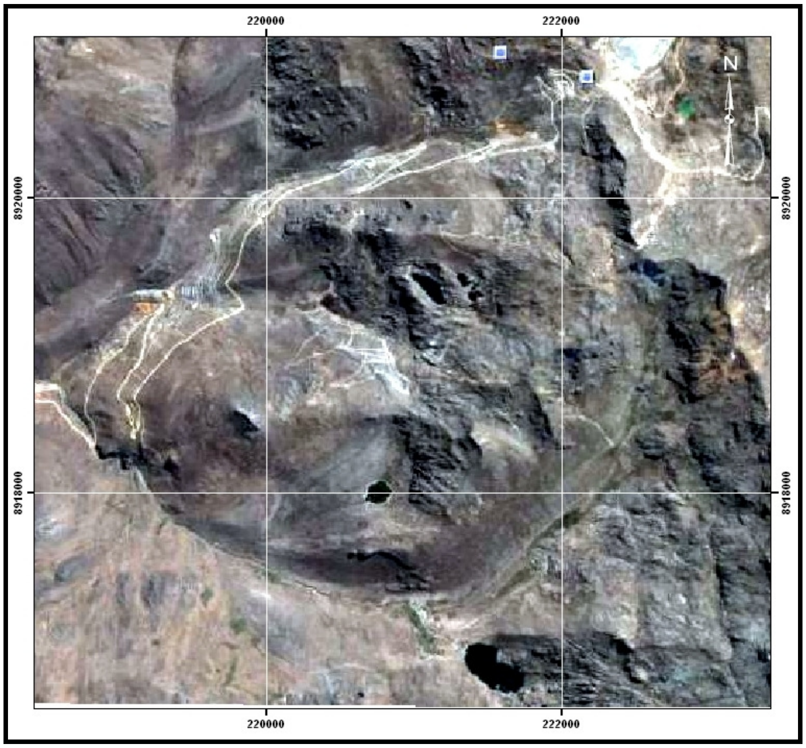


Fig. 2.10 Aija -Ticapampa Subvolcanic structure

A) FAULT ZONE EVIDENCE

Among the most important zones that showed evidence of fault we have Ocros, Tucochira and Catac sectors. For example:

A.1) OCROS SECTOR

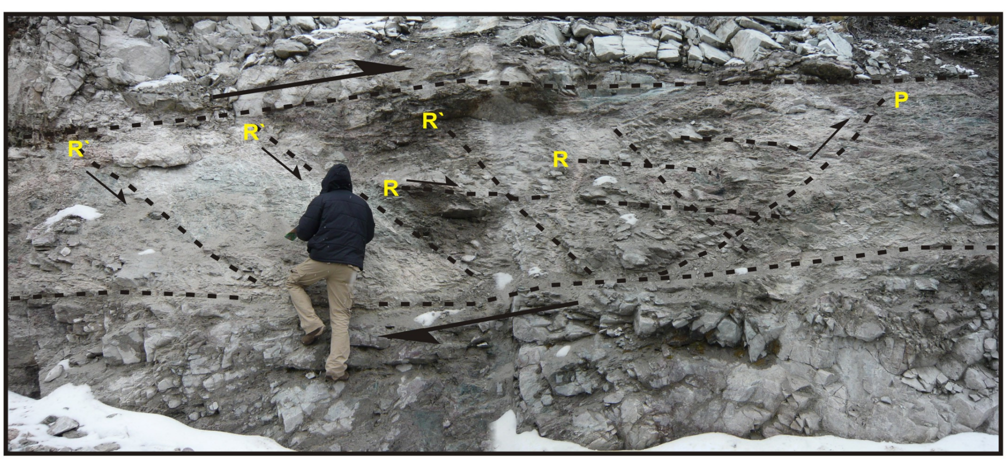


Fig. 2.11.- Fault zone located in the part NE of the subvolcanic structure. Direction N50°, fault area thickness is approximately 1.50 m. in volcanic rock (Riedel model).

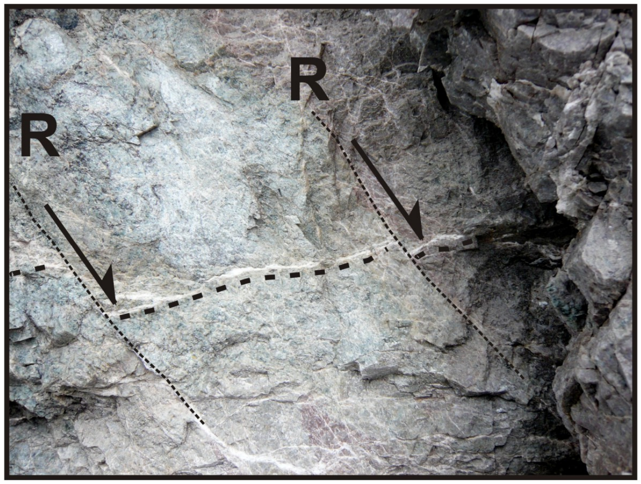


Fig. 2.12.- Amplification of the fig 2.11 showing the Riedel normal movement expressed in the quartz veins that cut the volcanic rock

Fig.- 2.13 subvertical fault in volcanic rocks (Calipuy Group) with inverse displacement and approximate thickness of 1.20 m.

Fig. 2.14.- Sigmoid Fault with direction N50° and 45° dip (rules of the right hand). These sigmoid generally works as areas very import for the mineralization (mineralized shoot).

A.2) TUCO CHIRA SECTOR

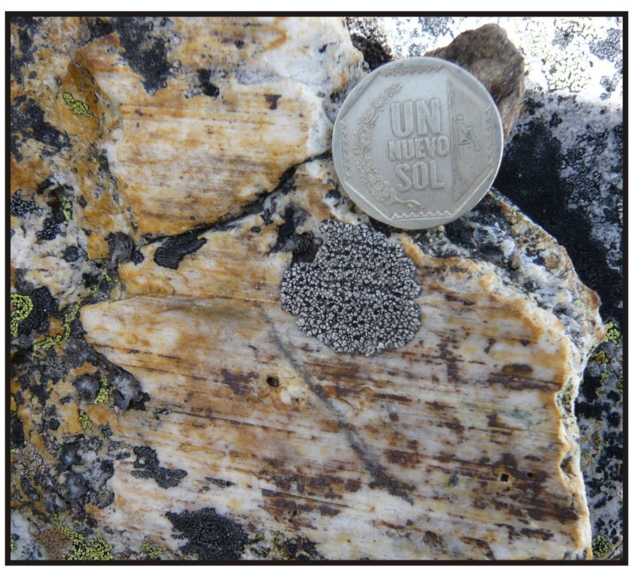


Fig. 2.15 Slickensides fault N240°, horizontal Pitch

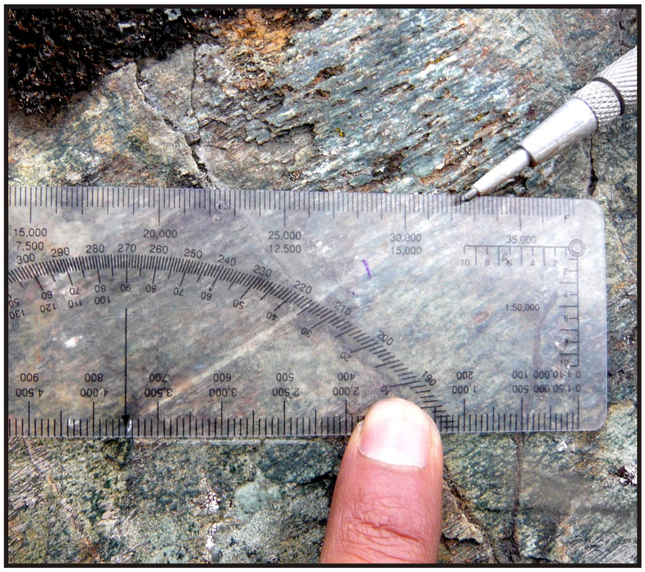


Fig.- 2.16 Slickensides fault N245°, Pitch 37°, dextral

A.3) CATAC SECTOR

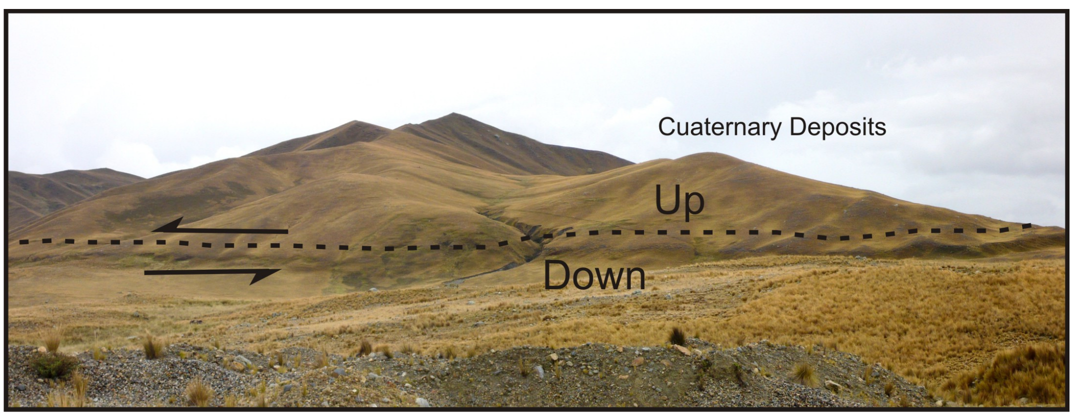


Fig. 2.17 Quaternary deposits with displacement sinistral.

DISCUSSION

It is possible that in the study area the paleotectonic structure of the crust exercised an important paper in the distribution of the different types of mineral deposits. Each one of the basins (Casma, Santa and Cajamarca) has different lithology characteristics. These characteristics become more evident in the proximities of the limits of the basins, which were controlled by kilometric faults that not only had a vertical movement, but they also had strike slip movement, making very complex the structural system in the study area.

The Santa basin / Sihuas sector is the most important from the point of view metallogenic, where exist deposits type porphyry, ephytermal and veins. Are very few the deposits that are assumed an singenetic origin (Huanzalá), most of the deposits are of epigenetic origin. It is thought that the main motor of this mineralization was the Cenozoic magmatism (Calipuy Group and the stock related to the Cordillera Blanca batholith).

This demonstrated that the sulvocanic structures type caldera are very common in the study area, especially in the Cordillera Negra. These structures are kilometric and host different types of deposits (veins and porphyries). The structure more known is Aija-Ticapampa where the mining district of the same name is developed.

The presence of veins with a traverse direction to the Andean, it can be explained because some of the main faults had direction movements of sinistral strike slip (Huayri - Recuay system faults with relationship to the Cordillera Blanca system faults). This structural system originated areas of tension with orientation NE that can have favored structurally the development of the veins.

The reduction of the sedimentary sequence in the basin Santa it played a vital paper in the generation of folded structures with strongly fractured flanks. This areas favored the circulation of the mineralization flow and the generation of mineral deposits.

The biggest thickness of the fm Santa (Group Goyllarisquizga) in the basin you their same name favored the development of mineral deposits (Huanzalá, tuco Chira, Aija Ticapampa, etc).

3. ECONOMIC GEOLOGY

3.1 Ore deposits type

Toward the north zone exist high and low sulfidation epithermal deposits (Pierina, Parón, Sacred Toribio); as well as Cu-Mo porphyries (Los Latinos, Jacabamba, Pashpap). Toward the oriental side exists a predominance of polymetallic skarn as Antamina mine and others as Huanzalá, Contonga, Pucarrajo, Paclla, etc.

In the area of Ocros, Pachapaqui, Aija and Ticapampa, there are diverse anomalies and polymetallic prospects of Ag, Pb, Zn.

3.1.1 Epithermal deposits

PIERINA

The Pierina deposit is in the Cordillera Negra of north-central Perú at latitude 9º26.5' S and longitude 77º35' W, between 3800 and 4200 m in elevation, and 10 Km northwest of Huaraz (Fig. 3.1). Politically, Pierina lies in the District of Jancas, Province of Huaraz and Department of Ancash.

Pierina Mine belongs to the Barrick Misquichilca S. A. Mining Company which is a subsidiary of the consortium Barrick Gold Corporation, Toronto, Canadá, the world's third largest producer of gold. In Peru, Barrick operates the gold mines Pierina, in Ancash and Lagunas Norte,in La Libertad.

Fig. 3.1 View to the Pierina deposit

Pierina is a high-sulfidation (acid-sulfate) epithermal deposit hosted by pyroclastic volcanics of the Tertiary Calipuy Group (Fig. 3.2). This volcanics overlie rhyodacitic pumice and lithic tuffs. Smaller and more restricted bodies of crystal tuff occur locally at the base of the pumice tuff, and a quartz-feldspar porphyry intrusion occurs on the south flank of the deposit. The chaotic nature of the rocks on the south flank of the ore deposit suggests the presence of a dome complex or vent area. All rocks types within the ore deposit, except the basal andesite, are present in this southern dome/vent area. The quartz-feldspar porphyry (Fig.3.3) is though to be either contemporaneous with the later stages of mineralization or post-mineral.

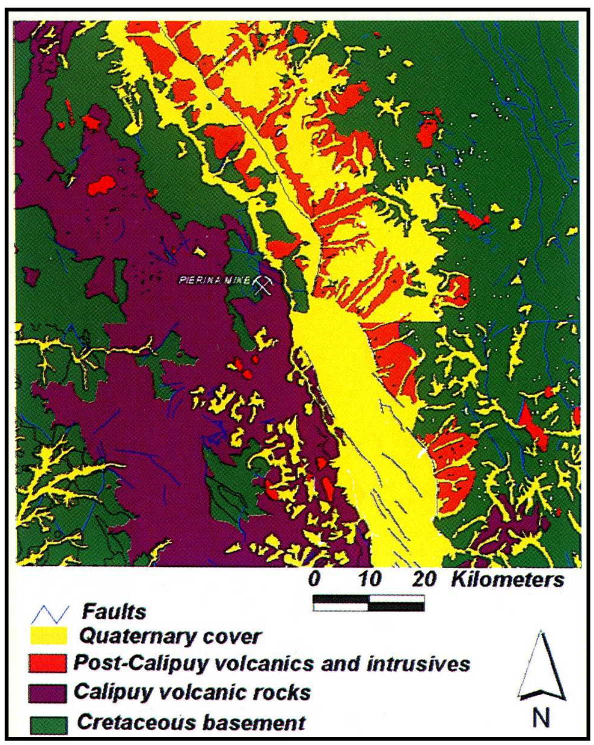


Fig. 3.2 Geological Map (Volkert et al., 1999)

Fig. 3.3 The left photo show outcrop of quartz feldspar porphyry (View looking to north). The right photo show hand sample of the porphyry.

The rhyodacitic porphyries vary dacite to rhyolite which present in form of dome, pugs or filling volcanics necks across the Calipuy volcanics. The elongated shape of the intrusive subvolcanic coincides spatially with the longitudinal faults that make up the Callejón de Huaylas Graben and its transverse faulting (Fig.3.4).

This situation in the most important evidence of structural control to the location of the intrusive and therefore different polymetallic and gold deposits associated with these intrusive.

Dominant structures in the deposit trend NNW, WNW, and NE. In the Fig. 3.5 is showed the fault with strike N120º and 45º-50º S dip. This fault puts in contact argillic alteration with quartz-alunite zone.

Alteration and mineralization at the Pierina deposit are typical of volcanic-hosted high-sulfidation system. Residual vuggy silica containing alunite is the host for most of the ore (Fig. 3.6). Surrounding the Vuggy silica alteration is a zone of alunite with minor pyrophyllite and dickite. This alteration also host ore, but generally of lower grade than in the vuggy silica. The alunite zone is succeeded outward by clay alteration (Kaolinitic to illitic). (Fig. 3.7)

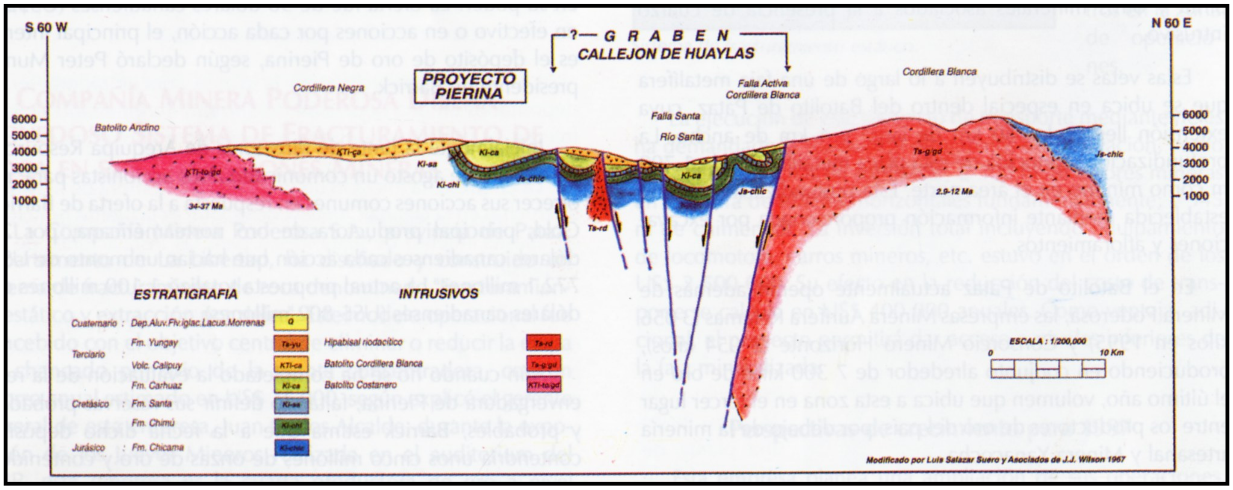


Fig. 3.4 Pierina mine and Callejon de Huaylas Graven, transversal section of regional geology looking to northeast.

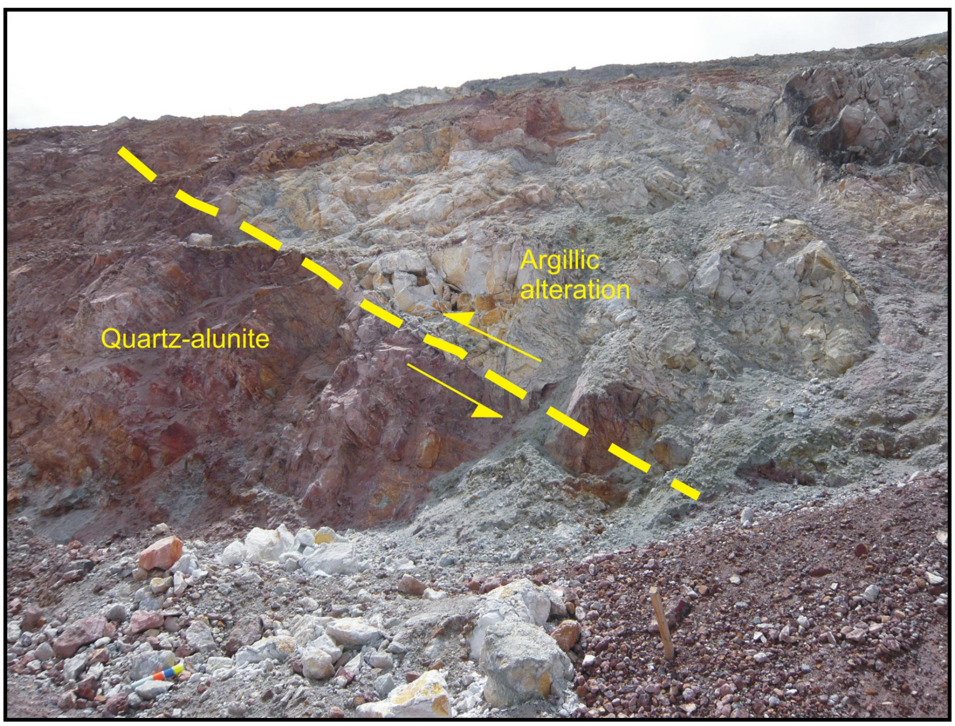


Fig. 3.5 Inverse Fault, view looking to northeast

Gold mineralization at Pierina is disseminated in the vuggy-silica altered rhyodacitic pumice tuff. More than 95% of the mineralization defined at Pierina is oxidized. The Au is present as micrometer grains of native gold associate with Fe oxides, quartz, and pyrite. In parts of the orebody, kernels of pyrite-enargite-covellite-native sulfur are present.

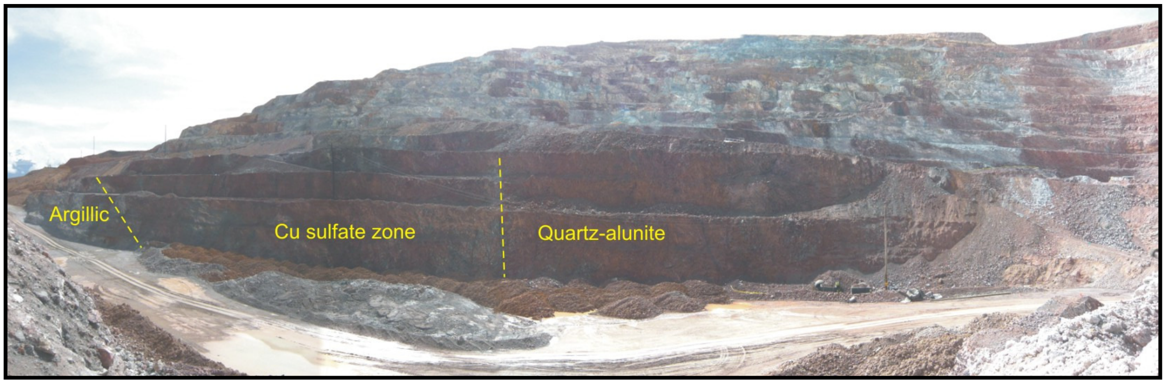


Fig. 3.6 Photo of the Level 3800 of Pierina Mine, showing the alterations zones. View looking to west

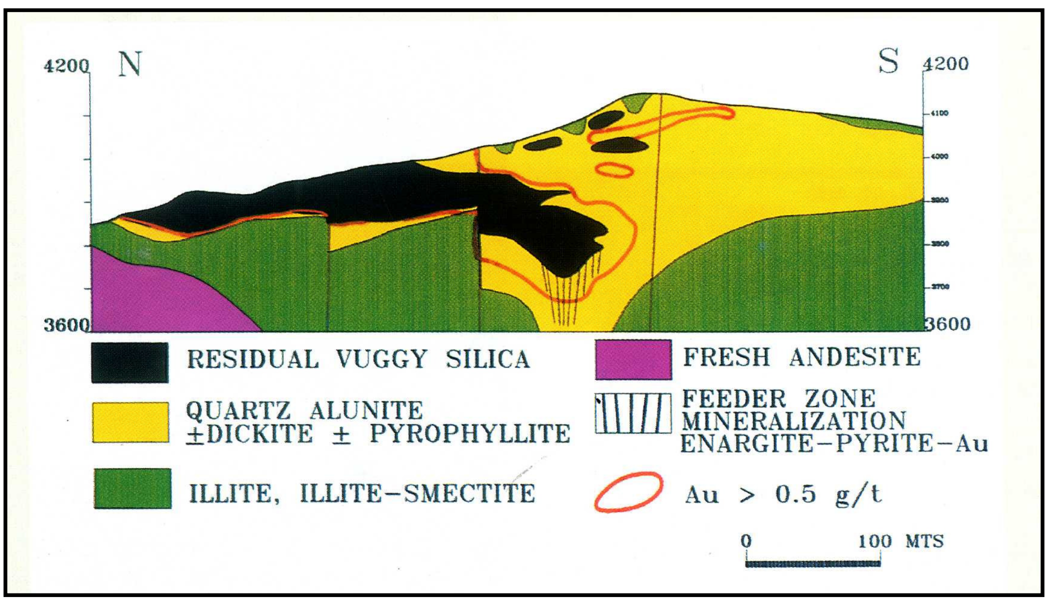


Fig. 3.7 Simplified alteration and mineralization (Volkert et al., 1999)

PACHAPAQUI

The Pachapaqui mine is located in the Minapampa stream to 6 Km. of Pachapaqui town, between 4000 – 4900 m. above sea-level. Politically Pachapaqui lies in the district of Aquia, province of Bolognesi, department of Ancash, to 375 Km, from Lima (Fig. 3.8).

The Pachapaqui mining unit belongs Pachapaqui Mining Company S.A., which is a medium peruvian mining company.

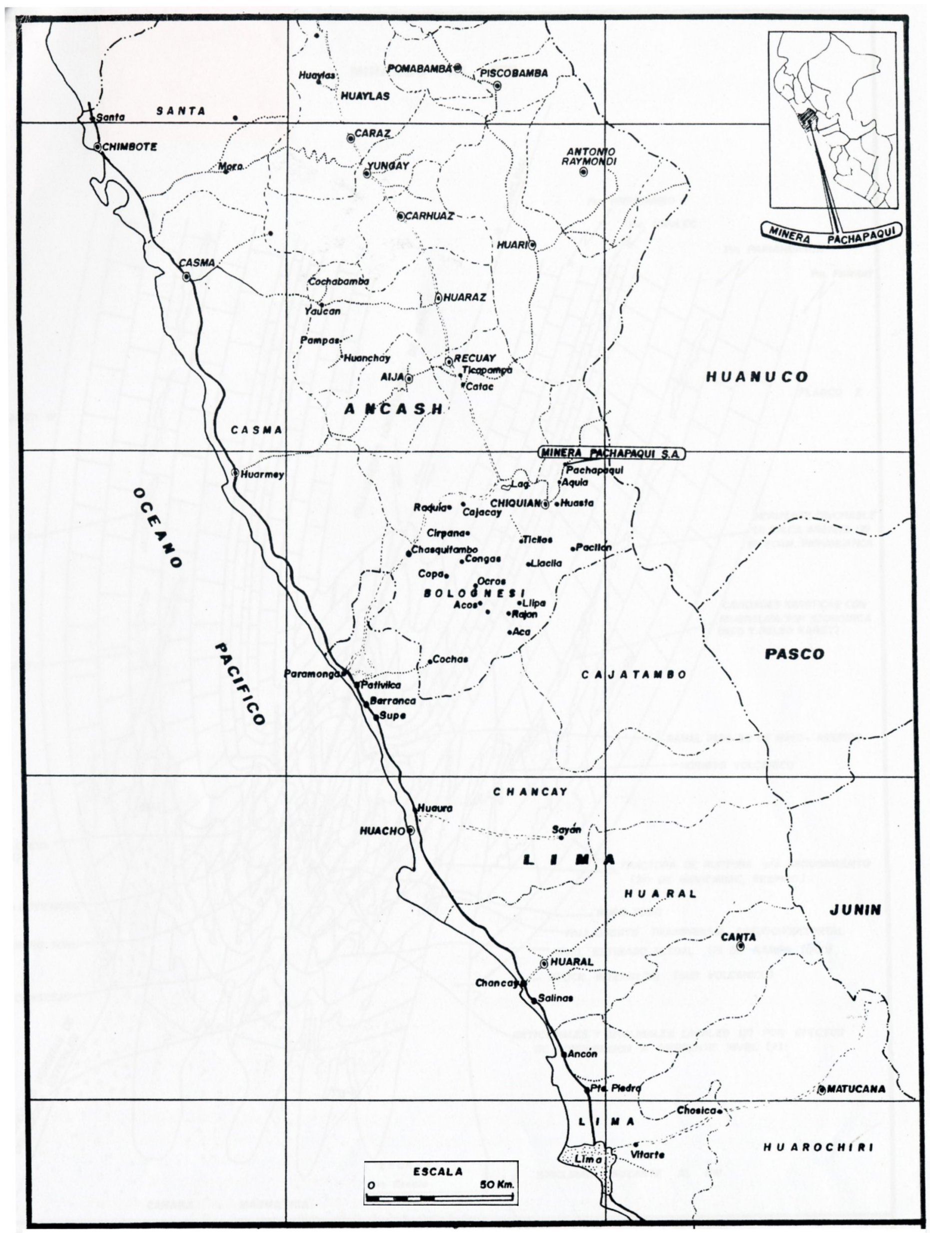


Fig. 3.8 Location map (Lujan, 1996)

In the area exists sedimentary rocks which ages vary from Jurassic to Upper Cretaceous, which the siliciclastic sequence of the Goyllarisquisga Group is the most representative. In the Cenozoic appear volcanic rocks of the Calipuy Group that consist of rhyolitic, rhyodacitic, and dacitic lava flow.

The sedimentary sequences located toward south are cut by small and medium intrusions of acid composition. These intrusives are emplaced in form of stocks, dikes and sills.

El Pachapaqui anticline is the principal structure of compression due to Andean Orogeny with strikes NW-SE (Fig. 3.9). In both flanks of the syncline between the sedimentary formations of Carhuaz-Farrat-Pariahuanca there is mineralization in form of bed (mantos), veins and irregular bodies.

The sedimentary sequence has suffered a strong deformation due to Andean Orogeny (folding). There are folds with strike NW-SE and its nucleus could be quartzites of the Chimú Formation.

There are 3 fractures systems pre-mineral of the mineralized structures: System NW-SE, system NE-SW and system E-W. These structures are a group of veins with the same direction and aligned spatially that could be formed by the same pre-mineral fracture to relate a one o more sources of mineralization.

The ore mineral are: sphalerite, galena, tennantite, freibergite, chalcopyrite, marmatite, marcasite and bornite.

The gangue minerals are: Pyrite, quartz, calcite, rhodonite, phyrrhotite, fluorite, grossularite, epidote, barite, plaster, diopside, wollastonite, siderite, goethite, limonite and aragonite.

Three mineralization phases:

1. Rhodonite, calcite, alabandite, galena, sphalerite, freibergite, argentite and chalcopyrite.

2. Pyrite, sphalerite, galena, freibergite, chalcopyrite and quartz.

3. Small quartz-pyre veins that cut through the magmatic breach.

The economic mineralization seems to be related to the last stages of the magmatic activity.

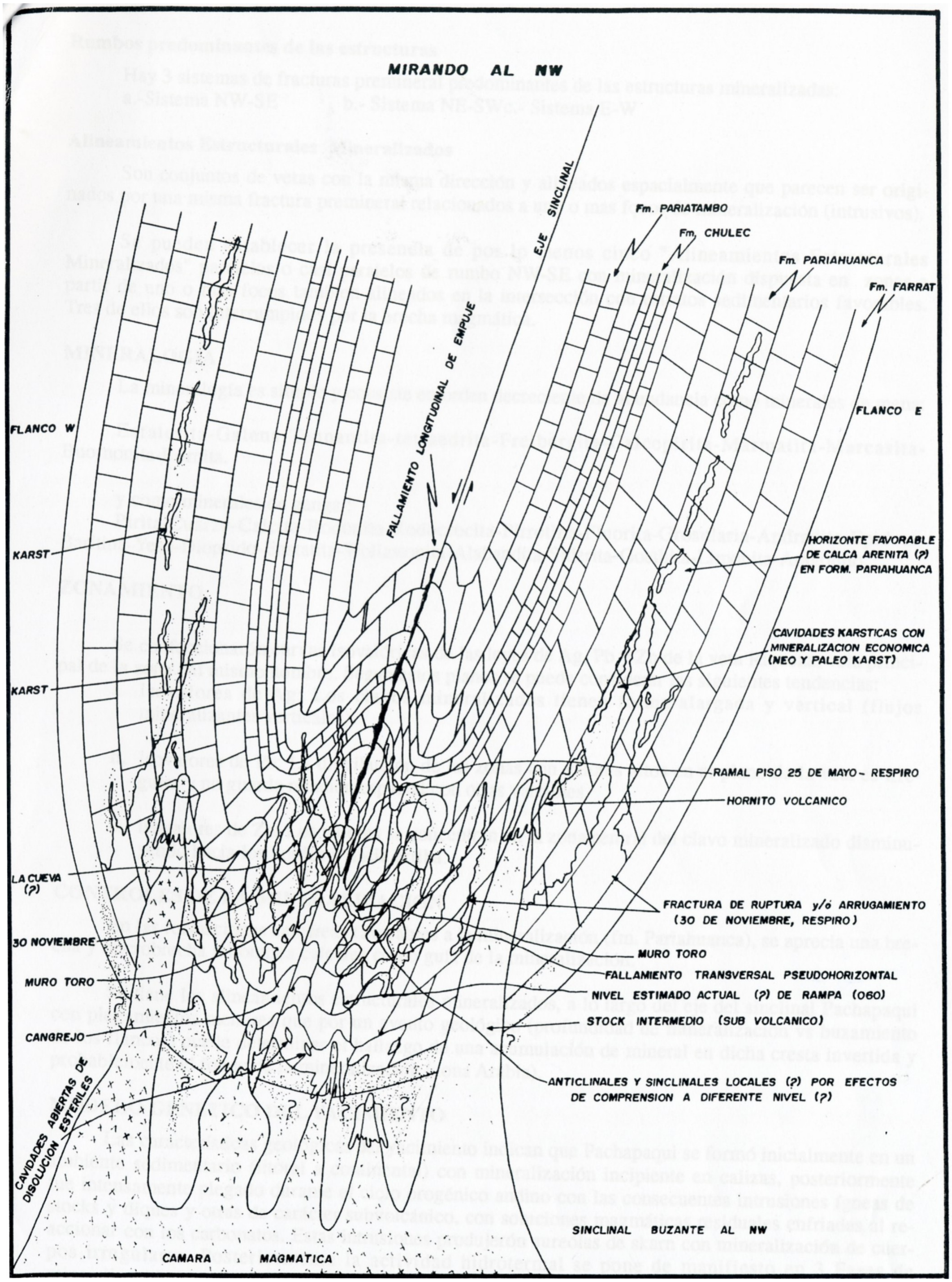


Fig. 3.9 Structural section of Pachapaqui syncline (Lujan, 1996)

HUINAC

Huinac is an epithermal deposit of Pb-Ag-Zn-Cu. This deposit is located in the western flank of the Cordillera Negra, Ancash department, Aija province, La Merced district, in the approximate geographical coordinates: 77°40'42 '' west longitude and 9°41'36 '' south latitude. The access to the mine is made from Huaraz by an affirmed highway of 60 Km.

Huinac Mine belongs to the Huinac S. A. C. Mining Company which is a peruvian company that has two more mining units: Admirada Atila and Amapola 5. Both produce Pb, Zn and Ag.

Huinac is an epithermal deposit with mineralization of Pb, Ag, Zn and Cu; it is emplaced in early cretaceous sedimentary rocks (Chimú Formation) and volcanic of the Calipuy Group (Wilson et al., 1967). Both sequences are cut by two intrusives; the first type is conformed by a porphyritic granodiorite very altered with Kaolinite and pyrite due to hydrothermal solutions (Figure 3.10). A second type is dacitic-andesitic porphyry, of gray to gray greenish color. These rocks appear mainly in form of hypabyssal intrusive stock, it is also presented in form of dikes with NW-SE direction.

There are two main systems of veins (Vizcarra and Linares, 1991), the first with orientation NE-SW and second system with orientation NW-SE. The first system has a strike N79ºE and 60º to 70ºSE dip; while the second system presents a strike N52ºW with 76ºNE and 72ºSW dip. The structures with N60ºE and N77ºE constitute compression fractures; and the low angle are shear fractures.

According to the evidence of ductile deformation represented by the folds, the maximum deflection axis coincides with the axis of Huinac anticlinorium which has N30ºW strike. The asymmetric shape of Huinac anticlinorium with its axial plane dipping to the east means that the axial plane coincides with the plane formed by maximum and intermediate deformation axes. For this reason, it appears that the axis of maximum effort has N60ºE strike, and 30ºNW dip (Fig. 3.11).

The mineralization consists of Zn, Pb, Ag and Cu veins. The main minerals in the veins are sphalerite, tetraedrite, chalcopyrite and argentiferous galena. The gangue minerals are the quartz, calcite, rhodochrosite, pyrite, realgar and arsenopyrite.

The hydrothermal alteration consists of silicification, pyritization and Kaolonization, which vary according to the rock type. The sedimentary rocks present mayor silicification and pyritization; by other hand the volcanic rocks present mayor Kaolinization, silicificación and pyritization.

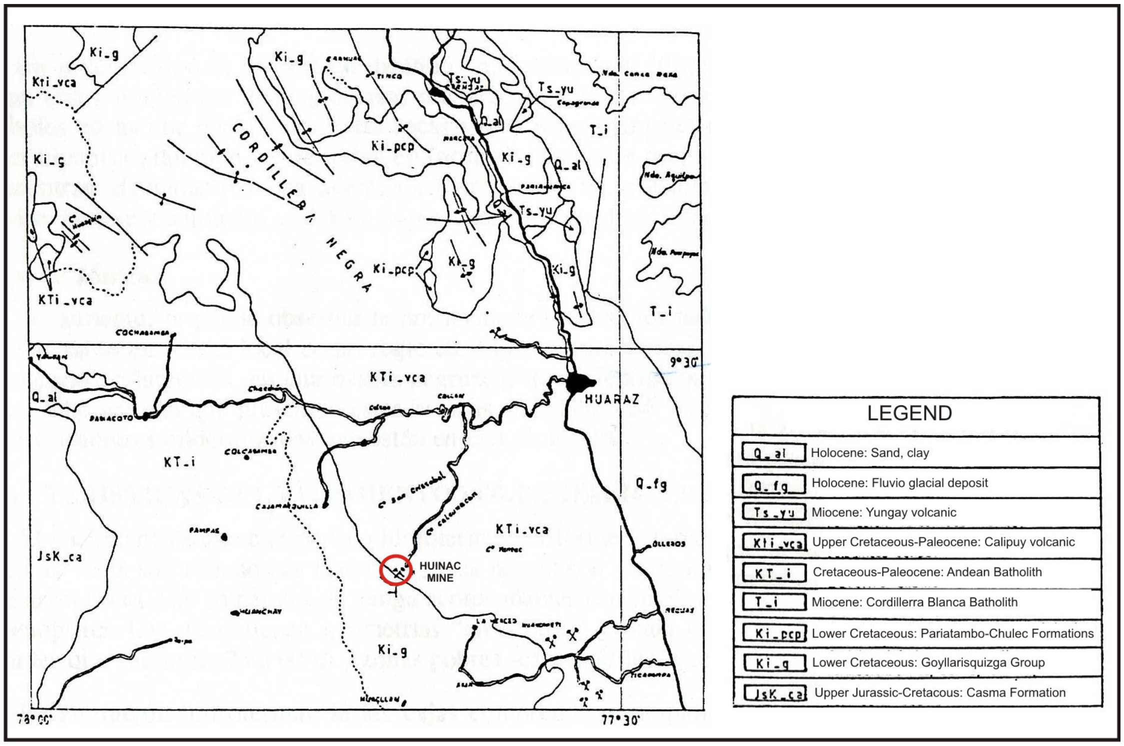


Fig. 3.10 Geological map (Vizcarra and Linares, 1997)

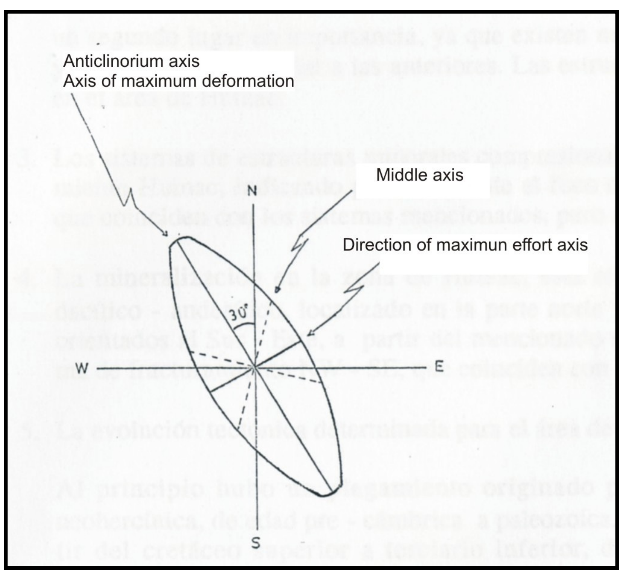


Fig. 3.11 Ellipse of deformation and direction of the efforts (Vizcarra and Linares, 1997)

SANTO TORIBIO

Santo Toribio ore is a low sulfidation epithermal Ag-rich polimetalic deposit. This deposit is located in the western flank of the Cordillera Negra, Ancash department, Aija province, La Merced district, in the approximate geographical coordinates: 77º35'7'' west longitude and 9º29'12'' south latitude (Fig.3.12).

Fig. 3.12 Photo of Santo Toribio Mine. View looking to southeast.

Nowadays Santo Toribio deposit belongs to communal society Santo Toribio, which is not in active because of problems between its owners.

This deposit is hosted in the Quiruvilca-Pierina subbelt, which also contains the world-class, high sulfidation Pierina deposit (Noble and McKee, 1999). Both deposits are hosted by upper Oligocene-middle Miocene andesitic to rhyolitic, subareal, volcanic rocks of the upper Calipuy Group (also referred to as the Huaraz Group), and formed between 16.5 to 13.3 Ma. (Strusievicz et al., 2000).

The Santo Toribio deposit is regionally controlled by NW-SE-trending lineaments (Chamorro, 1984) and has been intermittently mined since 1951. It comprises NW, NE and EW striking quartz and/or carbonate veins (up to 220 m. in length; Chamorro, 1984) with variable proportions of sulfides, mainly pyrite, chalcopyrite, galena, arsenopyrite and sphalerite (Fig. 3.13). The Ag and Au grades in the polymetallic ore average 744 and 3 g/t, respectively (Vachon, 1999).

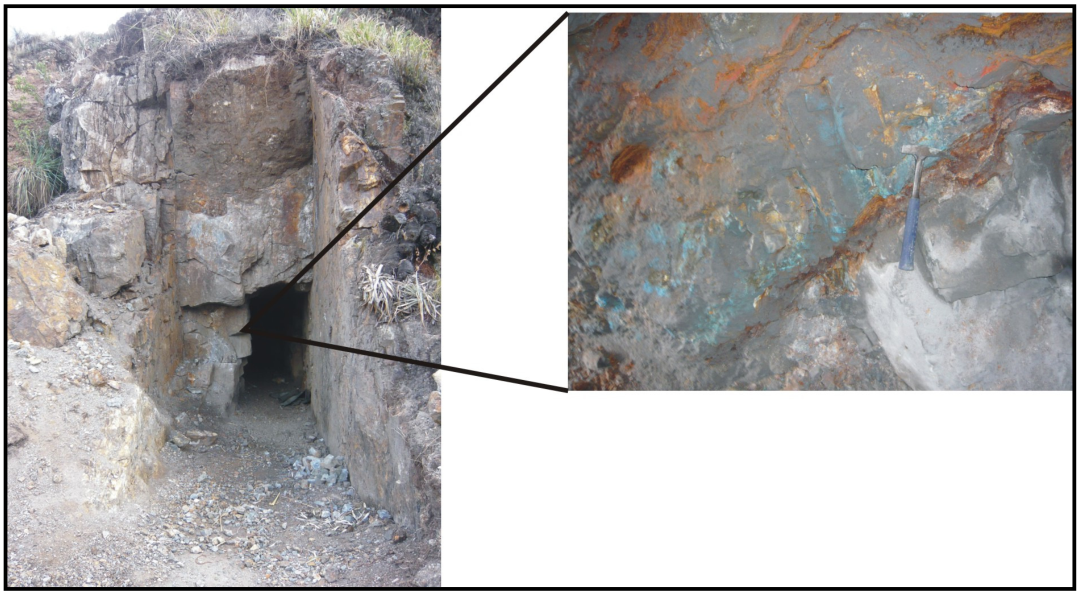


Fig. 3.13 In the left photo is showed Santo Toribio tunnel mine, and the right is showed the mineralization (oxides and sulfates of Cu).

3.1.2 Porphyry deposits

JACABAMBA

The Jacabamba molybdenum prospect is located in north central Perú on the eastern flank of the Cordillera Blanca, province of Huari and department of Ancash. This prospect is between 4400 and 5400 m above sea-level. The geographical coordinates of the prospect are: 9° 18' and 9°19' south latitude and 77° 17' and 77° 18' west longitude at the valley head of the Jacabamba River to 15 Km. toward the west of the Huari town (Fig. 3.14).

The prospect area (Fig.3.15) is underlain by a miogeosynclinal sequence, which exceeds 1000 m. in thickness and is composed entirely of the Upper Jurassic Chicama formation (Wilson et al., 1967): this consist of siltstones, wackes and quartz arenites, in descending order of importance, and is succeeded to the east by sediments of cretaceous age.

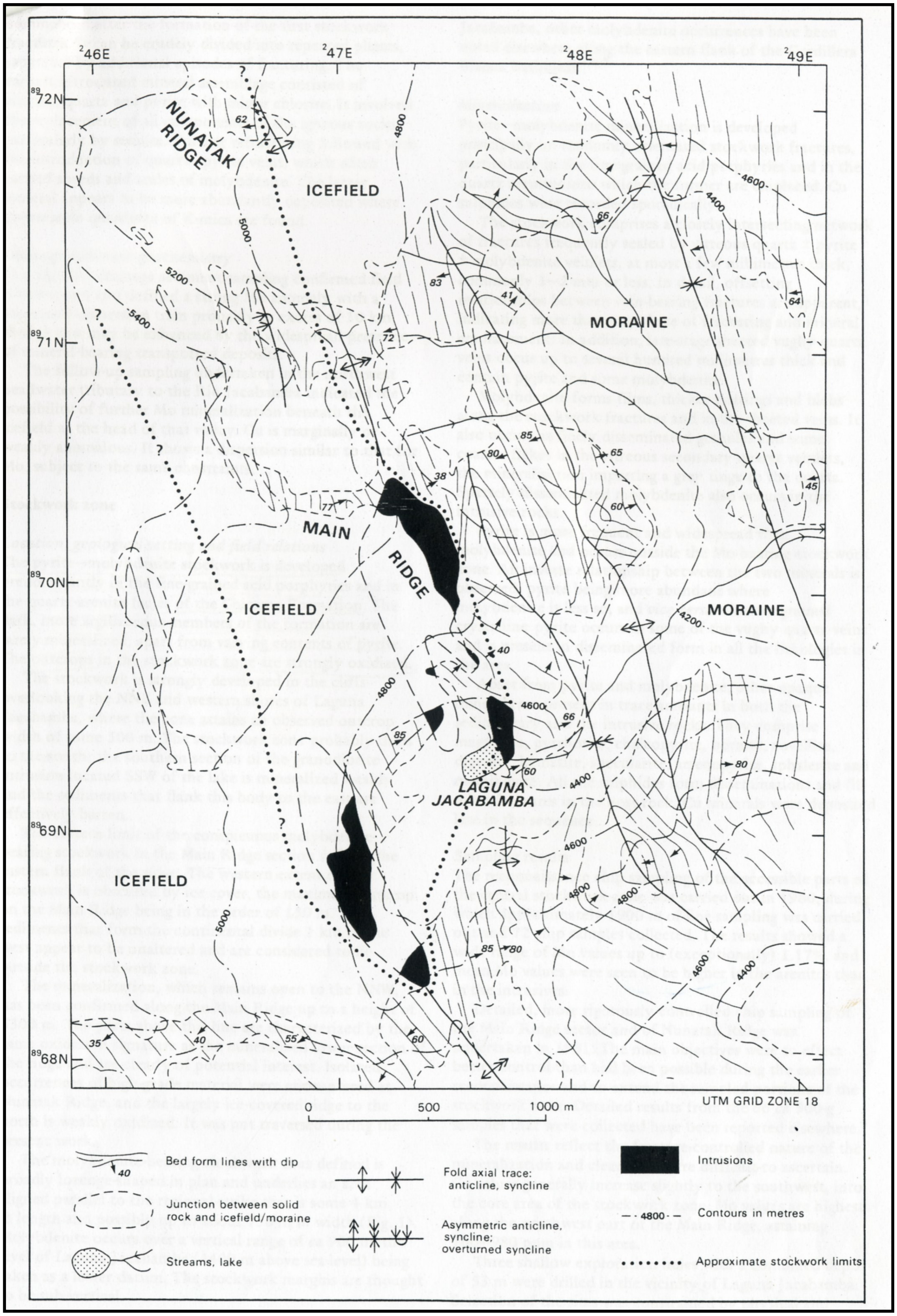


Fig. 3.14 Location Map (Lynas and Bennett, 1983)

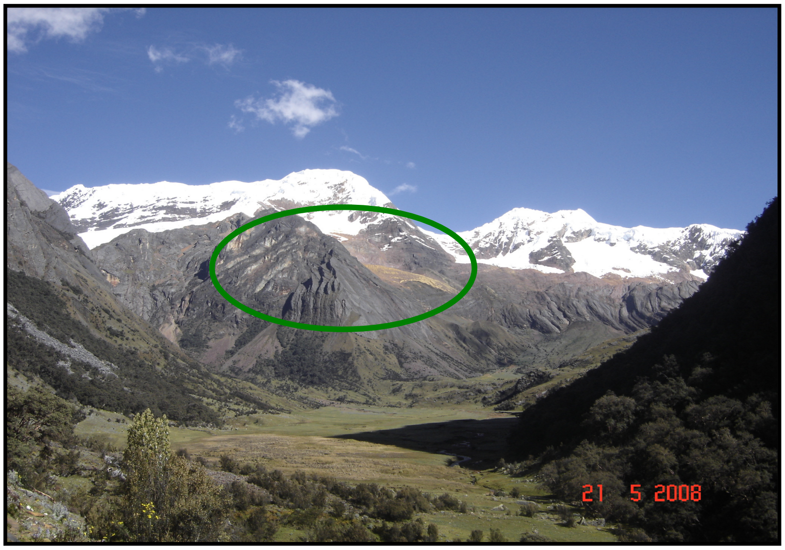


Fig. 3.15 Panoramic view to the Jacabamba porphyry

Three types of intrusive rocks are present within the area. They fall into two distinct groups: the group I rocks comprise high-level dacitic to rhyodacitic porphyries and monzogranitic to granodioritic plutonic intrusives. Most of the intrusive rocks adjacent to the prospect area are of the latter type. The group II rocks are hypabyssal and quartz-diorite to tonalitic composition.

The group I rocks are consanguineous with the Cordillera Blanca Batholith, the main axis of which lies to the west of the area. The batholith, subordinate in size only to the Coastal Batholith of Perú, has given radiometric ages of around 9 m.y. (Cobbing et al., 1981). It is implicated in the mineralization seen at Jacabamba and at other localities for example, 5 Km. south in the valley of the Rurichinchay river, 20 Km northwest at the California Mo prospect (Vidal Ingenieros, 1974) and 13 Km NNW at small prospect near the town of Chacas (Bennett, 1981).

The sediments were strongly folded about sub-horizontal NNW-trending axes during the end of Cretaceous to early Tertiary Andean orogeny. The folds are usually angular and normal to steeply inclined (Fletcher, 1977) and they tend to verge to the southwest. Disharmonic structures are developed within the less component lithologies. The folding pre-dates the intrusion and the development of the mineralized stockwork.

Faulting is of minor importance in the area, though high-angle reversed faults occur on the limbs of some major folds. Joints and mineralized fractures, which include sheeted, often vuggy quartz veins, post date the main stockwork development. The joins are strongly developed in all the rock types and show trends related to the Andean folding.

The development of most of the jointing is best ascribed to the regional epirogenic uplift that post-date the Andean orogeny. The geometrical relationships suggest an inherited control that is coaxial with the Andean deformation and a relict effect of it. A strong set of sheeting joints of low to moderate dip is prominent in the roof zone of the Main Ridge intrusion.

Pyrite-molybdenite mineralization is developed principally on randomly orientated stockwork fractures (Fig. 3.16), particularly in the fine grained acid porphyries and in the quartz arenites into which the former are emplaced. Cu sulphides were recorded sporadically.

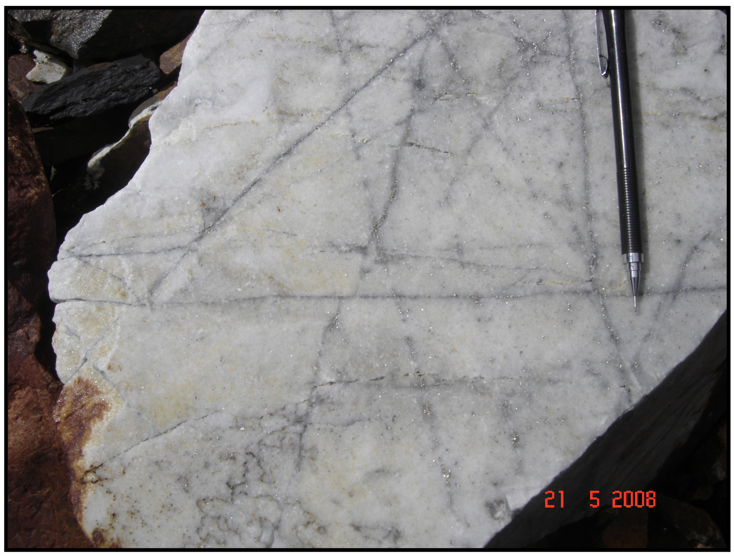


Fig. 3.16 Stockwork with molybdenite veins

The stockwork comprises a closely intersecting network of fractures frequently sealed by vitreous quartz ± pyrite ± molybdenite veinlets, at most a few millimeters thick, commonly 1-2 mm or less. In detail, offsetting relationships between vein-bearing fractures are apparent, indicating more than one phase of fracturing and mineral emplacement. In addition, late-stage sheeted vughy quartz veins occur up to several hundred millimeters thick and contain pyrite and some molybdenite.

Pyrite is more frequent and widespread than molybdenite and occurs outside the Mo-bearing stockwork zone. An inverse relationship between the two minerals is observed, pyrite being more abundant where molybdenite is less so, and vice versa. Coarsergrained crystalline pyrite occurs in some of the vughy quartz veins and is present in disseminated form in all the lithologies in the area.

Apart from pyrite and molybdenite, other opaque minerals are present in trace amounts in both the sedimentary and the intrusive rocks. They comprise magnetite, pyrrhotite, chalcopyrite, bornite, covellite, digenite, hematite, specularite, arsenopyrite, sphalerite and melnikovite.

The hydrothermal alteration is manifested by the development of the quartz-sericite-biotite alteration, orthose (in veins and disseminated), pyrite and silicification. The phyllic alteration is presented preferably in tonalite and monzonite stocks, while the silicification is present in the host rock.

PASHPAP

Pashpap is Cu-Mo porphyry and is located in the flank northwest of the Cordillera Negra of the Andes, province of Santa and department of Ancash (Fig. 3.17). This deposit is between 3000 to 4700 m above sea-level, approximately to 370 Km to north of Lima and 153 km. to the northeast of Chimbote. The geographical coordinates are: 8º46'30'' south latitude and 77º59'30'' west longitude.

The outcrops in Pashpap consist in silic-clastic and carbonated rocks. The stratigraphic units from the oldest to the youngest are: lutites and limestones of the Chicama Formation, sandstones and quartzites of the Chimú Formation, limestones and lutites of the Santa Formation, lutites and sandstones of the Carhuaz Formation, limestones of the Pariahuanca Formation, conglomerates and sandstones of the Huaylas Formation (Fig. 3.18).

At south of the project outcrops of tonalite-granodiorite are present which are the oldest and have been intruded by small outcrops of monzonite distributed irregularly and mainly in North and South Huacacuy and Loma Blanca. Post intrusives of porphyritic granite with important development of stockwork and restricted hydrothermal alteration, contour outcrops of porphyritic quartz monzonite where the main hydrothermal alteration in Pashpap is development.

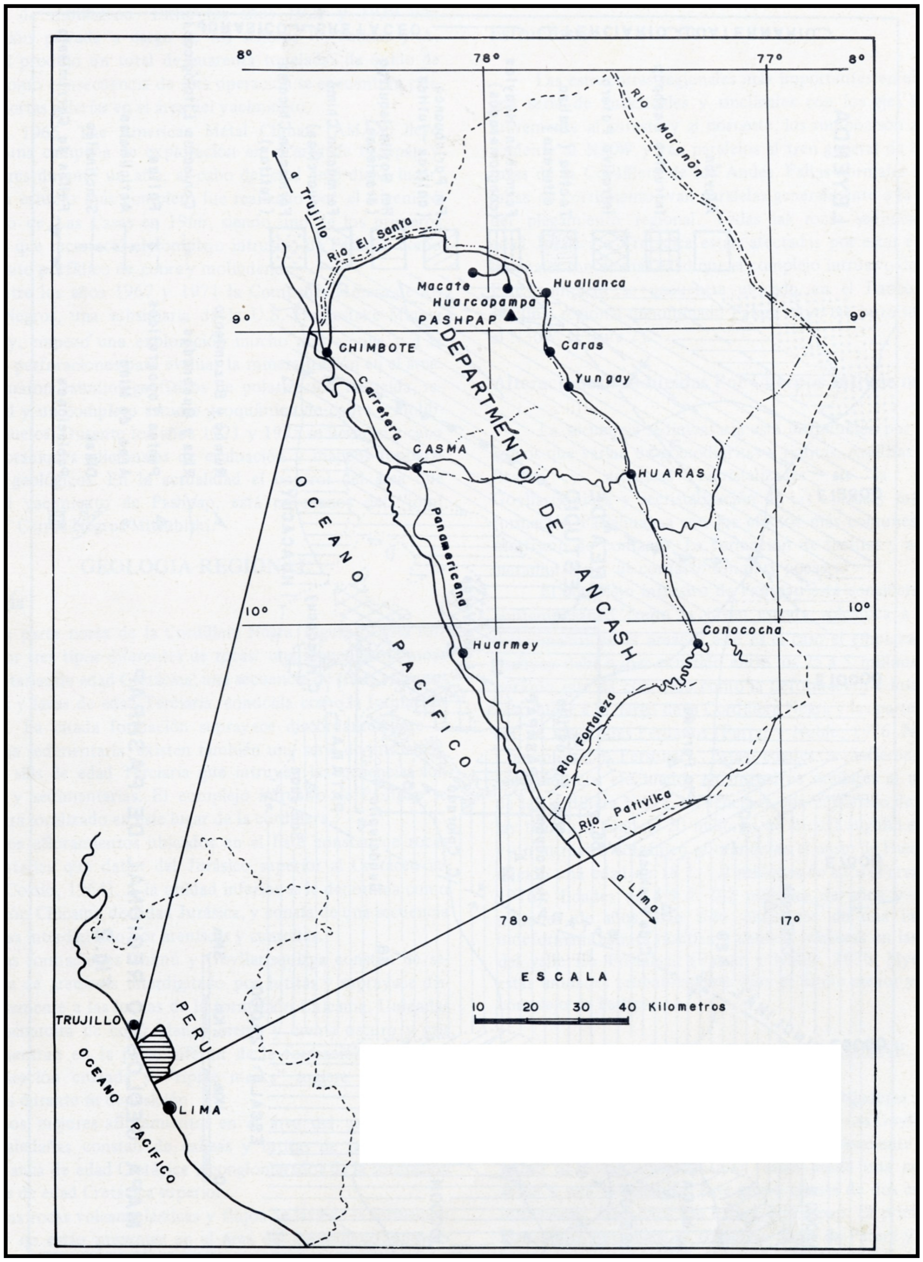


Fig. 3.17 Location Map

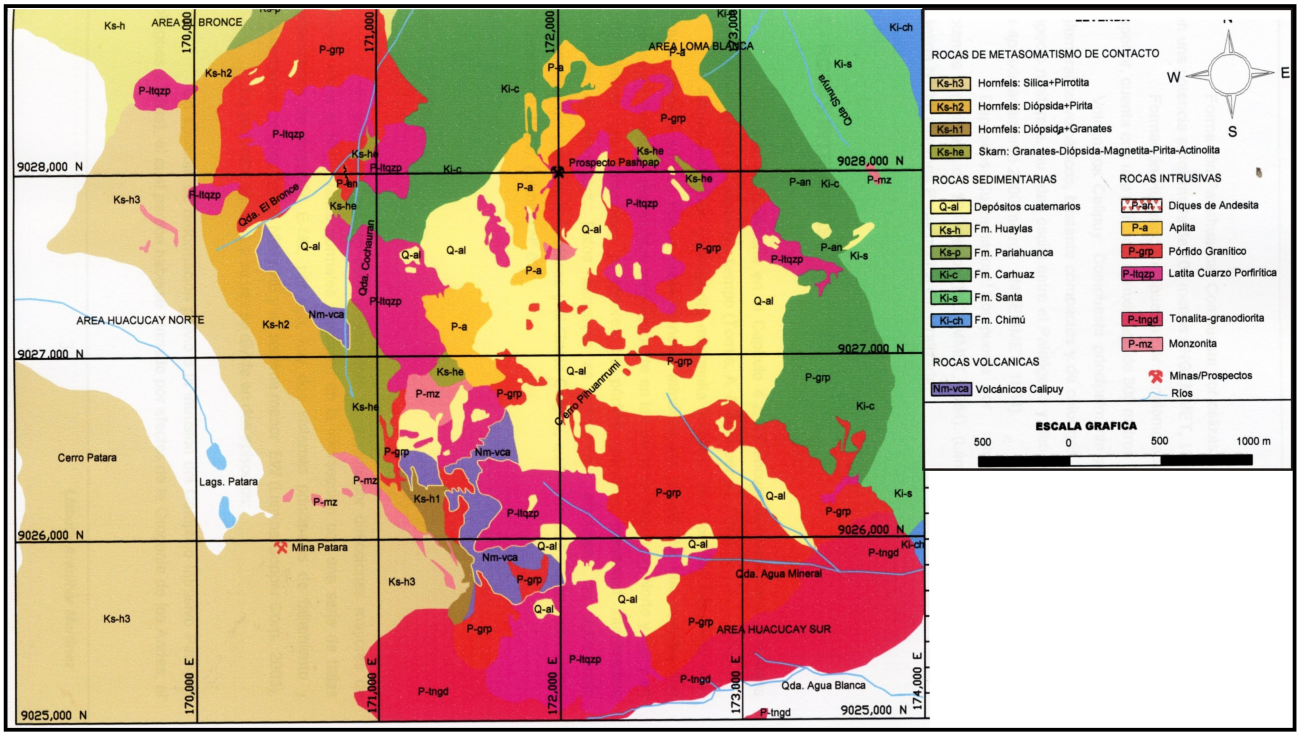


Fig. 3.18 Geological Map (Aranibar, 2006)

The most important regional structures are anticlines and synclines which axis dips slightly to the southeast and northwest, the strikes are approximately N30W and are parallel to the Cordillera de los Andes structures. Normal-inverse faults and strike slips are parallel to the direction of the regional folding.

Two important faults have been recognized in the Pashpap area, and these are: Alicia and El Bronce (Fig. 3.19). The first is a normal fault with strike east-west and dip 65ºN. The second is normal too with strike N10ºE and dip 70ºNW, which is displacing an andesitic dike in Pico Portachuelo town, the granodiorite, the porphyritic dacite and the strike of the Alicia fault in the Pashpap area.

Five magmatic centers are recognized, which control the hydrothermal alteration and mineralization: El Bronce, Huacacuy norte, Huacacuy sur, Loma Blanca y 12 de Octubre.

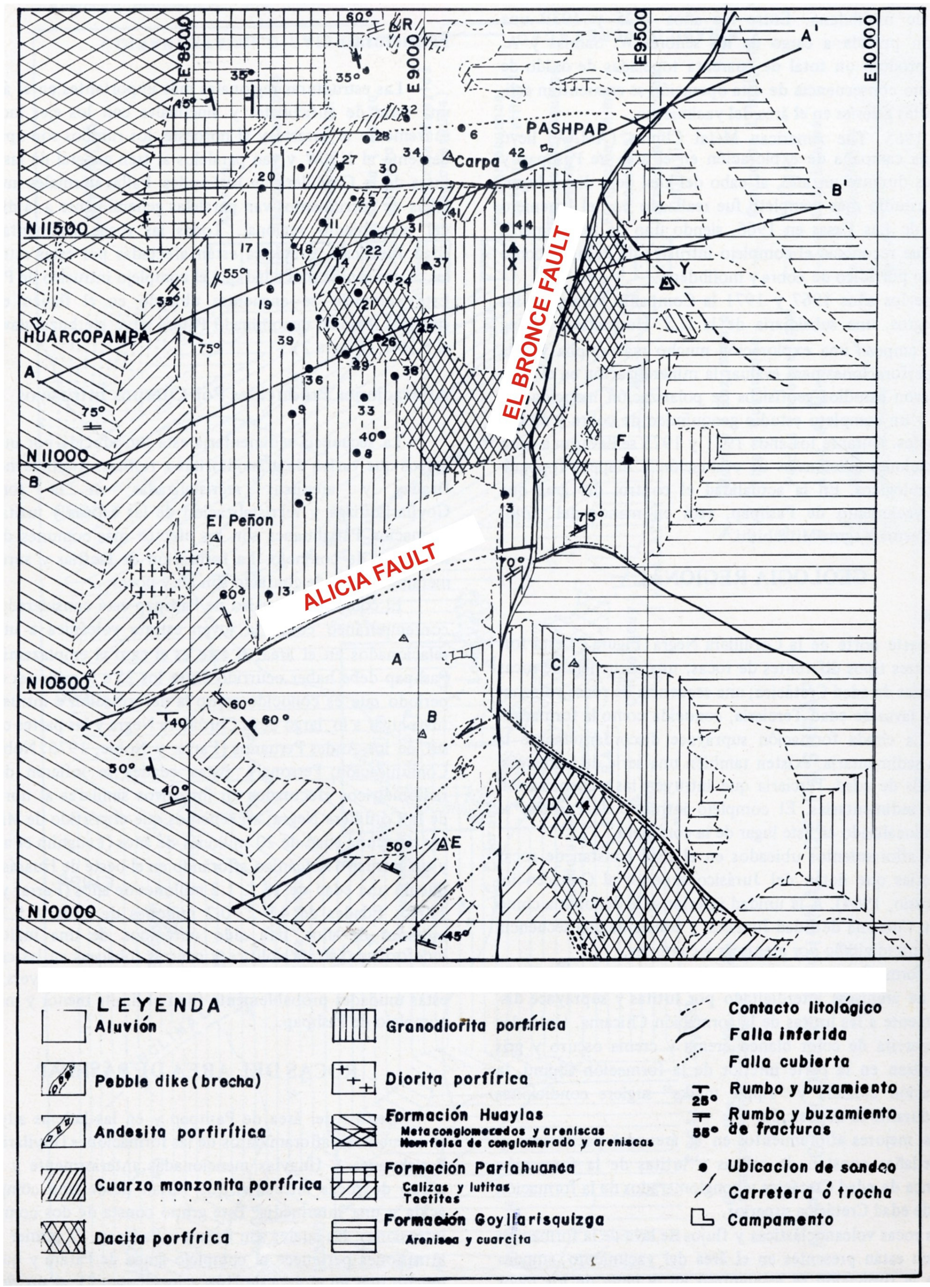


Fig. 3.19 Structural Map (Escarrachi, 1979)

The hydrothermal alteration is zoned. The Bronce area presents alteration of K-silicates, with hydrothermal biotite in veins accompanied by pyrite, chalcopyrite and molybdenite. A mixed zone is enveloping the alteration of K-silicates, which consists in phyllic alteration with K-silicates relicts. It is frequent the occurrence of quartz-sericite, pyrite, chalcopyrite and molybdenite stockwork veins (Torres, A. and Enríquez A., 1997). (Fig. 3.20).

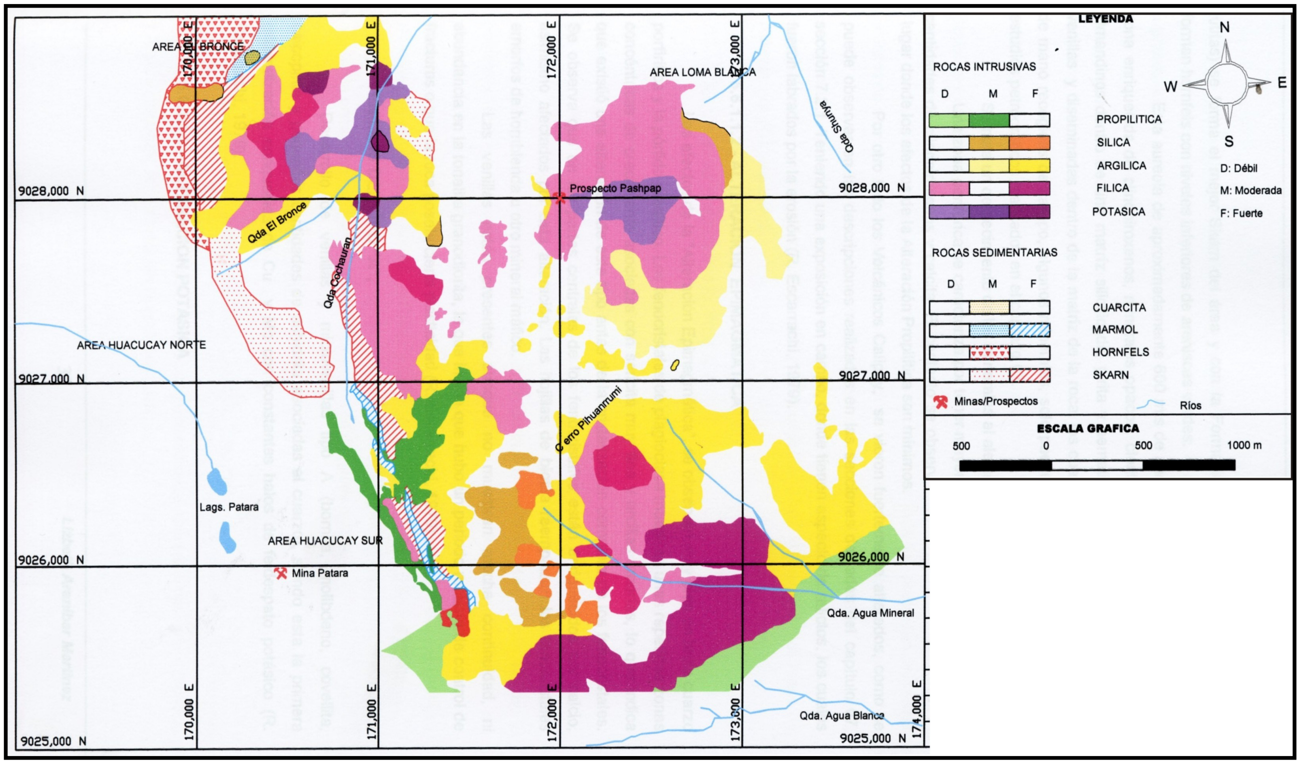


Fig. 3.20 Alterations Map (Aranibar, 2006)

OCROS

The Ocros area is located in the “Pucallpa “town, district of Ocros, province of Bolognesi and department of Ancash, between 4300 to 4700 m (Fig. 3.21) above sea-level. The area is delimited by the next geographical coordinates: 10º17’11’’ – 10º18’16’’ of south latitude and – 77º18’11’’ - 77º19’17’’ of west longitude.

The geological regional setting in the area of Ocros is defined by rocks of the lower Cretaceous-lower Tertiary to Holocene. The first two are represented by volcanic-sedimentary, volcanics and hypabyssal intrusive; the third are represented by alluvial and moraine deposits.

The oldest rocks belong to volcanic-sedimentary sequence; these are showed in form of lavas and andesitic pyroclastic rocks with some layers of sandstone, lutites and white quartzites of the Casma Formation (Cosio, 1964). Overlying to this formation in angular disconformity is the Calipuy Group which is constituted by andesite and dacite rocks in massive form (Fig. 3.22).

The volcanic-sedimentary sequence described is cut by plutonic and hypabyssal rocks that show the intense magmatic activity in the zone. These rocks are showed in form of stocks or as small bodies that constituted ramifications or apophysis of the Coastal Batholith. The hypabyssal rocks consist in dacite, rhyodacite and quartz porphyry.

Fig. 3.21 View of Ocros Prospect

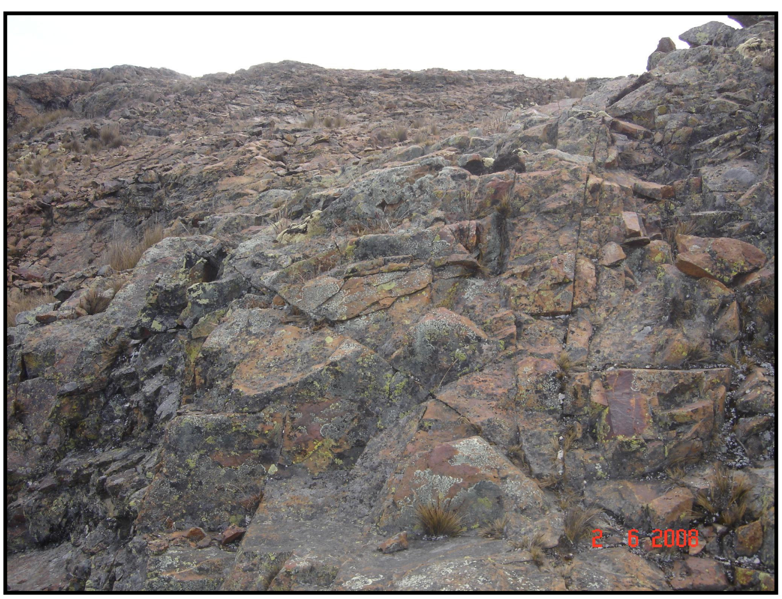


Fig. 3.22 Andesitic rocks of the Calipuy Group

Structurally the area is dissected by normal faults with strike N-S, NW-SE and little displacement mainly affect the volcanics of the Calipuy Group. There are two main systems of faults: The first system with strike N 60º-70º E and dip 70º-80º SE, and the second system with strike N 60º-85º W and dip 75º-80º SW.

Ocros is a porphyry of Cu-Mo (± Pb,Zn), with mineralization of molybdenite, pyrite, chalcopyrite, galena and pyrrhotite.

Three types of hydrothermal alteration were recognized: Phyllic, silicification and propylitic. The first alteration is present in the center of the dacitic stock and is constituted by minerals of quartz-sericite, tourmaline and clay. This alteration is related to molybdenite with quartz and pyrite. The second alteration (silicification) is joined to pyritization with high content of tourmaline. Finally the propylitic alteration is the mayor distribution in the area and is constituted by pyrite, chlorite, calcite and clay.

3.1.3 Skarns

ANTAMINA

Antamina is Cu-Zn skarn deposit located in the central Andes of northern Perú at latitude 9º32’17’’ south and longitude 77º03’51’’ west, between 4300 and 5073 m in elevation, and 270 Km north of Lima and 130 Km east of the Pacific Ocean (Fig.3.23). The topography is characterized by steep northwest trending ridges, deep canyons, and short glacial valleys with lakes. Politically, Antamina lies in the Distric of San Marcos, Province of Huari and Department of Ancash. The nearest town is San Marcos, 10 Km to the west at an elevation of 2964 m.

The Antamina mining company is one of the most important companies of the great Peruvian mining. Antamina has become one of the largest national producers of copper and zinc concentrate and is one of the largest exporters of Peru. Also produces lead, silver and molybdenum.

Antamina mining company S. A., is a company incorporated in Peru whose shareholders are four leading companies in the international mining:

Xstrata with 33.75%, BHP Billinton Plc with 33.75%, Teck/Cominco Limited: 22.5% and Mitsubishi Corporation: 10%.

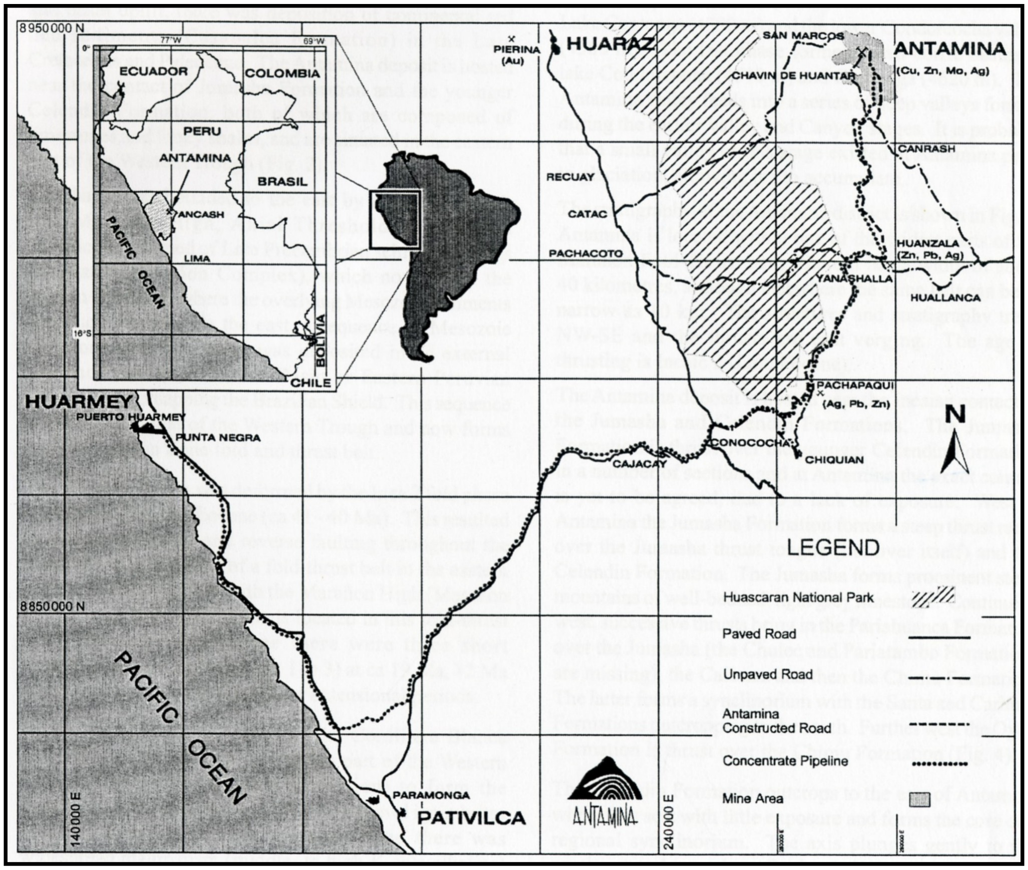


Fig. 3.23 Location Map (Lipten and Smith, 2005).

The host rocks of the Antamina deposit are formed by a sequence of limestone, marl and calcareous siltstones of the Celendín Formation of upper Cretaceous age, which are intruded by many apophysis of a porphyritic intrusive of the Miocene. Both the rocks of the Celendín Formation and calcareous layers and clastic of the formations underlie the lower Cretaceous are folded with faulting of overthrust that follow a general direction northwest (Fig. 3.24).

The skarn deposit is developed around the Antamina intrusion (9.8 Ma; McKee et al., 1979; 10.34-10.27 Ma; Love et al., 2003a), a multiphase, quartz monzonite porphyry. Numerous intrusive phases were identified during core logging, with relative ages being shown by grouping them as early-interlate and postmineral in timing, in addition to several dike phases (Sillitoe, 1997). All the quartz monzonite porphyry phases contain phenocrysts of plagioclase, quartz, biotite, orthoclase, and lesser hornblende; some have megacrysts of orthoclase up to 10 cm long. Intrusion within each relative age group tend to have evolved to more potassic compositions, as shown by orthoclase phenocrysts or megacrysts in the later phases. Early mineral intrusions form the central part of the stock, with inter and late mineral intrusion emplaced around the margins. A late mineral intrusion forms the main Valley and Usu Pallares dikes (Fig. 3.25).

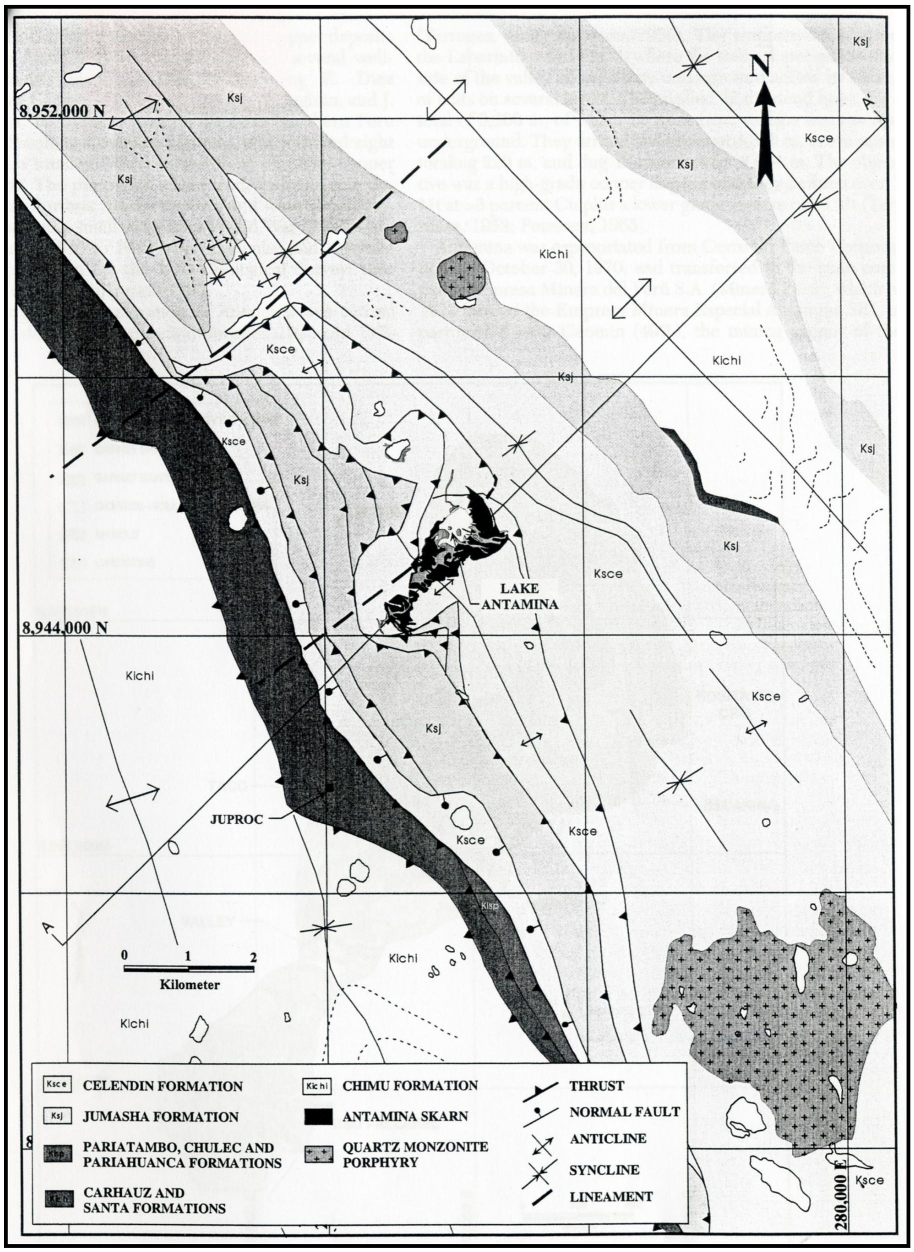


Fig. 3.24 Geological Map (Redwood, 2004).

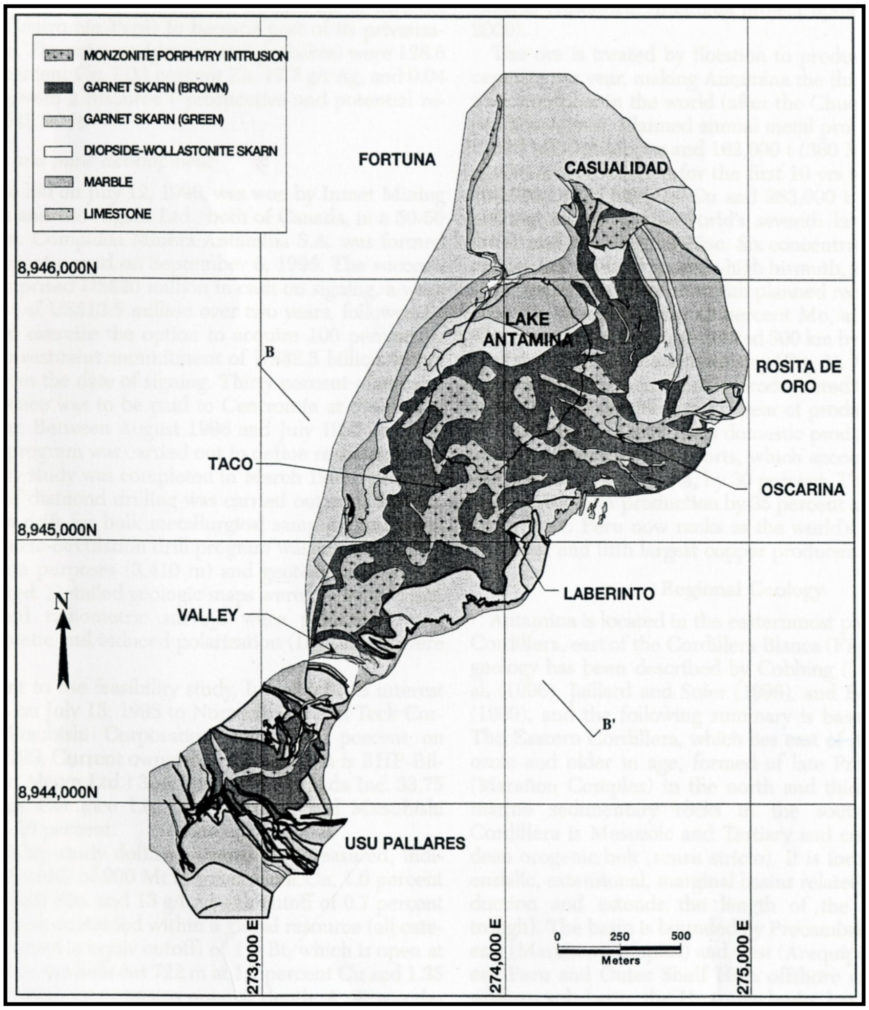


Fig. 3.25 Geology of Antamina copper-zinc skarn deposit, showing locality names (Redwood, 2004)

Structure is the main control on both intrusion and skarn alteration at Antamina (Fig. 3.26). The main deformational period is thought to be Incaic (43-42 Ma; Mégard, 1984), although the district has also potentially been subjected to three later compressive events at 19 Ma, 12 Ma and 6 Ma, that are noted regionally and are termed Quechua 1, 2 and 3 (Q1, Q2 and Q3) respectively (McCuaig, 2003).

The thrust sequence developed during the Late Eocene, Incaic 2 phase (41-40 Ma) is northeast verging. The Antamina deposit is situated within a localized thrust tongue formed by at least six flat-lying thrust sheets. This tongue is 3 km wide by 3 km long, although it may have had a greater original extent. The thrust sequence is an imbricate stack, which has resulted in a super thickening of the favourable host rocks (Jumasha) in the area.

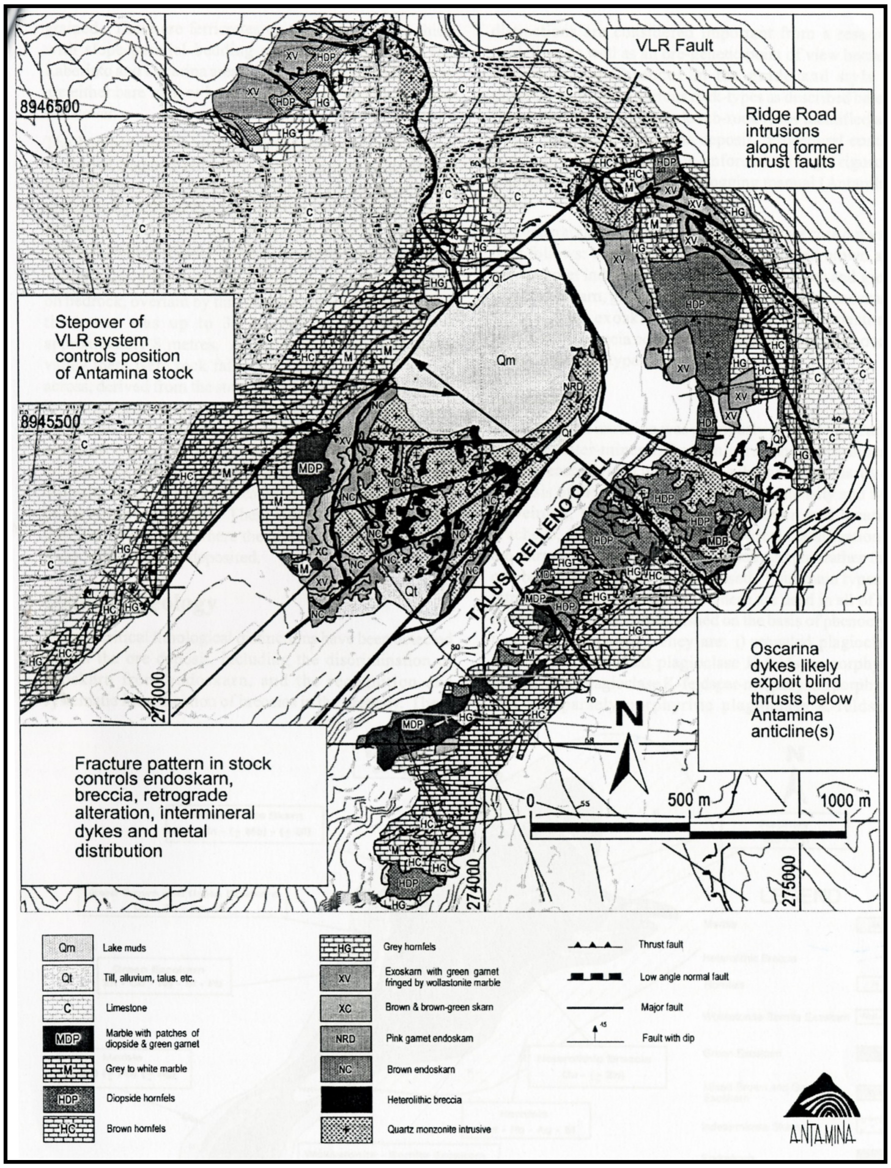


Fig. 3.26 Structural Map (Lipsen and Smith, 2005).

A NE-SW striking longitudinal fault (the VLR fault of Love et al., in review) is the oldest structure in the mine area. This structure initially underwent compression (Fig. 3.27). During subsequent extension it controlled part of the intrusion and the Antamina valley (Fig. 3.28) where it is exposed below a later thrust at the head of the valley.

Temporally, the Antamina stock was emplaced between the Q2 and Q3 compressive events. The final phase of Q3 compression is noted in the mine, particularly in the

Oscarina area, where it is represented by moderately to shallow-dipping thrusts postdating all alteration and mineralization.

Very localized extension occurred on the southeastern side of the present day Antamina valley, accommodated by listric faulting and by strike-slip movement along the main NE-SW longitudinal fault. This minor extensional phase may be correlated regionally with the Quechua 2 phase. The Antamina intrusion are interpreted to have been controlled by the listric faults as they are seen to occupy postulated fault planes in the limestone above the deposit. Within the deposit no obvious sing of this faults remain as their loci are now completely obliterated by intrusion and skarn.

Within the skarn and intrusions there are zones of brittle breakage and slickenside surfaces, although no significant post-mineral fault displacement have been identified.

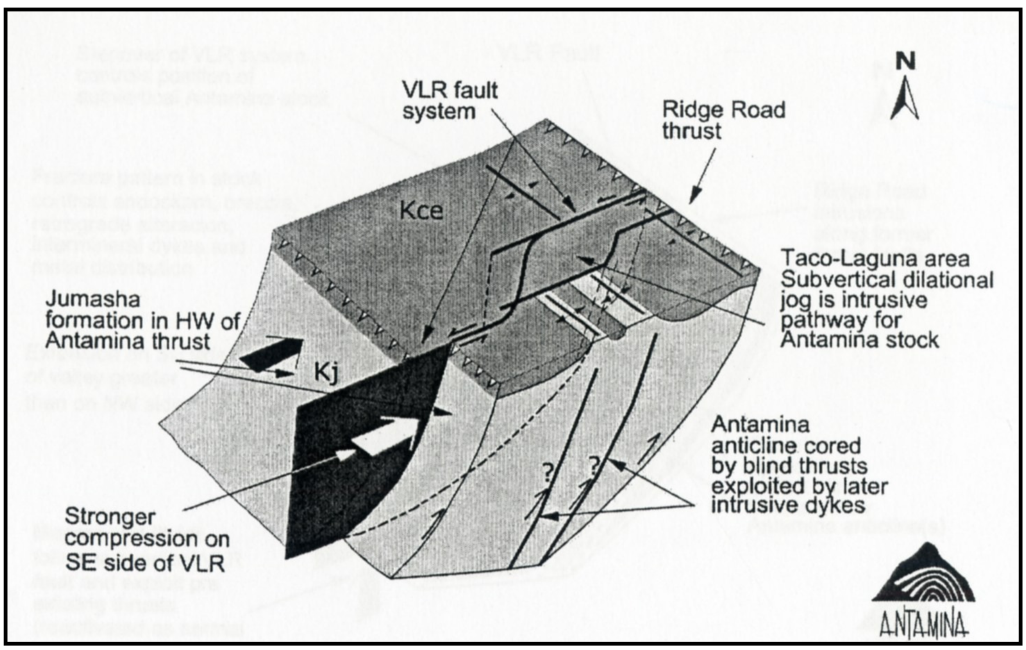


Fig. 3.27 Schematic diagram of VLR Fault during compression (Lipsen and Smith, 2005)

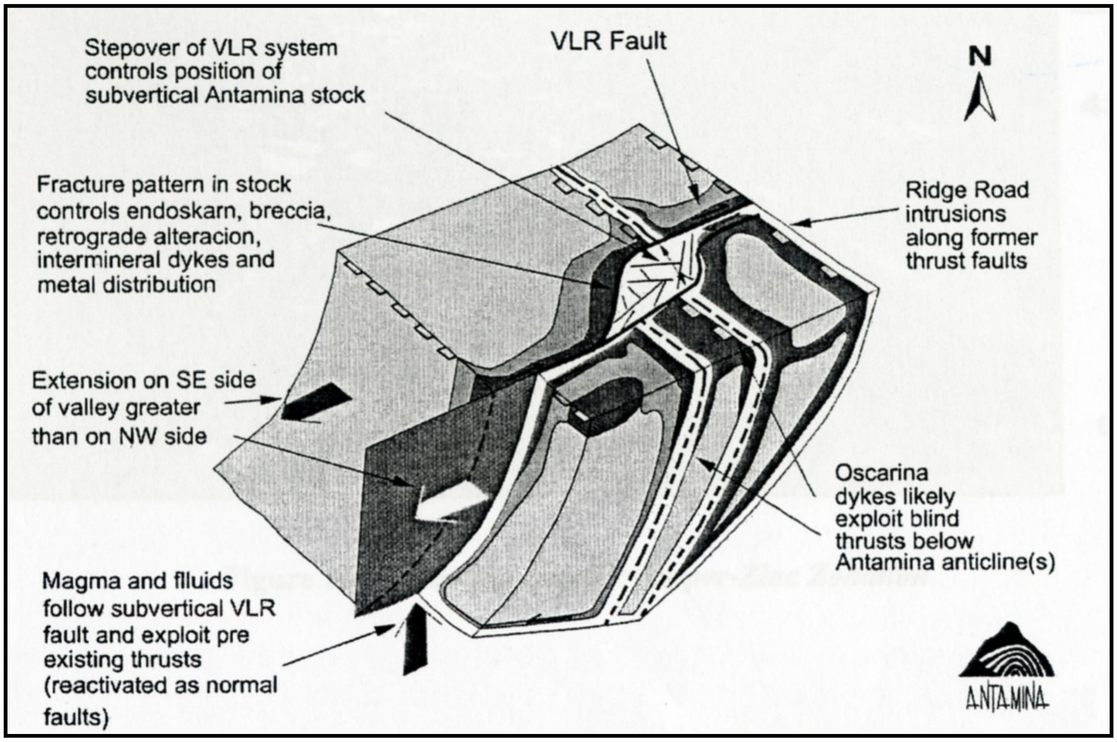


Fig. 3.28 Schematic diagram of VLR Fault during extension (Lipsen and Smith, 2005).

The early, inter and late mineral intrusive phases were affected by potassic alteration, which decreases progressively in intensity as the phases become younger. In core, the potassic alteration is characterized by fine grained, red brown hydrothermal biotite in the groundmass and metastable black biotite phenocrysts. Thin sections also show K-feldspar in the groundmass, as coronas to plagioclase, and in veinlets. A and B type quartz veinlets containing pyrite, chalcopyrite, and molybdenite accompany the potassic assemblage. Veinlet density is highest in the oldest intrusions and decreases progressively as they become younger.

Phyllic alteration is poorly developed although widespread. It is generally characterized by weak to moderately intense alteration of plagioclase, biotite (magmatic and hydrothermal), and porphyry groundmass. The altered plagioclase has a pale to strong green, beige, or white color. The alteration assemblage includes sericite, muscovite, clay, chlorite, and calcite. The sericític alteration is sporadically developed, and remnants of preexisting magmatic and potassic alteration minerals are abundant. Silicification may occur, typically as a selvage to D type quartz pyrite veinlets, which are abundant only in the Oscarina area (Fig. 3.25) where they are narrow (1 cm) and parallel. An unusual variety of phyllic alteration is found locally, typified by leached quartz phenocrysts in a strongly silicified groundmass, with purple to colorless fluorite found in veinlets and as filling of the leached quartz vugs.

There is no definable zone of propylitic alteration at Antamina, although chlorite and calcite are present in parts of the phyllic alteration assemblage and, locally, the biotite is chloritized. Hydrothermal alteration has been dated at 10.18 to 9.75 Ma (Love et al., 2003a)

PUCARRAJO

Pucarrajo polimetalic skarn of Zn-Pb-Ag located in the central Andes of northern Perú at latitude 9º49'37'' south and longitude 77º05'49'' west, between 4400 and 5000 m in elevation, to 425 Km north of Lima (Fig. 3.29). Politically, Pucarrajo lies in the District of Huallanca, Province of Bolognesi and Department of Ancash

The Pucarrajo mining unit belongs Minera Huallanca SAC, which is a small mining company constituted by peruvian entrepreneurs. Nowadays, the unit Pucarrajo is constituted by eleven mining concessions called Lucero, Maria del Pilar, Maria del Pilar Numero Tres, Maria del Rosario, Maria del Rosario Numero Tres, Maria del Rosario Numero Cinco, Maria del Rosario Numero Seis, Nuevo Perú, Santa Juana Cuatro, Santa Juana Numero Tres and Excepción Santa Juana Numero Cinco, in addition to the two mining concessions Mina Tuco and Grall.

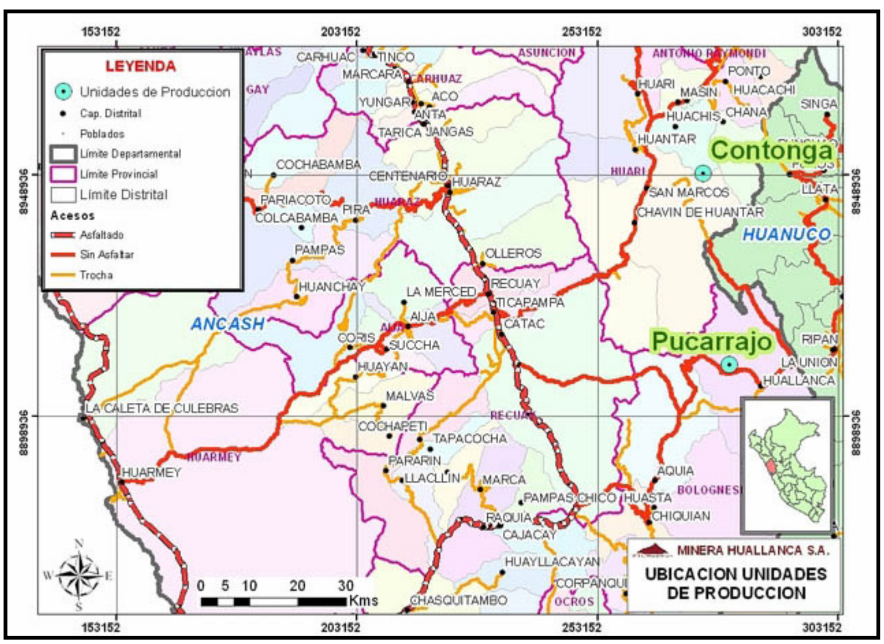


Fig. 3.29 Locataion Map

This deposit is originated by metasomatic replacement emplaced in the lower albian limestone sequences of Chulec Formation, in which have been formed irregular bodies, mantels and veins, to temperatures of mesothermal to epithermal deposition.

Pucarrajo is located in a sedimentary basin folded in anticlines and synclines some symmetrical with Andean orientation NW-SE, this basin presents lower to upper cretaceous formations. These formations from the oldest to the most recent are: Chimu, Santa, Carhuaz, Farrat, Pariahuanca, Chulec and Pariatambo. All formations have been intruded for the Ishpag stock, which composition varies of granodiorite to diorite. This stock in contact with the sedimentary formations caused the hydrothermal metamorphism. The ore minerals are constituted by marmatite, galena and in few quantities by chalcopyrite accompanied by the pyrrhotite, pyrite and magnetite.

CONTONGA

The Contonga Mine is located to NE of San Marcos town, province of Huari, department of Ancash, approximately to 470 Km to NE of Lima and 10 Km to north of Antamina mine (Fig. 3.29). Geographically Contonga is located in the oriental flank of the Cordillera Blanca to 4300 m, the geographical coordinates are: 77º04'20'' west longitude and 9º29'40'' south latitude (Fig. 3.30). Both Pucarrajo and Contonga mine belongs Minera Huallanca SAC

Nowadays, the unit Pucarrajo is constituted by fifteen mining concessions called Contonga Nº 1, Contonga Nº 2, Contonga Nº3, Contonga Nº4, Contonga Nº 5, Contonga Nº 6, Delicias, La Florida, La Inmaculada, Prosperidad, Prosperidad Numero Dos, Flor de Contonga Uno, Contonga Trece, Contonga 15 y Contonga 16. The approximate area of these concessions is 1550 hectares

Contonga is a skarn with mineralization of Ag, Pb and Zn. In the area there are outcrops of limestones forming anticlines and synclines, which axis have a direction NW to SE. The sedimentary rocks are represented by clastic formations of the lower cretaceous (Goyllarisquisga Group), limestone, limolite and lutite of the Chúlec Formation, limestone of the Pariatambo Formation, limestone, mudstone and graywacke of the Jumasha Formation, and finally limestone and marl of the Celendín Formation (Fig. 3.31). These sedimentary sequences are cut by alignment of intrusive rocks which direction is NW-SE, this intrusive bodies are extended by 15 Km. The intrusive rocks appear as "stocks" in the sector of Contonga (Contonga Stock), and to the south of this (Taully Stock).

Fig. 3.30 View of Contonga Mine

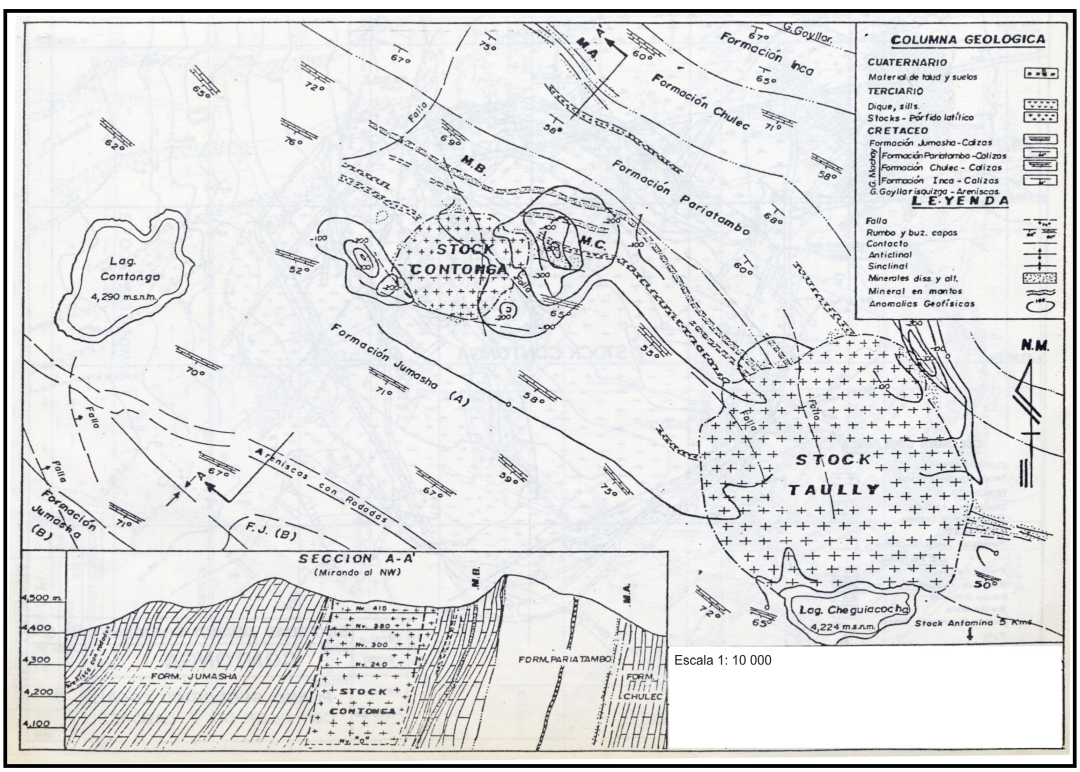


Fig. 3.31 Geological Map

The Taully stock is dacitic porphyry and is similar to the Contonga stock but has less alteration and mineralization. This stock has 800 m of diameter in the surface and cut the limestones of the Pariatambo and Jumasha formations. The Contonga stock is monzonite porphyry constituted by phenocrysts of plagioclase, feldspar and quartz within groundmass of k-feldspar, sericite and plagioclase (Miranda, 1980; Montreuil, 1982-1983).

The limestones of the middle-upper Cretaceous at Contonga are strongly folding and form the southwest flank of the anticline, the direction of the limestone stratification is N 65º-70º and 50º-75º SW dipping. In the area exits 4 main fault systems and fractures pre minerals with reactivation post-intrusive and post-mineralization (Cayetano, 1979), these systems are:

System Nº1: Direction N 55º-60º W, dip 60º-85º SW. This area correspond the zone NW and SW of Contonga and consist of breccias with high content of mineral.

System Nº2: Direction N 50º-60º W, dip 60º-80º SW. This system consist extension fractures.

System Nº3: Direction N 25º-30º W, dip 70º-85º SW.

System Nº4: Direction N 20º-30º E, dip 50º-65º NW.

These two systems consist of extension fractures and these would have generated to the continued efforts of compression that folding of the rocks.

The alteration - mineralization is related to the intrusives, which cut the sedimentary sequence and in the contacts with the calcareous produce a skarn. Skarn mineralization presents grains of sphalerite, galena, pyrite, chalcopyrite and occasionally tetraedrite, the first increase in depth.

3.1.4 Stratabound

HUANZALÁ

The Huanzala mine is located in central Perú on the southeast flank of the Huayhuash Cordillera, about 80 Km SE of the town of Huaraz and 250 Km north of Lima. Politically Huanzala lies in the district of Huallanca, province of Bolognesi and department of Ancash, between 3900-4500 m. above sea level (Fig. 3.32). Huanzala mine belongs

Santa Luisa S.A. mining company and its owners are Mitsui Mining & Smelting Co. Ldt (70%) and Mitsui & Co Ltd (30%), both are Japanese companies.

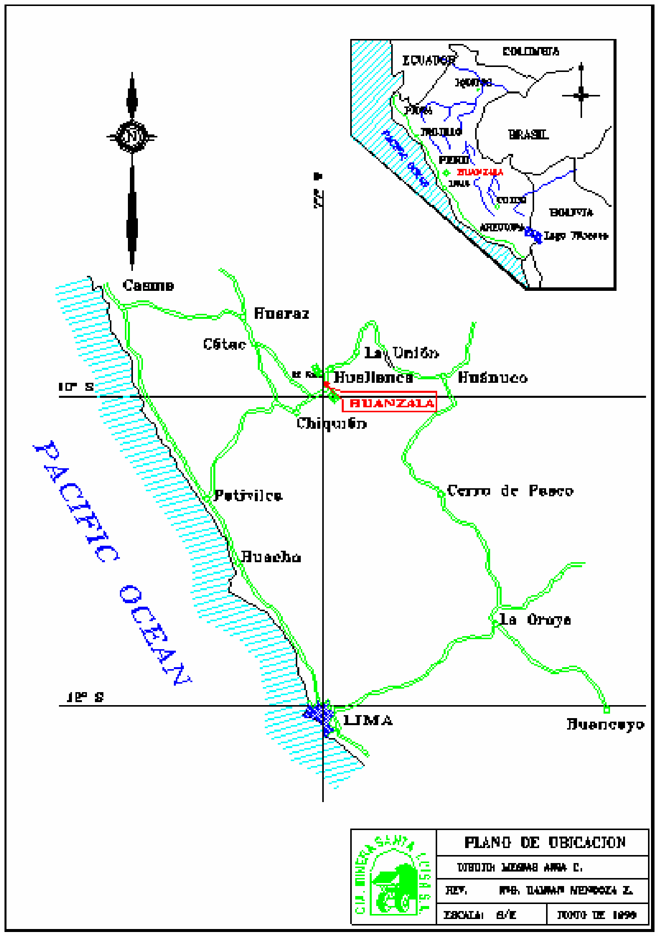
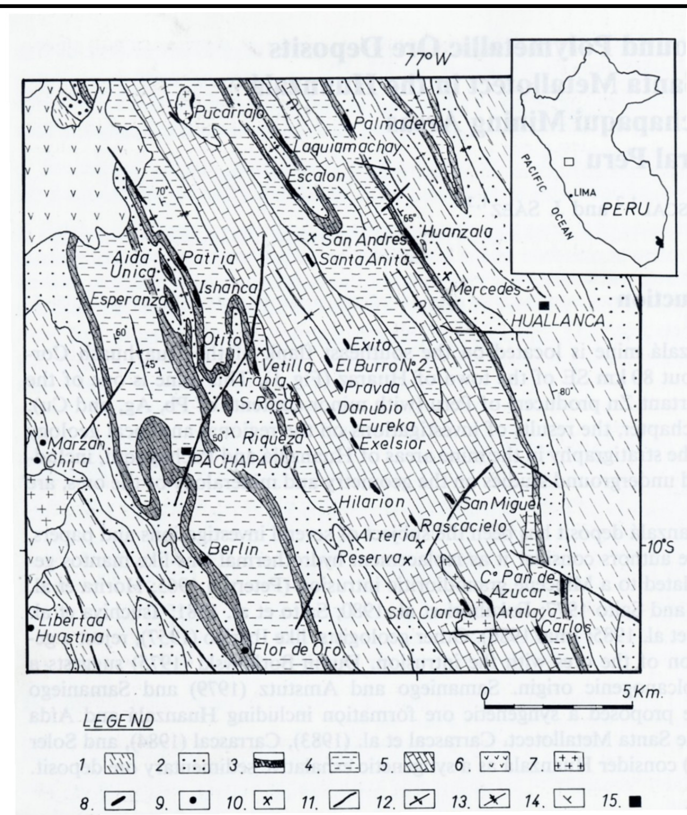


Fig. 3.32 Location Map

The Huanzalá is a stratabound ore deposit located at the eastern border of the Santa Basin. In the mining area, the Cretaceous sedimentary rocks are, from the bottom to top, chert (Chimu Formation), limestone (Santa Fornation), and an alternating unit of sandstone and slade (Carhuaz Formation) (Fig. 3.33). Bedding in these rock units strikes N 20º-40º W, and dips 70º-80º NE. The strata were intensely folded during the Andean orogeny about north-northwest-trending anticlinal and synclinal axes. The Huanzalá mine is located in the eastern inverse limb of an inverted syncline, whose axis trends N 30º-35º W with 70º NE dip and SE plunge (Fig. 3.34).

Sheet dikes of Miocene or Pliocene intrusive rocks were emplaced in this area (stewart et al., 1974). Granodiorite porphyry in form of laccolith was intruded into the Chimu Formation just to the east of the mine while in the Santa Formation this intrusive is showed in form of dikes and sills parallel to the stratification. The absolute age of the granodiorite porphyry is 9.2 ± 0.5 m.y. by the K-Ar method (Stewart et al., 1974). The stock has an ellipsoidal shape with about 2 Km. in length and 200 m. wide, the sills and dikes have varying widths between 2 m. to 50 m. with a total exposure approximately of 6 Km.. Quartz porphyry, perhaps an offshoot of the granodiorite porphyry, occurs as a sheet dike along the ore deposit. The quartz porphyry was subjected to sericitizacion. The absolute age of the quartz porphyry is 7.7 ± 0.4 m.y., based on K-Ar analysis, which represents the age of sericitizacion. The age data on the acidic intrusions in the mining area agree with the geologic descriptions prepared by Stewart et al. (1974).



Generalized geologic map of the Huayhuash Cordillera showing the localization of stratabound mineral occurrences (Afer Dunin-Borkowski 1975). 1 Chicama and Oyon Formations (Jurassic); 2 Chimu Formation (Berrasian-lower Valanginian); 3 Santa Formation (Upper Valanginian); 4 Carhuaz and Farrat Formations (Hauterivian-lower Albian); 5 Pariahuanca, Chulec, Pariatambo and Jumasha Formations (Lower Albian-Cenomanian); 6 Calipuy volcanics (Upper Cretaceous-Tertiary); 7 Intrusives (Upper Cretaceous-Tertiary); 8 Stratabound stratiform ore deposits; 9 Ore deposits of unknow geometry; 10 Non-stratabound ore deposits; 11 Fault; 12 Anticline; 13 Syncline; 14 Bedding; 15 Location of town. (Carrascal and Saez, 1990)

Fig. 3.33 Geological Map

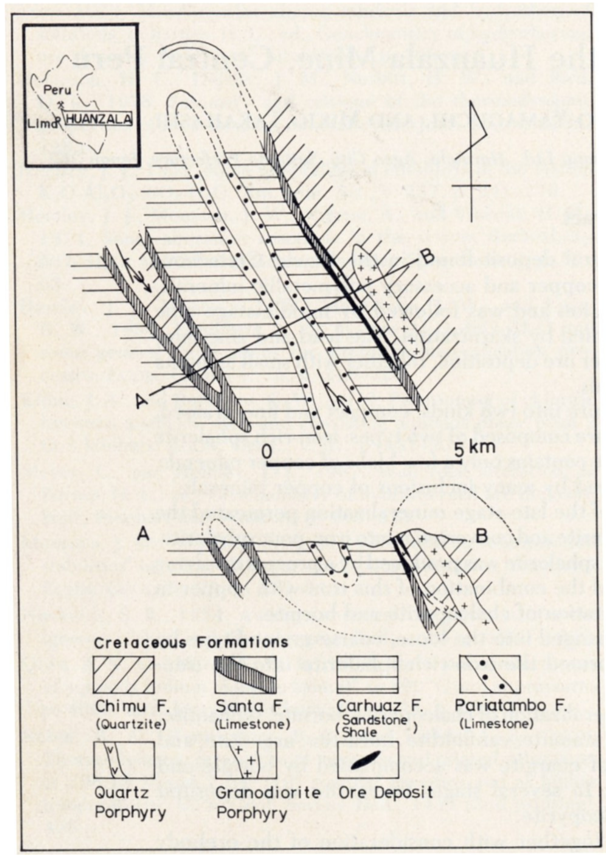
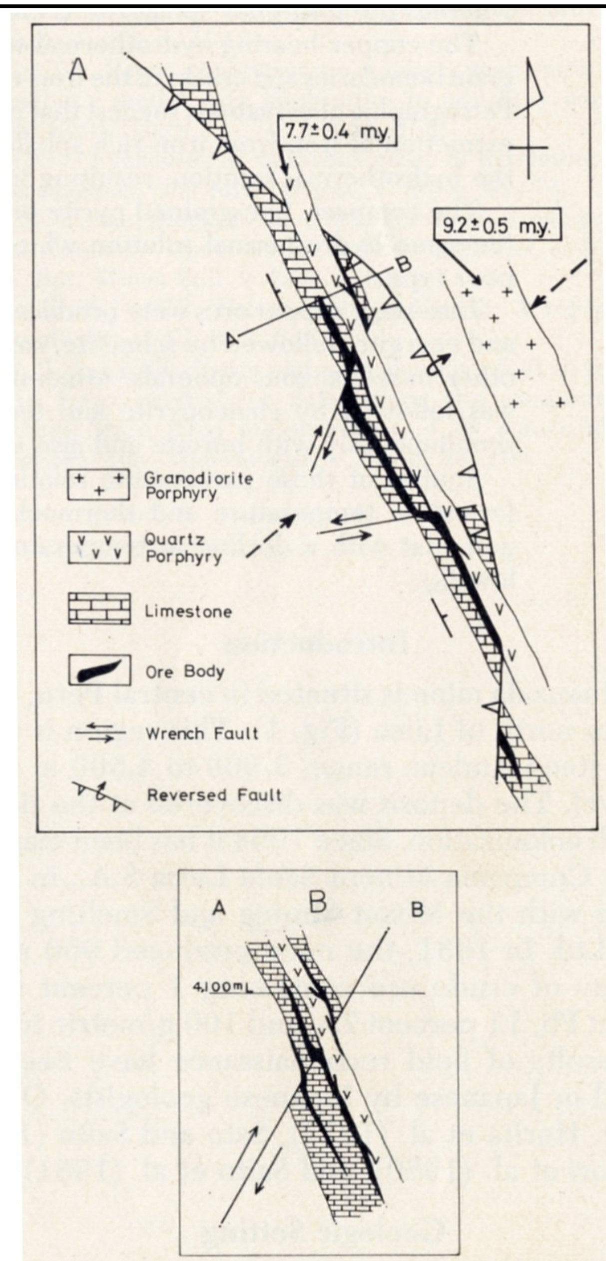


Fig. 3.34 Section of the Huanzala mining area (Imai et al., 1985)

The sedimentary rocks in the mining area are displaced by two main faults (Fig. 3.35). One is a group of thrust faults, running N 30º-40º W with a dip of 40º-60º SW. The other is a conjugate pair of wrench faults, striking N 20º E and N 80º E with steep dips. The two kinds of faults were formed by the lateral pressure that caused the regional folded structure. There is a thrust fault (inverse fault) known as the “Lower Fault” with other minor parallel faults in Huanzalá Sur decreasing to Recuerdo which have a good influence on the concentration of the economic mineralization because they have served as conduits (Fig 3.36 and 3.37). The quartz porphyry sheet dike runs across these faults with no displacement, indicating that the intrusion of quartz porphyry occurred after formation of the faults.



A schematic representation of the relationship of the fault systems and igneous rocks at the Huanzala mining area: (A) plan, (B) section. The numerals in (A) represent the absolute ages of the igneous rocks. The broken arrows in (A) indicate the direction of the lateral pressure. The arrows in (B) represent the displacement of the thrust fault.

Fig. 3.35 Structural section (Imai et al., 1985)

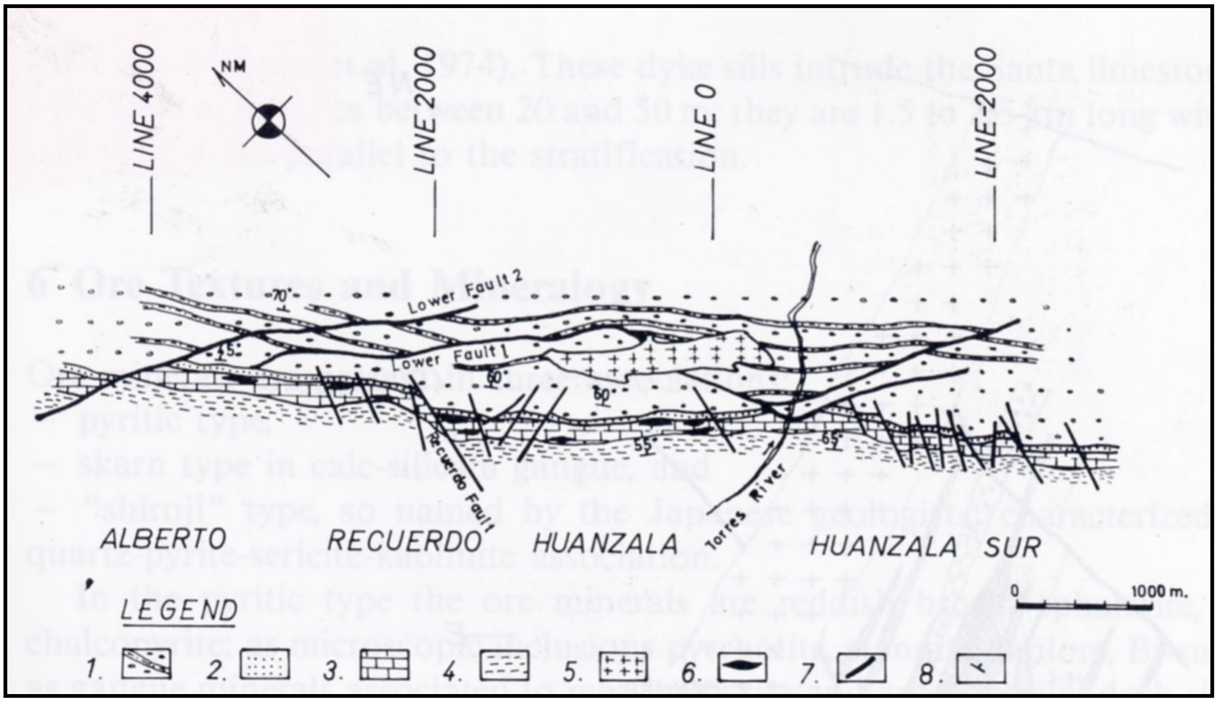


Fig. 3.36 Geologic map of Huanzala mine (After Saito et al. 1981). 1 Shale quartzite (Chimu Foramtion); 2 Sandstone (Lower Santa Formation); 3 Limestone (Upper Santa Formation); 4 Shale and quartzite (Carhuaz Formation); 5 Granodiorite porphyry (Miocene); 6 ore lenses; 7 Fault; 8 Bedding (Carrascal and Saez, 1990).

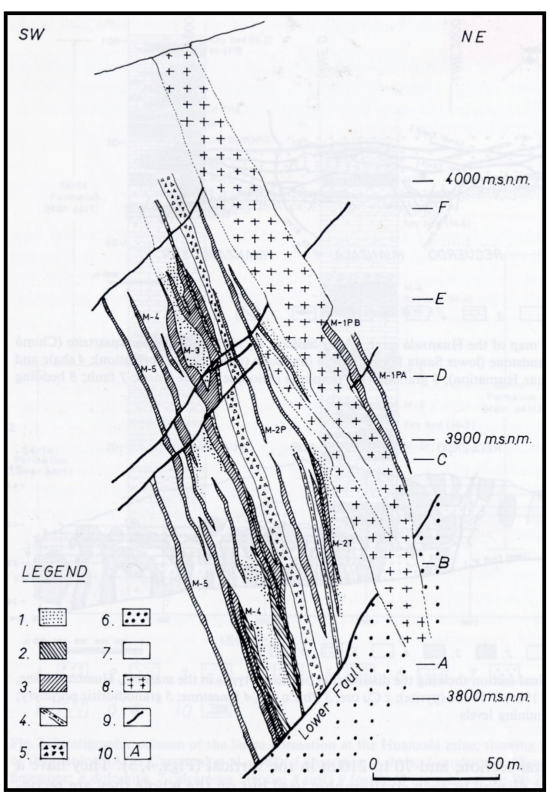


Fig. 3.37 Geologic cross-section along the 280-295 line in the Huanzala mine. (After Carrascal, 1984). 1 Fe ore (piryte); 2 Cu ore; 3 Pb-Zn ore; 4 Key bed; 5 Calcareous breccias; 6 Sandstone (Lower Santa Formation); 7 Limestone (Upper Santa Formation); 8 Granodioritic Porphyry; 9 Fault; 10 Mining level (Carrascal and Saez, 1990).

The ore bodies of Zn, Pb, Ag and Cu are present in form of mantos, lens-shaped and massive into the 5 veins (Fig 3.38). Veins 1, 2, 3 and 4 in Santa Formation and the vein 5 in Carhuaz Formation with strike N 30º-50º W and 50º-70º NE dip.

There are 3 zones of mining operations, front NW to SE: The Carlos Alberto zone, Recuerdo - Huanzalá Superior and finally Huanzalá Principal-Huanzalá Sur.

The Pb-Zn mineralization has been divided into 3 types:

Pb-Zn minerals into pyrite

Pb-Zn minerals into skarn

Pb-Zn minerals into Shiroji (Argillic alteration)

The Shiroji mineral is produced by hydrothermal alteration of minerals of pyrite and skarn.

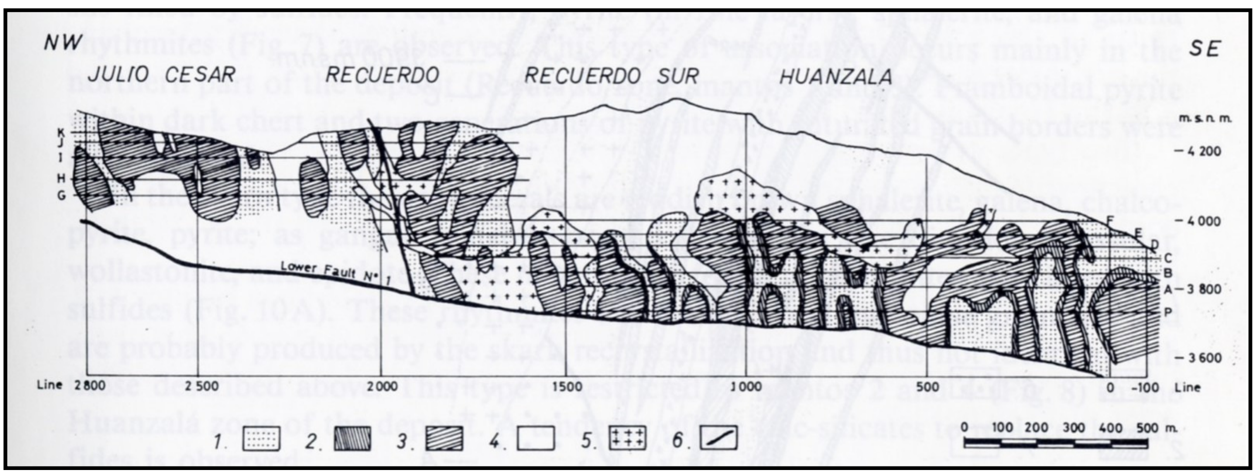


Fig. 3.38 Longitudinal section showing the distribution of the ore types in the manto3, Hunazala mine. (After Carrascal 1984). Fe ore (Pyrite); 2 Cu ore; 3 Pb-Zn ore; 4 Limestone; 5 Granodioritic porphyry; 6 Fault; A to P mining levels (Carrascal and Saez, 1990).

3.1.5 POLYMETALLIC DEPOSITS

TUCO CHIRA

Tuco Chira is a mining district located in the south end of the Cordillera Blanca, to 20 Km to the NE of the Conococha lagoon (Fig. 3.39). The zone is between 4500 to 5000 m. obove the sea-level. Politically Tuco Chira belongs to province of Recuay and department of Ancash.

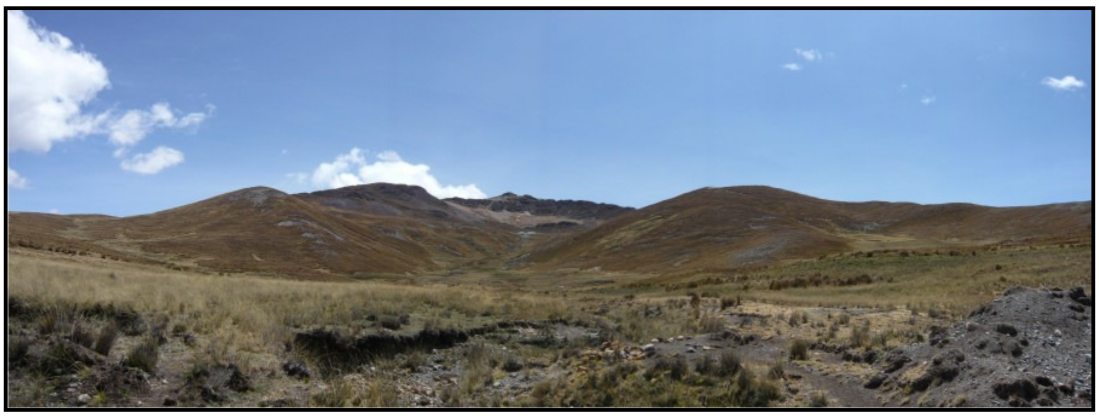


Fig. 3.39 View looking to south of Tuco Chira Prospect

In the area outcropping sedimentary and volcanic rocks, the first group consist in sequence of sandstones, lutites and shist with some layers of limestone of the Goyllarisquisga Group (Cretaceous). The volcanics rocks belong to Calipuy Group (Cenozoic), and can be grouped in two members (Fig. 3.40). The lower member is constituted by sequence of rhyolitic, rhyodacitic and dacitic flows, with intercalation of some sedimentary material horizons. The upper member is lacustrine and is conformed mainly by andesitic flow with porphyritic texture.

These rocks have been intruded by granodioritic stock, many dikes and small, irregular stocks of granitic porphyry, sills of rhyolitic porphyries and dikes and sills of andesite.

Fig. 3.40 Small mining tunnel, the volcanic rocks of the Calipuy Group are very fracture.

The rocks have been folding and faulting with main strike NE-EW. As result of this compression many of the rocks that outcropping in the area are fractured.

The mineralization is present in form of polimetalic veins of Pb,Zn,Cu (Ag±Au), with strike to NE and dipping to NW. The ore minerals are Galena, sphalerite, chalcopyrite, tetraedrite and as gangue mineral are pyrite, quartz and calcite.

AIJA – TICAPAMPA

The Ticapampa mining district is located in the department of Ancash, in the Cordillera Negra (Fig. 3.41).

The mayor part of the area is covered by andesitic volcanic rocks of the Calipuy Group which have been intruded by acid porphyries called Collaracra, Jinchis and Tarugo, all of them of the Cenozoic. The breccias recognized in the zone are tectonic breccia and hydrothermal breccia, these structures were originated by the ascent of magmatic fluid to surface.

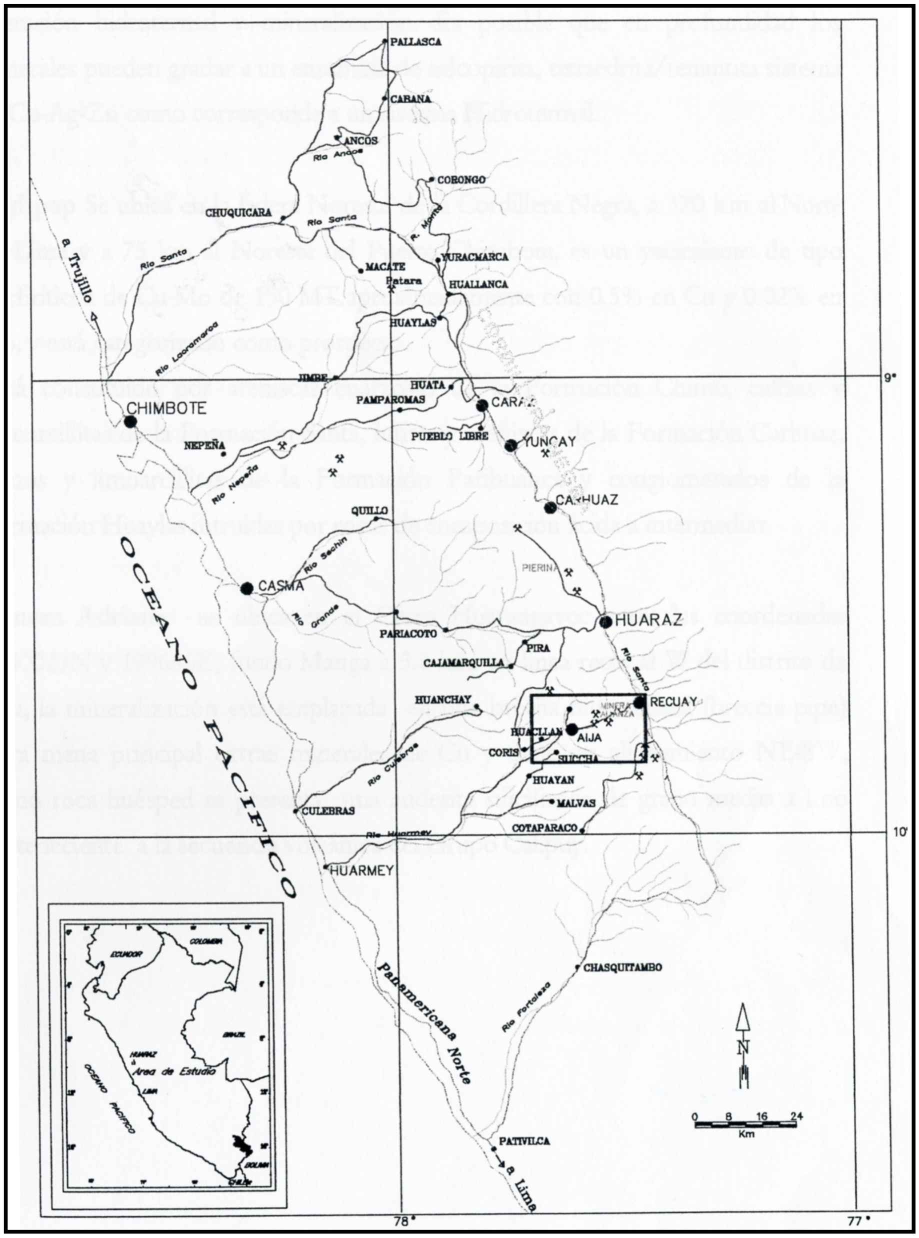


Fig. 3.41 Location Map

The Santa Fault with strike NW-SE has originated during Andina tectonic faults type strike slip and normal faults. This group of faults controlled the emplacement of the intrusives and the formation of ore veins.

The structural control of the area of Aija mining district not only constitutes a main factor of mineralization and alteration of the area of study but also originated the emplacement of the veins with strike NE-SW and the Neogene intrusive bodies.

In the zone there is a caldera of circular shape with diameter of 5 Km. This structure called Aija –Tijapampa Caldera is associated with circular structures of volcanic and subvolcanic rocks and intrusives. In the central part dacitic and rhyolitic porphyries are present, in the intermediate part exist quartz monzonite, and in the more distal zone outcropping andesitic porphyries and dioritic intrusives (Enriquez, 1999).

The main mineralized structures are distributed in 3 veins systems: Huanacapeti system (N 40º-50º E), Tarugo system (N 80º E – N 80º W), and Collaracra system (N 60º-70º E).

The mineralization consists of chalcopyrite, sphalerite, galena, argentite, tetraedrite, arsenopyrite and pyrite.

3.2 METALLOGENIC MAP

In the study area they there are 6 main metallogenic belts, all them with Andean orientation (NW), parallel on the edge of the coast line. These metallogenic belts are also parallel to the space disposition of the Cretacic -Cenozoic plutonism (Coast Batholitht and Cordillera Blanca Batholith), as well as to Cretacic - Cenozoic volcanism (Casma Group Casma and Calipuy Group).

According to the metallogenic map the proposed belts are (west - east):

3.2.1 VIII Belts. - Fe-Cu-Au Deposits (IOCG) of the lower Cretacic.

This belt is divided in two segments. Trujillo-mala-Paracas-Ocoña (TMPN) and Locuma-Sama (LS). in relation to the study area it corresponds the first segment located between the center and north of the Peru. The metallic deposits are related with the magmatic activity of the Casma basin (~112 and 100 Ma; Trujillo-mala-Paracas). The main mineralization controls are faults NO-SE of the Casma basin. In the study area until the moment has not been discovered a deposit of this type, but in the central part of the Peru we have important deposits such as: Tanguche, Raúl-Condestable, Monterrosas, Eliana, Acarí, among others. In general, the mineralization events that constitute this belt register between 115 and 100 Ma.

3.2.2 XI Belt. - Pb-Zn-Cu Sulfides massive volcanogenic of the upper Cretacic – Paleocene.

Between La Libertad and Ica, Romero (2007) it differentiates cal-alkalinealkaline sequences volcanic of the Cretacic-Paleocene, previously attributed as Casma Group Casma, but now denominated Maastrichtiano-Daniano basin, marginal type of back arch (Romero et al., 2008). This basin has deposits type sulfides massive volcanogenic of Pb-Zn-Cu (Kuroko type) whose regional mineralization controls are faults NO-SE Tapacocha and Conchao-Cocachacra system. The most important deposits are María Teresa, Aurora Agusta, Leonila-Graciela (Perubar), Cerro Lindo, Palmas and Balducho. The registrations of mineralization ages oscillate between 68 and 62 Ma.

3.2.3 Franja XIV.- Au-Cu-Pb-Zn deposits related with Eocene intrusions

Presenta dos segmentos, uno al norte en la región Ancash (9°-10° Zona de estudio) y otro al sur, entre las regiones de Huancavelica y Ayacucho (14°-15°). Las estructuras mineralizadas están conformadas por vetas de cuarzo-oro-sulfuros, con orientaciones son N-S, E-O y NO-SE. Las vetas están relacionadas con stocks tonalíticos y granodioríticos del Eoceno, emplazados en el límite oeste del dominio volcánico Cenozoico de la Cordillera Occidental y el Batolito de la Costa. La Cantera, Virahuanca, Tres Minas y Chuncas. Al sur, las principales vetas son El Encanto, Zorro Plateado, Jatun Pata, Melchorita, entre otros.

3.2.4 XXI belt. - Au-Ag epithermal and polymetallic deposits with overlapping of Miocene epithermal.

It is distributed thoroughly in the Cenozoic volcanic domain of the Western Cordillera, crossing all Peruvian territory. In the study area their main representative is the Pierina (High sulphidation epithermal). His main structural control this dominated by faults with orientation NW, but also there are traverse faults to Andean that generally related to Au-Ag (Cu-Pb-Zn) veins (low sulphidation epithermal). In the study area the best exponent in this type of deposits is the Cordillera Negra, where the epithermal is developed so much in the volcanic rocks (Calipuy Group), as well as in the sedimentary rocks (Goyllarisquizga Group).

3.2.5 XXII Belt. - W-Mo-Cu Deposits related with upper Miocene intrusions.

It is located in the center-notrh of the Western Cordillera (8º-10º). The mineralization of Cu-W associates with granitoide of the Cordillera Blanca whose emplacement is controlled by faults NO-SE and N-S of the Cordillera Blanca system. The most representative deposits are Pasto Bueno, Nuevo Mundo, Nueva California, Jacabamba and Señor de la Soledad. The mineralized structures present mainly geometries of veins with variable contents of quartz - gray coppers and also the occurrence of some porphyries deposits. The mineralization ages register between 9 and 6 Ma. The iso values maps of stream sediments support the idea that the Cordillera Blanca batholith behaves like a great county metallogenic province with anomalies of Cu-W-Mo + U

3.2.6 XX Betl. - Cu-Mo-Au Porphyries, Pb-Zn-Cu-Au skarns and polymetallic deposits related with Miocene intrusions.

It is located in the Western Cordillera of the north and center of Peru (5º-12º). This controlled for the inverse faults NO-SE of the Chota systems. This belt presents three magmatic events related with the mineralization, estimated in 22-20 Ma, 18-13 Ma and 10-5 Ma. The magmatic events are manifested by the diorite to granodiorite cal-alkalinealkaline stocks intrusive emplacement. The intrusive of 10-5 Ma controlled by the domain of the flaws of the Chonta system in contact with Cretacic calcareous rocks (9º-12º30') present skarns and Cu-Zn and Pb-Zn-Ag reemplacement bodies, as Antamina, Huanzalá, Pachapaqui, Raura, Ucchuchacua, Huarón, Yauricocha and others.

3.3 DISCUSSION

- The mains deposits types in the zone study are porphyry, ephytermal, skarn, stratabound, veins. This deposits are related with different mineralization events in different time. The special distribution of deposits are related with the rock type.

- In the central zone the mains deposits are porphyry generally are located in the Cordillera Negra where outcrop the Calipuy and Goyllarisquizga Group. The porphyries systems are related also to low sulphidation polymetallic veins and to high sulphidation epithermal. Characterized for a mainly miocenic magmatismo. Exist also reemplacement veins related to carbonate rock (Santa Formation), where the main mineralization control is lithologic.

- In the east zone the mineralization is related mainly with skarn and stratabound deposits. The main outcrop rock is limestone highlight the Santa, Jumasha and Pariahuanca Formation. The stratabound deposit have a strong structural control related with the fold, where the fracturing origined the favorable zones for the flow the mineralization fluid and emplacement of the miocenic stocks.

- The zone west where outcrop to cretacic Casma Group has litlle deposits know. This deposits are generally related to polymetallic veins of litlle dimensions, At the moment not exist a great deposit discoverd in this zone.

- The Cordillera Blanca Batholith has high potential in Mo – W - U mineralization. This mineralization is related to porphyry and veins deposits located in different zones of the batholith. The regional geochemistry in stream sediment showed strong anomalies in this Elements (see Item IV).

4.- REGIONAL GEOCHEMISTRY PROSPECTING

The works of geochemistry prospecting in the study area were developed during the years 2006 and 2007, recolleting a total of 1554 stream sediments samples, which have a design of sampling of 1 sample for each 10 Km2. The order of the studied streams has been of 1, 2 and 3 and inclusive the main rivers, for exmaple the Santa and Aija river. The stream sediments samples have been analyzed by the ICP - MS method, also taking their respective physical-chemical parameters of the water in each sample point, except in those dry streams.

4.1 Geochemistry Distribution Element

To continuation we will describe some of the main elements in the study area.

Silver (Ag)

Their values are in a range from 0.01 to 9.84 ppm. existing a total of 16 samples that have bigger values with respect the upper limit detection. The average of its values in stream sediment is approximately 0.16 ppm. having its higher values related to the space location of the Cordillera Negra: Tuco Chira, Adriana mining and to the hidrografic course of the Aija river (mining Pollution) (Fig. 4.2). The silver presents a moderate correlation with the copper and a strong correlation with the lead, antimony and zinc (Fig 4.1).

Gold (Au)

Their values are in a range from 5 to 1421 ppb, being 5 ppb the lower limit detection (LLD) of the ICP-MS. Their average values are approximately of 22 ppb. This element has a great quantity of samples for under LLD. The highest values are related in the first place to the highest part of the Cordillera Negra and in second place to Cordillera Blanca batholith. Highlighting in the Cordillera Negra the surroundings of the Huinac, Adriana and Pierina mining (Fig. 4.3). The Au doesn't present a good correlation with any element (Fig 4.1).

Cobalt (Co)

This element presents a normal distribution and its values are in a range from 0.6 to 150.4 ppm, with average values of 14 ppm. The highest values are related to the oriental part of the Cordillera Blanca batholith, where outcroop generally jurassic-cretacic sedimentary rocks (Fig. 4.4). The cobalt doesn't present a good correlation with any element (Fig. 4.1).

Mercury (Hg)

Their values are in a range from 0.01 to 40.8 ppm, being their lower limit detection (LLD) similar to 0.01. This element has a total of 587 samples below the LLD. Their average values are around 0.25 ppm. Their highest values are related to the oriental part of the mine Antamina, as well as to the Adriana and Huanzala mine (Fig. 4.5). The mercury doesn't present a good correlation (Fig 4.1).

Copper (Cu)

Their values are between 3.3 and 3412 ppm, with a average values of 50 ppm. This element presents a normal logarithmic distribution and its highest values are related to the Cordillera negra and to the hidrografic course of the Aija river (pollution mining). Other strongly anomalous areas outside of the Cordillera Negra are of Tuco Chira - Huanzalá mine and Llamellin - Acos town (Fig. 4.6). The copper presents moderate correlations with the silver, lead, antimony and zinc (Fig. 4.1).

Molibdenium (Mo)

Their values are between 0.43 and 120.9 ppm, with average values of 3.82 ppm. This element presents an normal logarithmic distribution. Their highest values are related to the space disposition of the Cordillera Blanca batholith, as well as to the sectors of the mHuanzala mine and the Huari, Carhuaz, Llamellyn and Aczo town (Fig. 4.7). The molybdenum doesn't present good correlations with the other elements (Fig. 4.1).

Lead (Pb)

Their values are among 2.5 to 8685 ppm, with average values of 69 ppm. This element present a normal logarithmic distribution. Their highest values are related to the sectors of Tuco Chira, Huanzalá, Antamina, Pierina and Santo Toribio mine (Fig. 4.8). exist a strong lead anomaly along the hidrografic course of the Aija river, which is product of the mining pollution that there is in the high part of the Cordillera Negra. The lead presents a strong correlation with the Zn (Fig. 4.1).

Antimony (Sb)

Their values are inside the range from 0.12 to 395 ppm, with a average values of 4.01 ppm. Their highest values are related to the hidrografic course of the Aija river (mining pollution), as well as to the sector of the Tuco Chira mine and to the highest areas in the Cordillera Negra (Fig. 4.9). This element presents a normal logarithmic distribution and has a strong correlation with the Zn (Fig. 4.1).

Uranium (U)

Their values are inside the range from 0.05 to 77.4 ppm, with average values of 2.35 ppm. The highest concentrations are related to the Cordillera Blanca batholith with a clear orientation NW (Fig. 4.10). This element doesn't have good correlation with the other elements (Fig. 4.1).

Zinc (Zn)

Their values are inside the range from 4 to 4819 ppm with a average values of 240 ppm. Their highest values are related to the hidrografic course of the Aija river (Mining pollution) and to the highest areas in the Cordillera Negra, as well as to the sectors of Pierina and Tuco Chira mine (Fig. 4.11). The Zn presents a strong correlation with the Ag, Pb and Sb (Fig. 4.1).

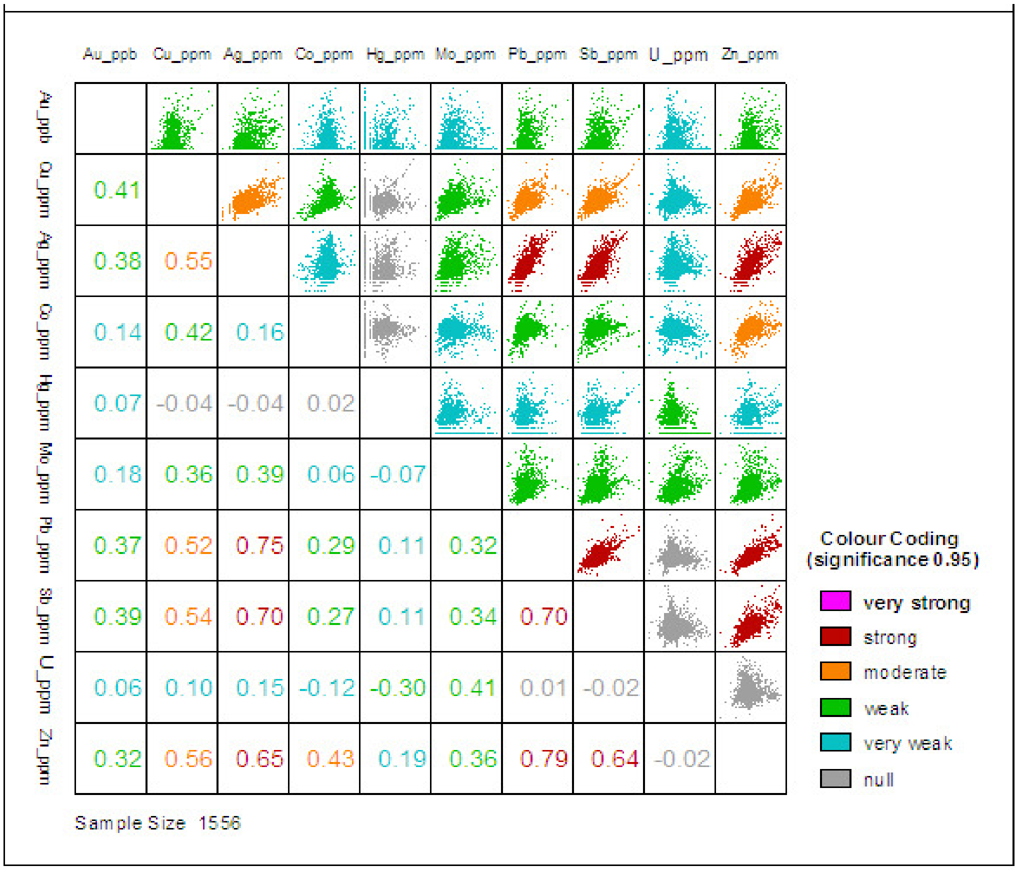


Fig. 4.1 Statistical Correlation of the Elements

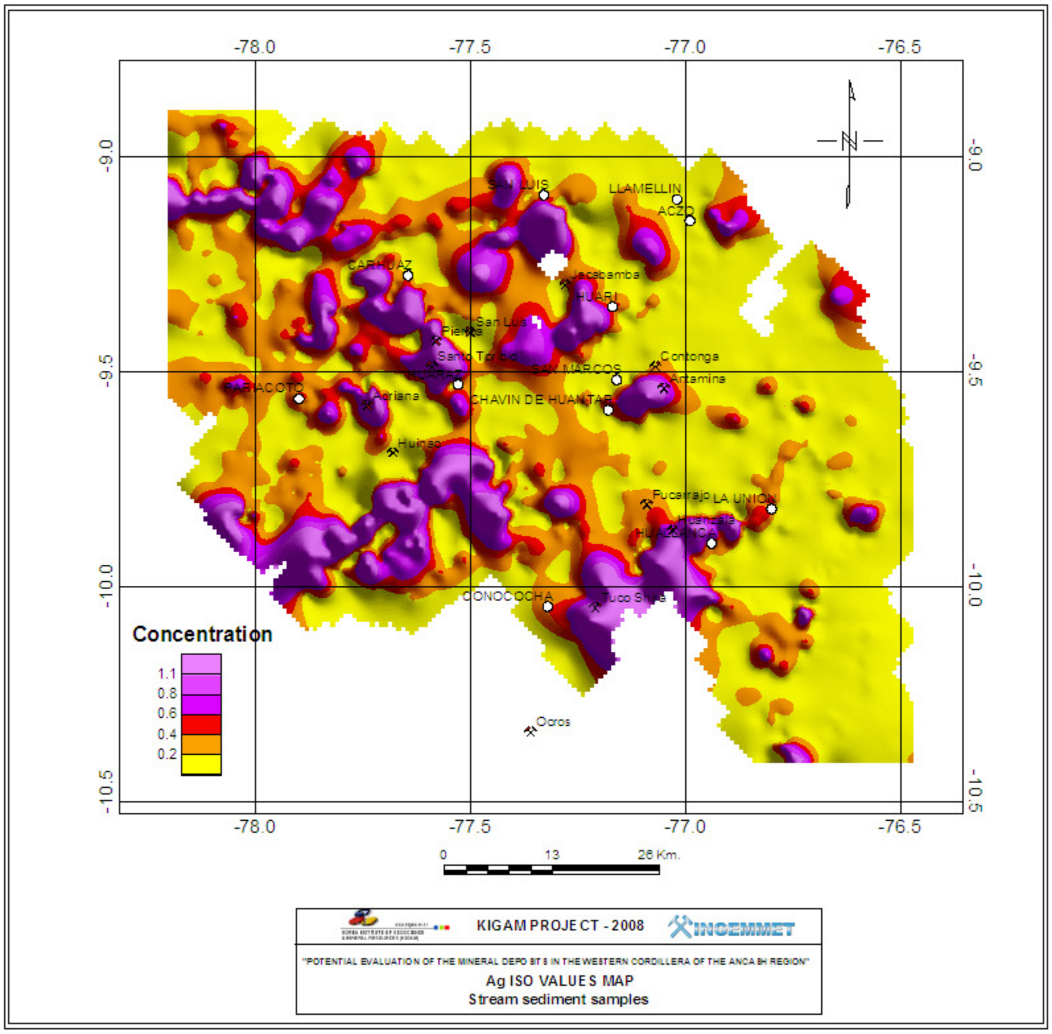


Fig. 4.2 Ag iso values map.

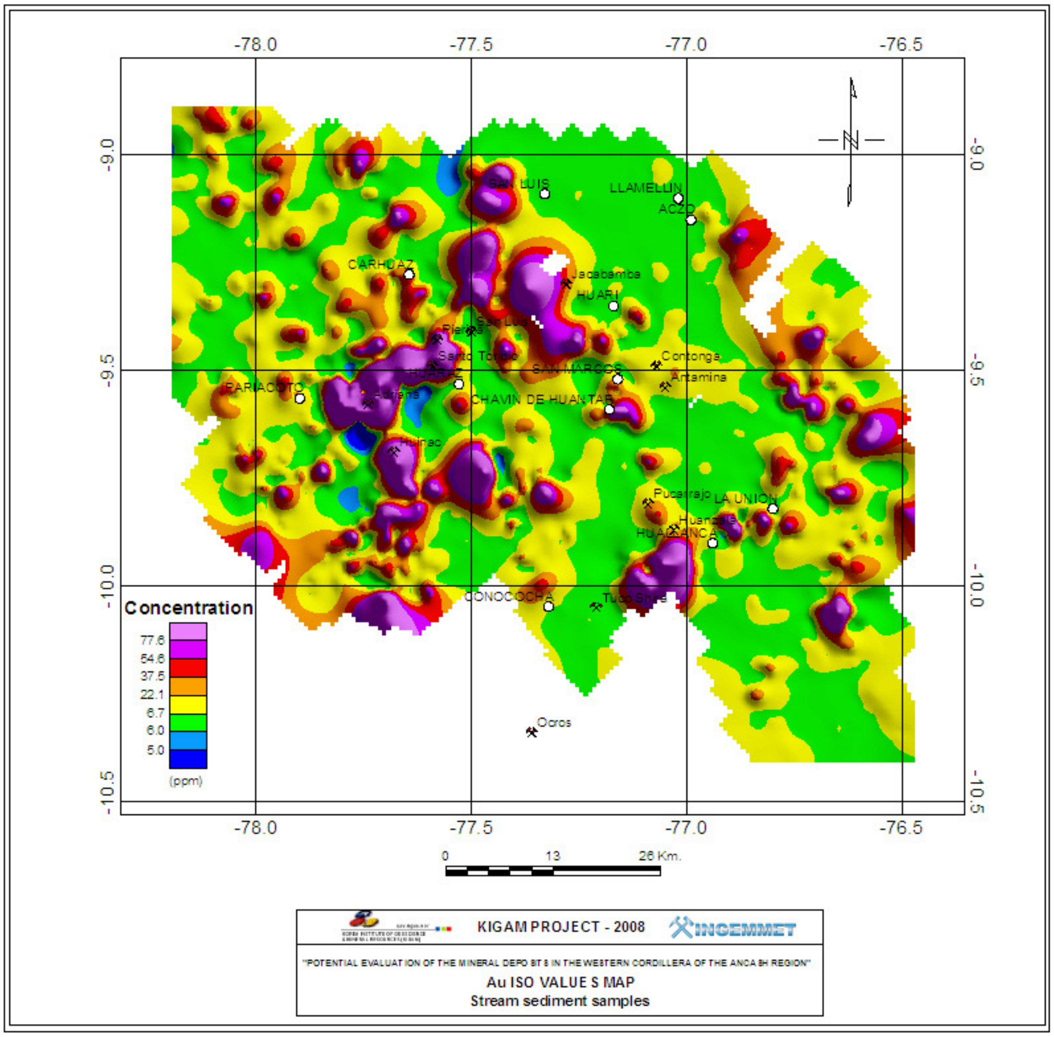


Fig. 4.3 Au iso values map.

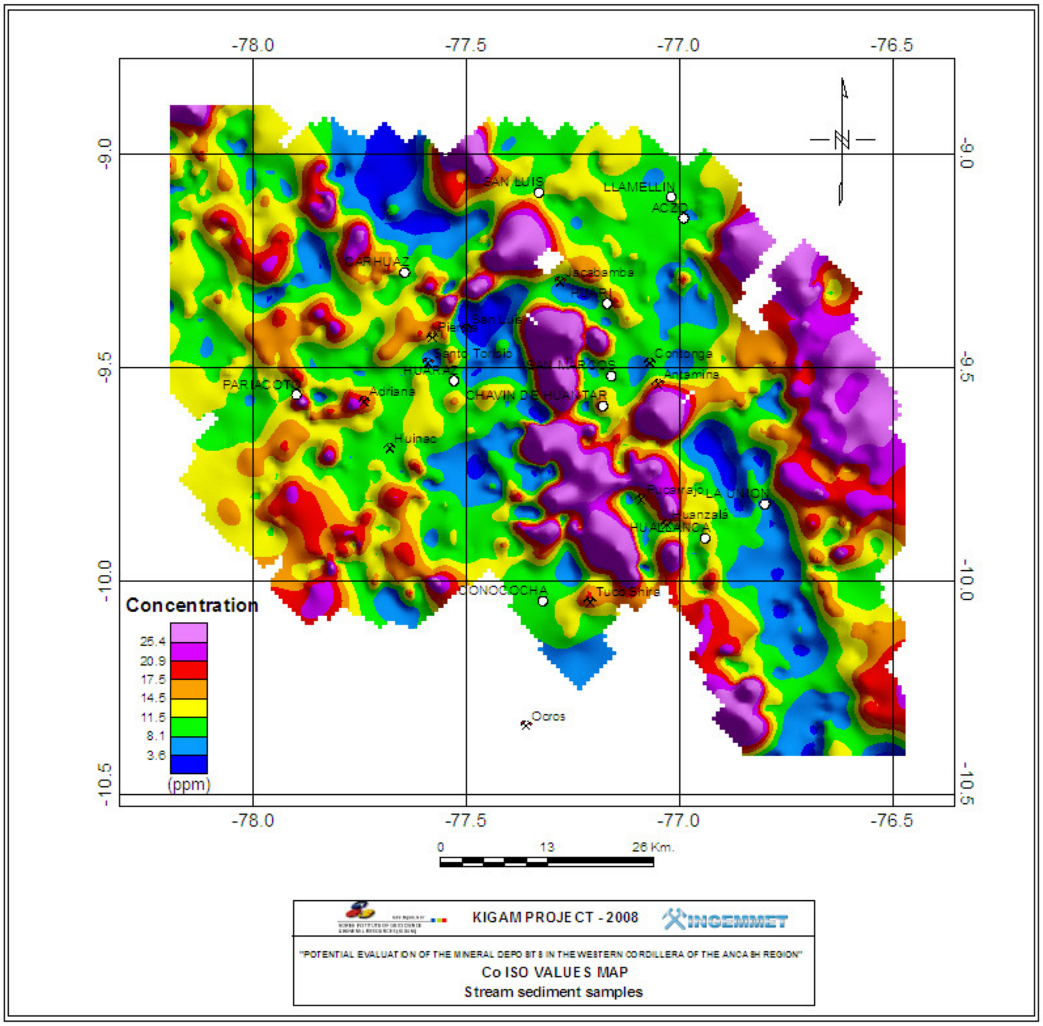


Fig. 4.4 Co iso values map.

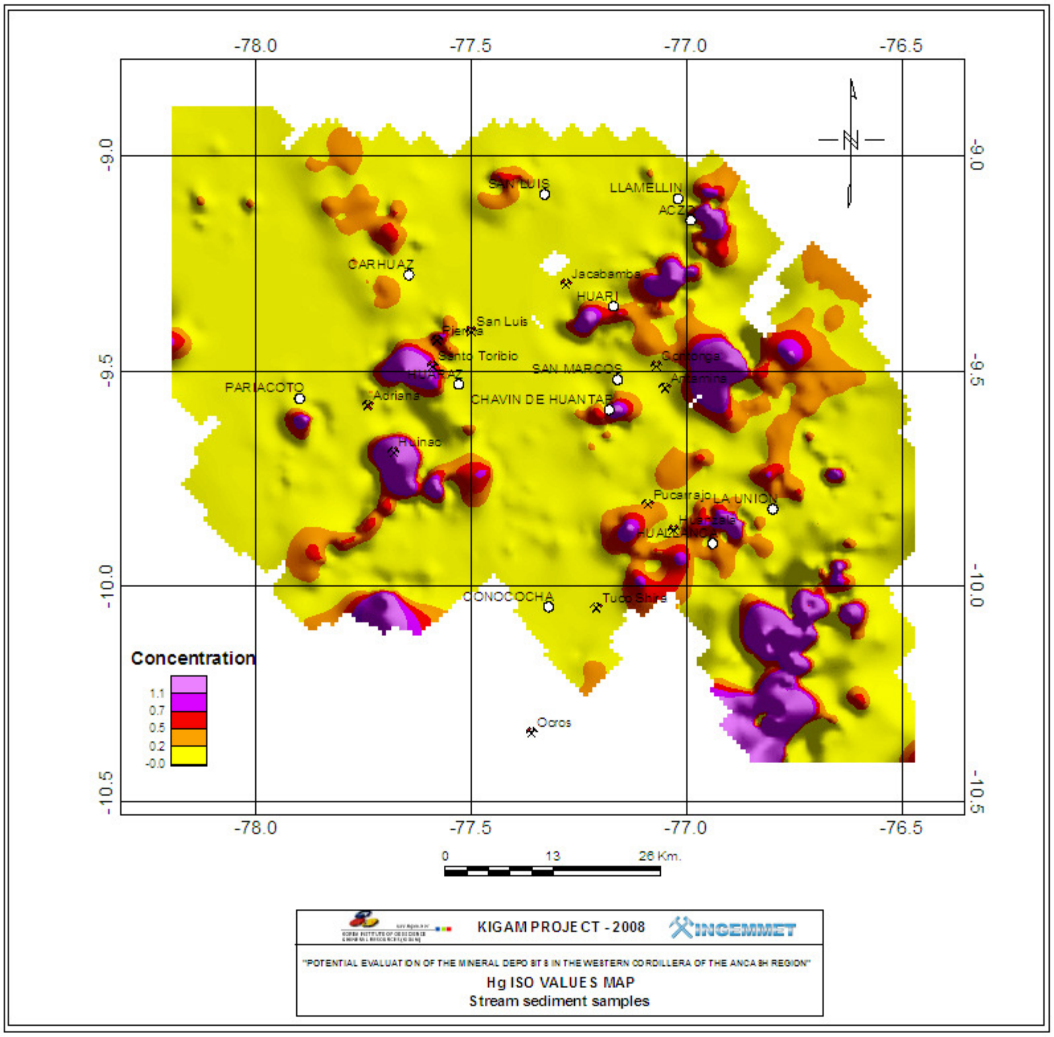


Fig. 4.5 Hg iso values map.

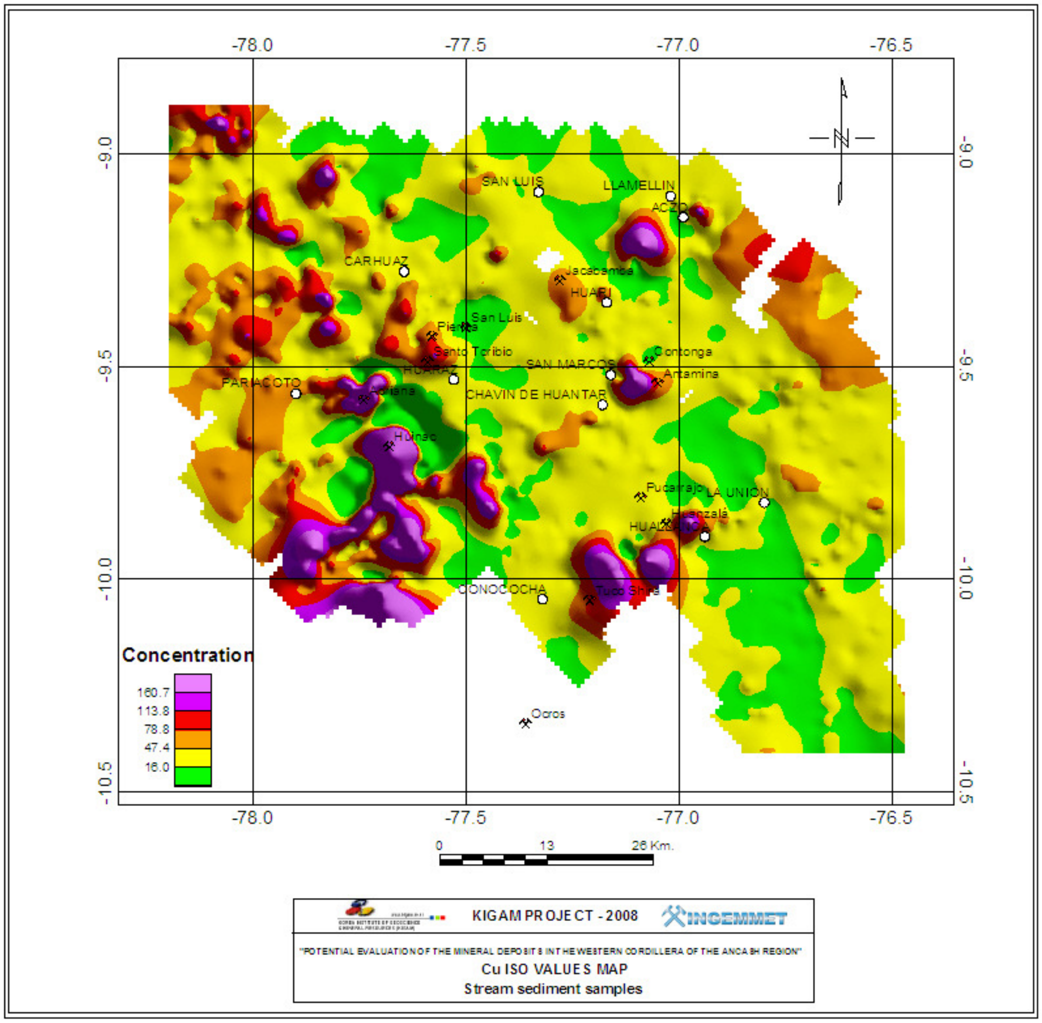


Fig. 4.6 Cu iso values map.

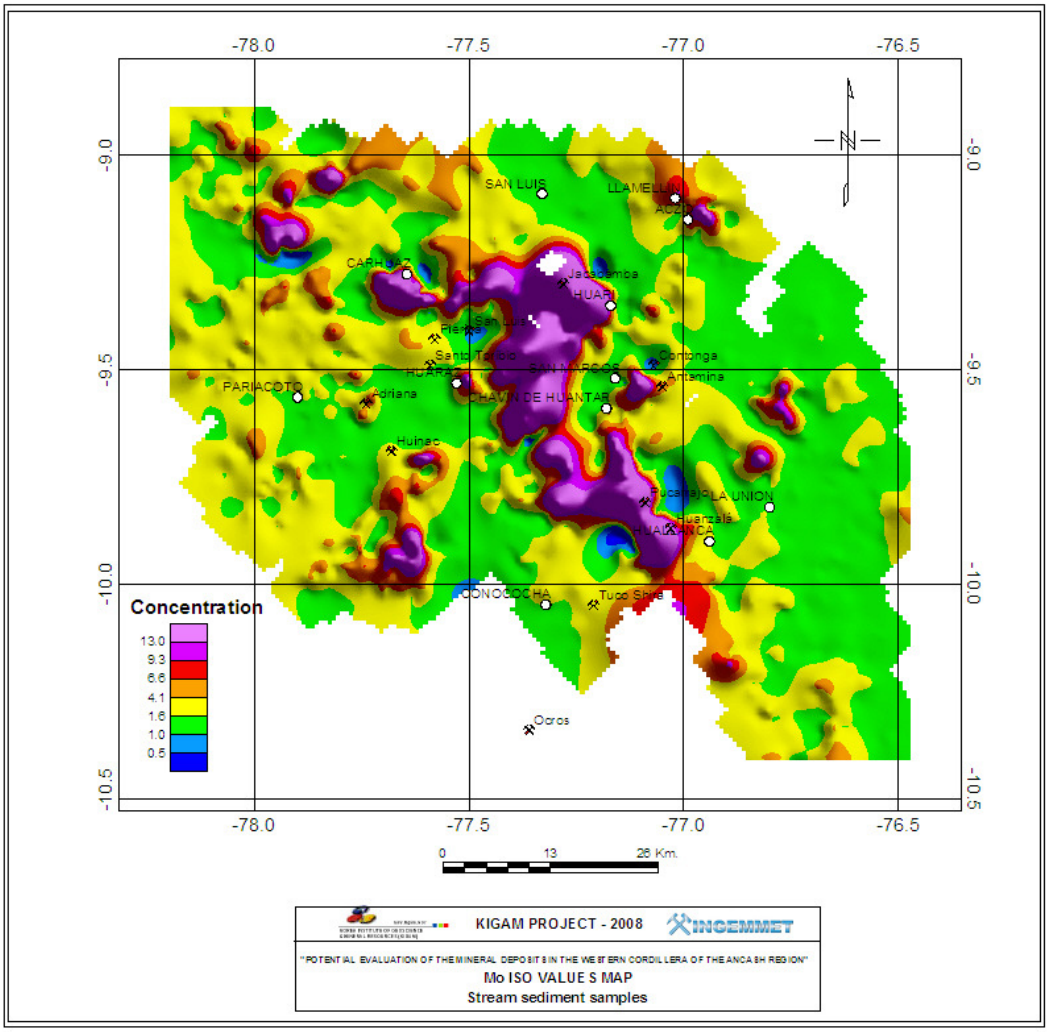


Fig. 4.7 Mo iso values map.

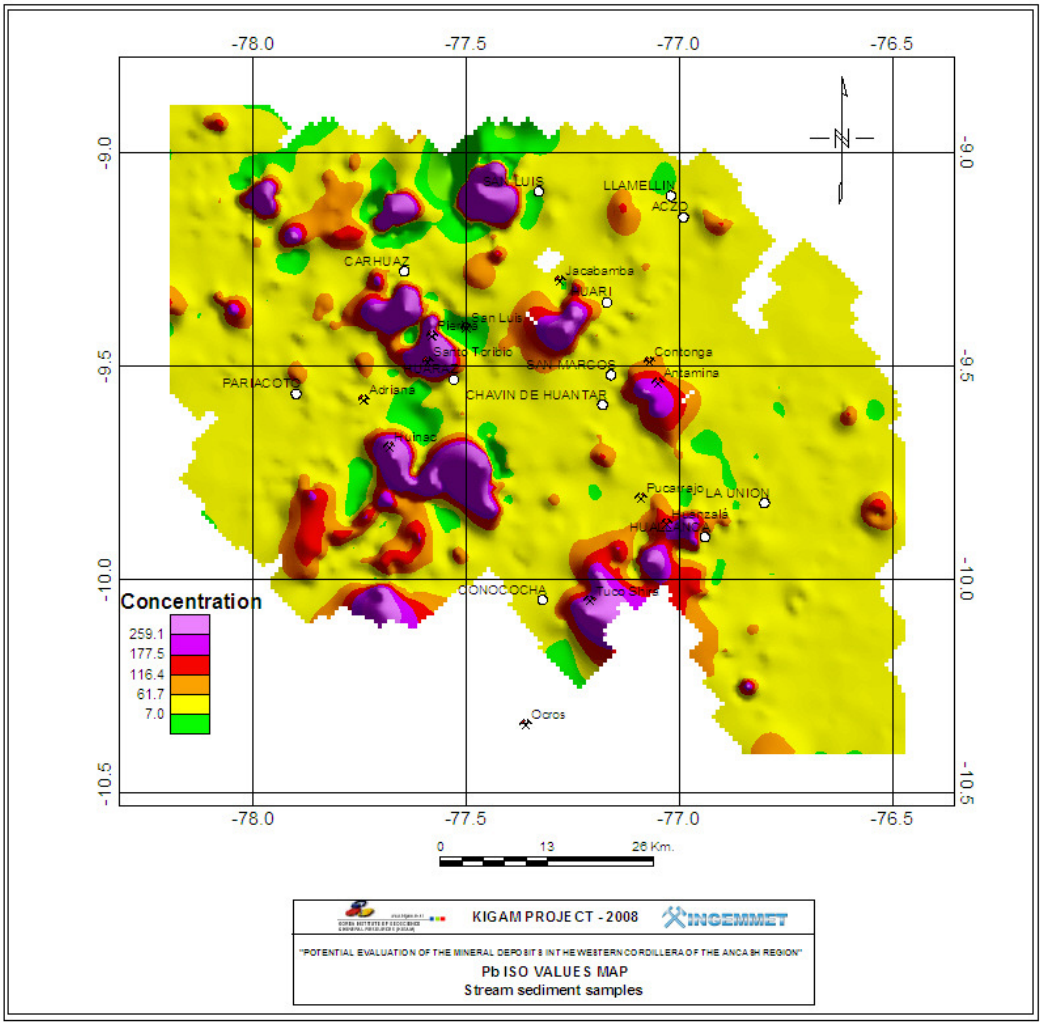


Fig. 4.8 Pb iso values map.

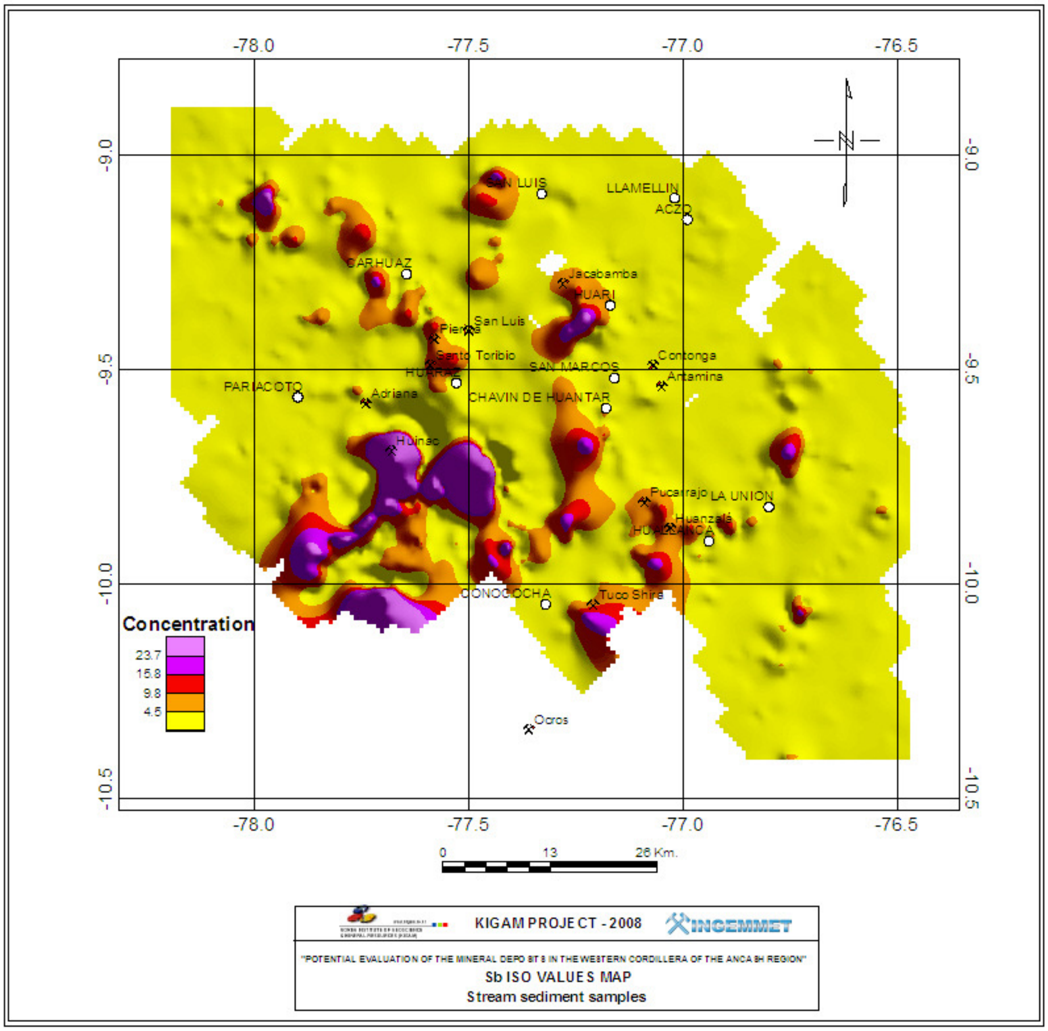


Fig. 4.9 Sb iso values map.

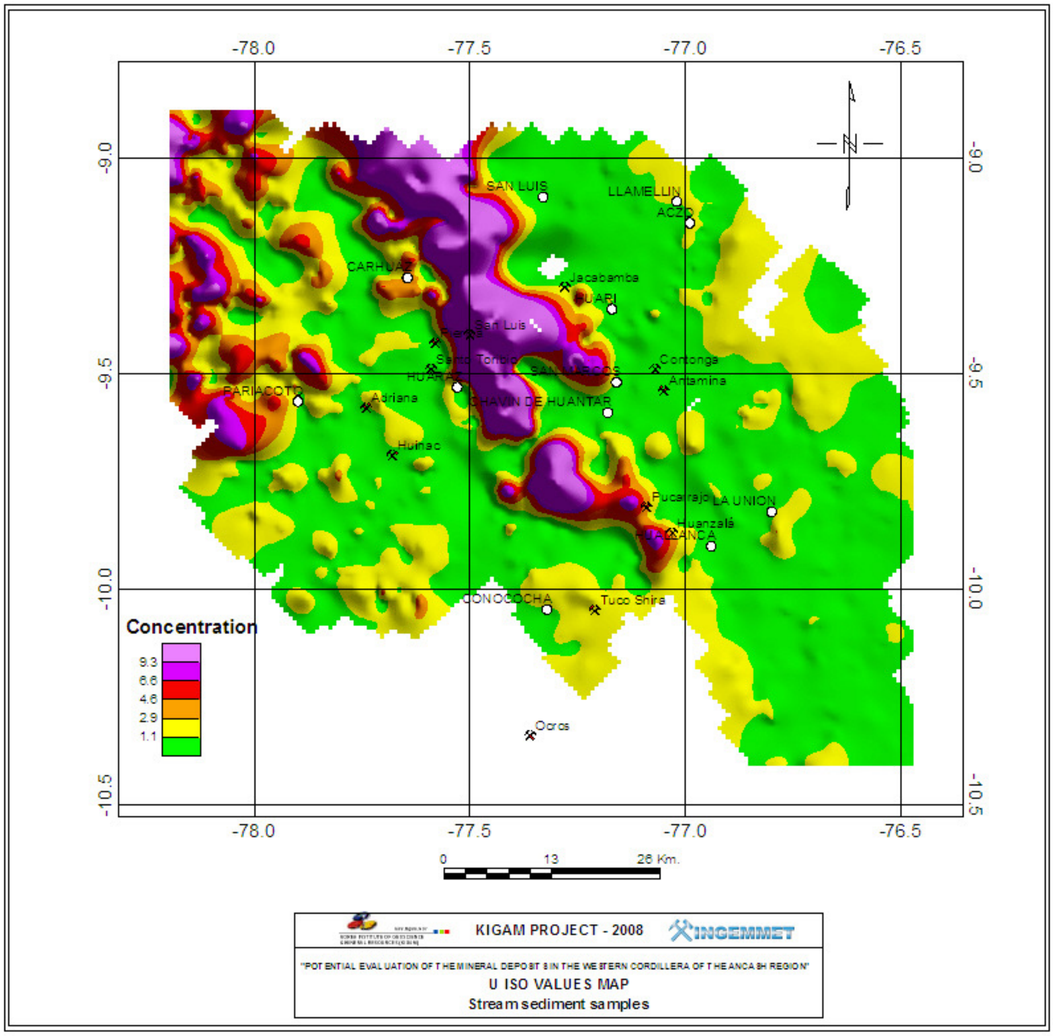


Fig. 4.10 U iso values map.

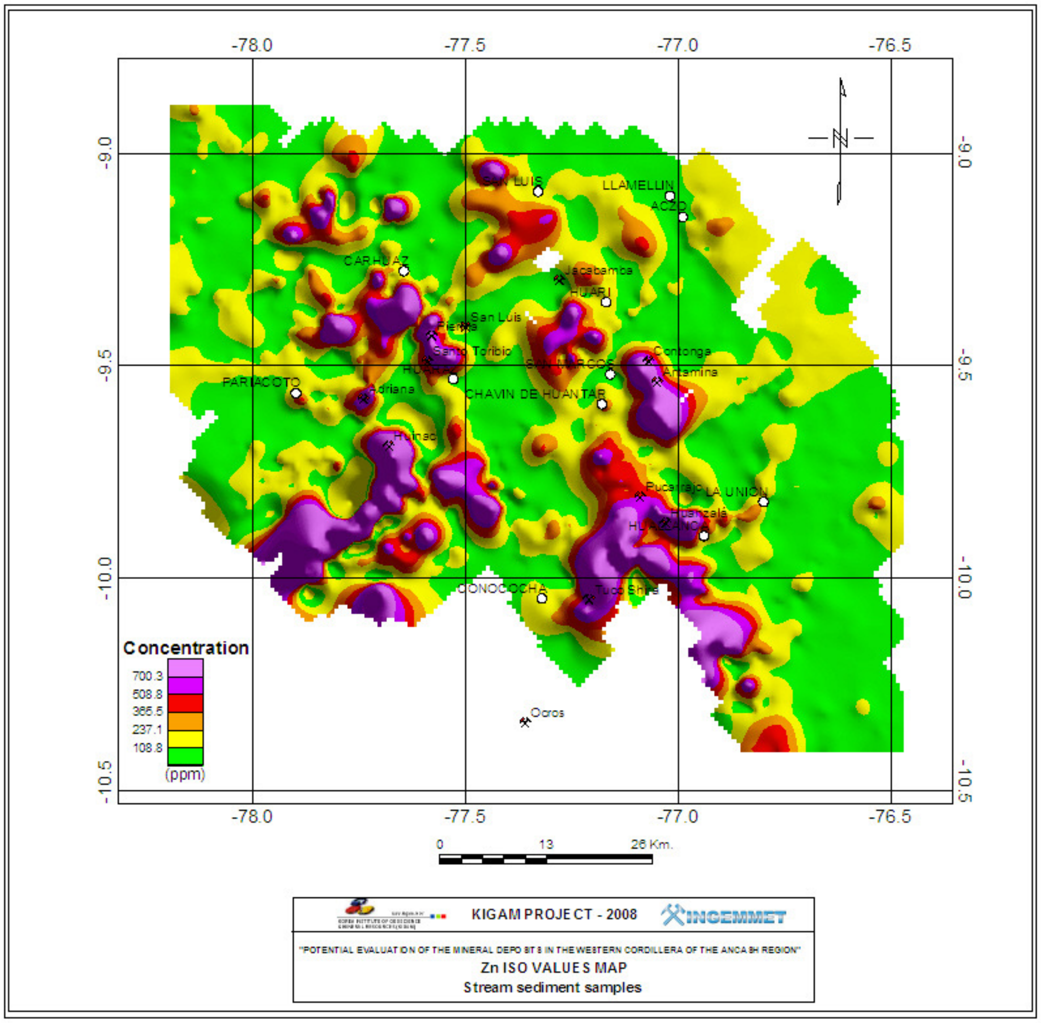


Fig. 4.11 Zn iso values map.

4.2.- Discussion

The stream sediment are a very important tool to define potential areas that have relative high concentrations of elements with respect to their regional rocks. However it is necessary to keep in mind that it is another geologic tool that helps to define inside another group of approaches if the area is economic or it is not economic.

It is better for a statistical treatment to separate the samples for lithology populations and to study separately, because for example the concentration of Cu is not same in a basic igneous rock that an a acid igneous rock. otherwise you can fall in errors of camouflage of anomalous values.

Then for a first reach they have been carried out the iso values maps showing the distribution of the elements and the lithology that favor or not their high concentrations.

Among the most important characteristics in these maps we have that they allow to corroborate the polimetalic character of the Cordillera Negra and also that they help to define to the Cordillera Blanca Batholith like a possible metallogenic entity with high concentrations of Mo and W.

5 PETROGRAPHY DESCRIPTION OF SAMPLE

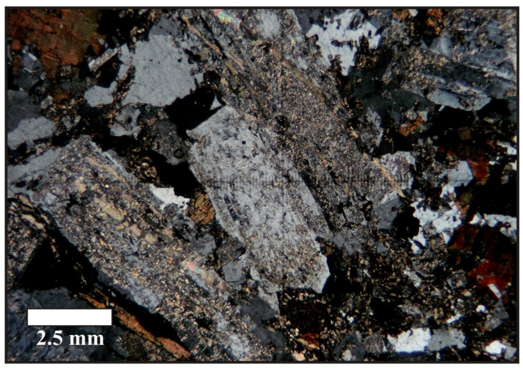
5.1 Jacabamba Prospect

Jacabamba – 003

The main minerals are feldspar and quartz. The secondary minerals are biotite and a very few potassium-feldspar. The plagioclases are anhedral and they have a moderate sericite alteration. These crystals of plagioclase have 5 mm. Whereas the biotite has a weak chlorite alteration and quartz is anhedral with less that 1 mm.

Composition: Tonalite

Texture: Hypidiomorphic Granular

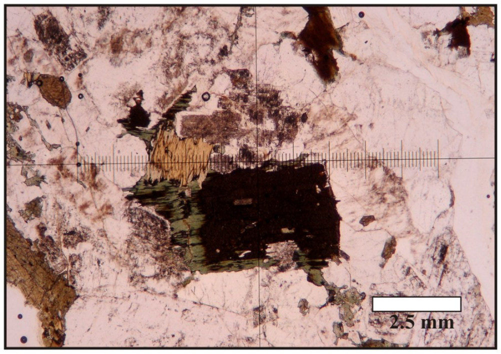


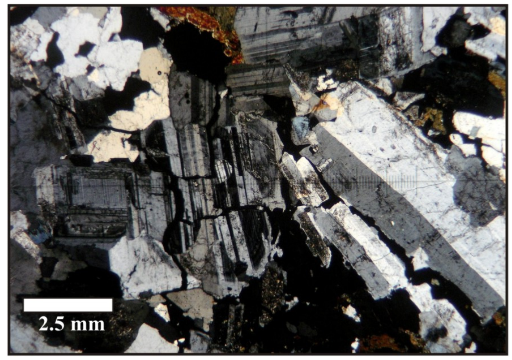
Jacabamba – 005

The main minerals are feldspar, quartz and biotite. The secondary minerals is potassium-feldspar. The crystals of plagioclase are euhedral-subhedral, they have as max 4 mm. Some plagioclases have a weak sericite alteration and they are zoning. The quartz is anhedral and it has as max 2 mm. The biotite has a weak chlorite alteration and it has as max 1 mm. The potassium-feldspar has anhedral shape and it hasn't alteration.

Composition: Granodiorite

Texture: Hypidiomorphic Granular



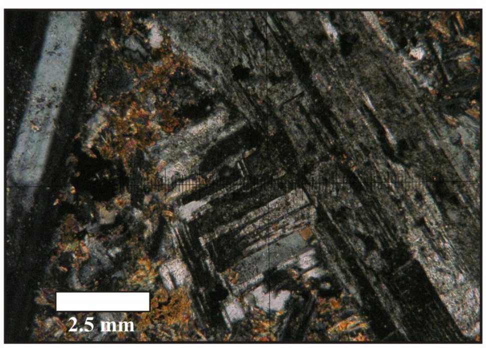


Jacabamba - 006

The main mineral is the plagioclase and the secondary mineral is the quartz. Both are anhedral and subanhedral. The groundmass has microcrystals of plagioclase and it has intense to moderate sericite alteration. The phenocrystals of plagioclase have a weak sericite alteration too.

Composition: Diorite and Quarzt-diorite

Texture: Porphyritic

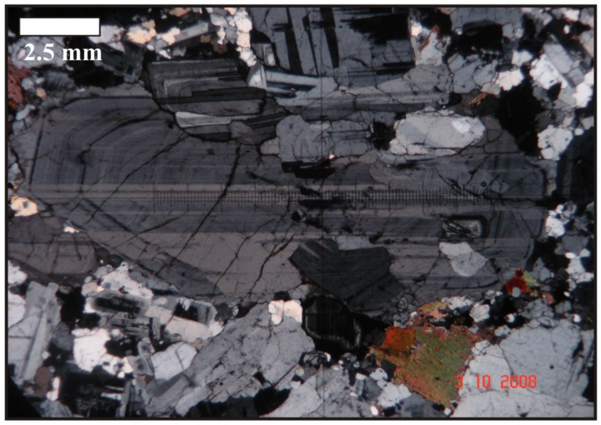


Jacabamba – 007

The main minerals are plagioclase, quartz and potassium-feldspar. The secondary mineral is the biotite. The phenocrystals of plagioclase are subanhedral and they have zoning, besides they have as max 6 mm. The phenocrystals of potassium-feldspar have subhedral shape and they have as max 5 mm. Whereas the biotite has a average of 2 mm.The quartz is anhedral and it has as max 12 mm.

Composition: Granodiorite

Texture: Seriada Porphyritic



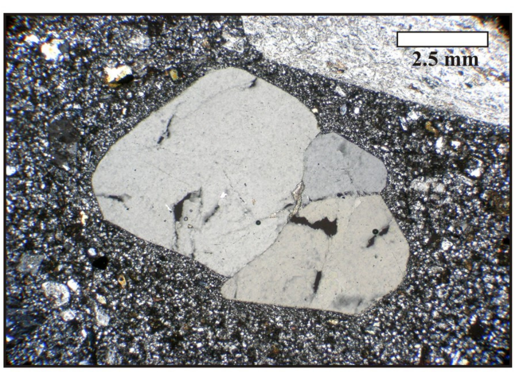
5.2 Ocros subvolcanic Structure

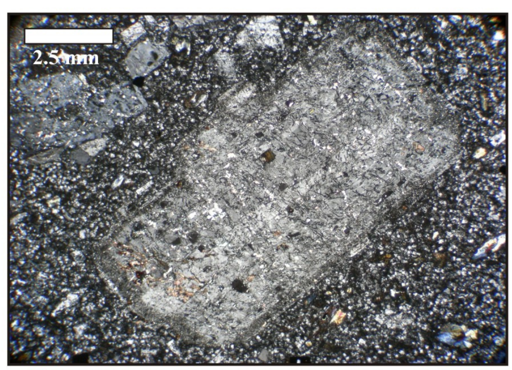
Ocros- 1A

The main minerals are plagioclase and quartz. The phenocrystals of plagioclase are euhedrals and they have a moderate sericite alteration. The phenocrystals of quartz are anhedral. The groundmass is very fine and it has a microlithic texture of plagioclase and quartz.

Composition: Quartz-dacite

Texture: Porphyritic

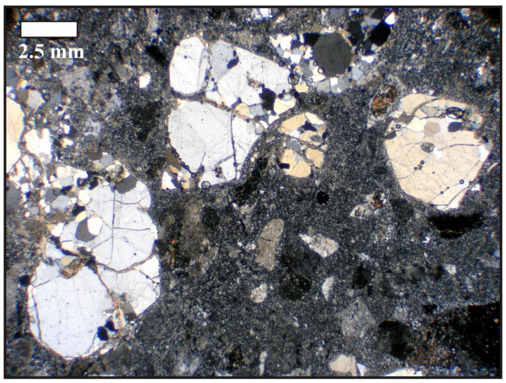


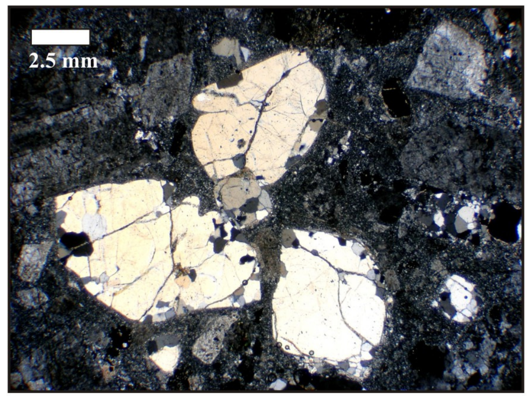


Ocros – 003

The main mineral is quartz. The secondary mineral is the plagioclase. The phenocrystals of quartz are very large as for watch without magnifying glass. They have anhedral shape and as max 5 mm. The groundmass is very fine and it has a microlithic texture of plagioclase and quartz.

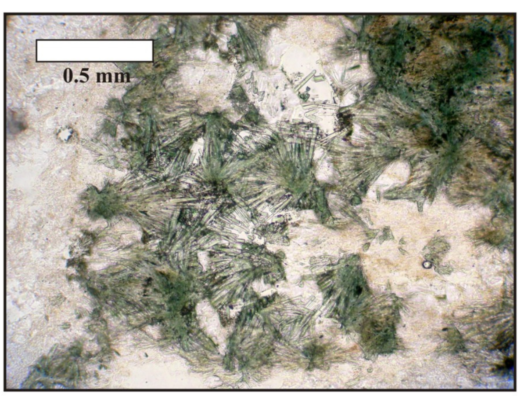
Composition and texture: Quartz Porphyritic

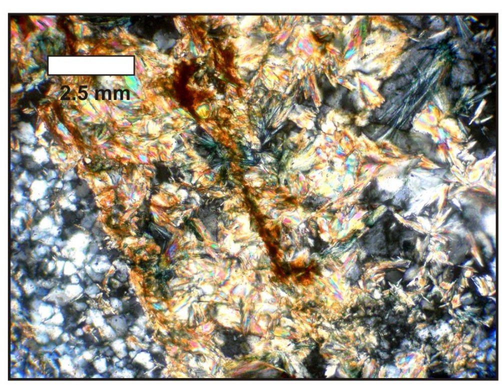




Ocros – 004 y 008

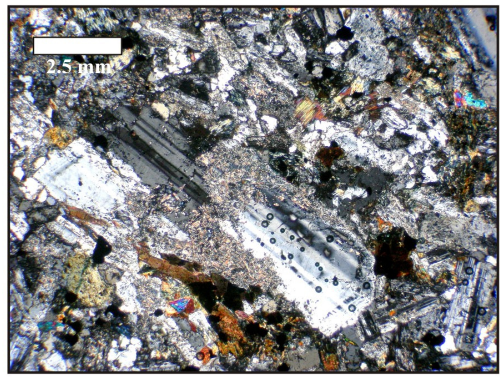
The main minerals are quartz and tourmaline. The secondary mineral is the plagioclase. The plagioclase and quartz have subhedrals shape. Whereas the tourmaline is anhedral. This rocks is associated with tourmaline breccia. The rocks is a Quartz-porphyritic or a Quartz-dacite.





Ocros – 005

The main mineral is the plagioclase. The secondary minerals are the biotite and the quartz. The plagioclase is euhedral and it has zoning with polysintetic twin. Some plagioclases have a moderate sericite alteration. The phenocrystals of plagioclase have as max 4 mm., but some plagioclases have of 1 to 4 mm. or less that 1 mm.



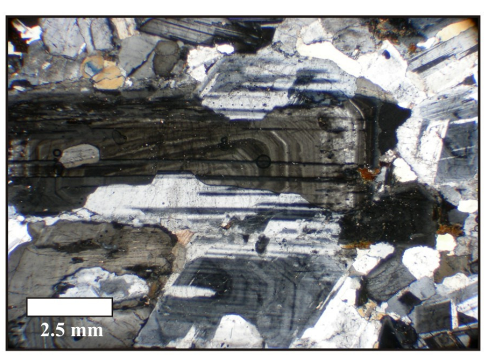
5.3 Cordillera Blanca Batholith

Bato – 001

The main minerals are the plagioclase and quartz. The secondary minerals are the biotite and potassium-feldspar. The plagioclase is euhedral and it has as max 5 mm. The quartz has anhedral shape. The biotite has a weak chlorite alteration.

Composition: Tonalite-granodiorite

Texture: Hypidiomorphic Granular

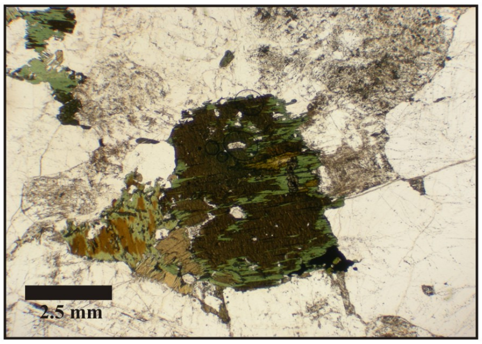


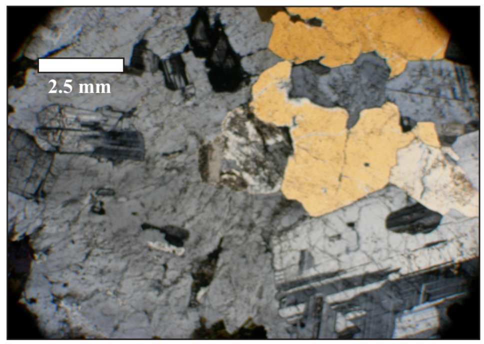
Bato -002

The main minerals are the plagioclase, quartz and potassium-feldspar. The secondary mineral is the biotite. The plagioclase has a weak sericite alteration. The biotite has a weak to moderate chlorite alteration.

Composition: Granodiorite

Texture: Hypidiomorphic Granular





5.4 Corpanqui High Level Stock

Corp-001B

The main minerals are the plagioclase, quartz and potassium-feldspar. The secondary mineral is the biotite. The crystals of plagioclase have as max 5.5.mm. The biotite has a weak muscovite alteration. The quartz has anhedral shape and it has as max 1 to 1.5 mm.

Composition: Monzogranite

Texture: Hypidiomorphe Granular

CONCLUSIONS

From point of view stratigraphic in the study area has been recognized two lithologic domain. The first of magmatic origin toward the west and the second of sedimentary origin toward the east. This two lithologic are evidences of two main tectonic basins, whose are limit for the Tapacocha Axe (Romero, 2008).

The magmatic domain is formed by volcanic rocks (Group Casma) and intrusive rocks (Batolito de la Costa), which are inside an age range from the lower Cretaceous until Paleocene. The sedimentary domain is formed by silicoclastic and carbonated rocks deposited in a basin of shallow depth, highlighting the Goyllarisquizga Group and the Jumasha formation. These rocks have an age range between the upper Jurassic and lower Cretaceous.

There is that highlight that the rocks in the sedimentary basin is overlayer for the miocenic volcanism (Calipuy Group) and cut for the Cordillera Blanca Batholith and other high level intrusives, Which is related to the mineralization in the study zone.

It recognized a migration of the magmatic arc from the west toward the east, with a volcanic and intrusive episode developed during the Cretaceous and other volcanic and intrusive episode developed during the Paleogene to Neógene. At the moment it is recognized that each magmatism has a very different economic potential.

The Jurassic and Cretacic sedimentary sequences of the north and center of the Peru were deposited in a series of interconnect basins, each one of those which is characterized by the development of specific phases. Among the main sedimentary sub-basins development inside the Peruvian Western Basin we have that highlight the Santa basin (Wilson, 2002) or also named Jurassic – cretacic Chicama – Goyllarizquisga basin (JKCHGB), (Romero 2008).

From the stratigraphic and structural analyses, Romero (2008) interpret that the Jurassic-Cretaceous Chicama-Goyllarisquizga basin was originated and controlled by the Tapacocha, Huacllan-Churín, and Huaraz-Recuay fault systems in the western boundary and by the Cordillera Blanca and Chonta fault systems in the eastern boundary of the basin. These faults at the beginning have presented normal motion, later due to compressive tectonic inversion change to reverse fault with west and east dip. Along the Chicama-Goyllarisquizga basin axes, limited by Cordillera Blanca and Huaraz-Recuay faults systems, we observe sinistral slip with normal component affecting Plio-Quaternary deposits. This last tectonic style indicates sinistral motion for the Cordillera Blanca zone.

By means of the interpretation of satelite images, structures and geochemistry anomalies has been able to recognize circular lineament that could be related to possible cauldron of kilometric dimensions, which can have been favorable for the location of continental volcanism (Group Calipuy). Among the main structures we have Ocros, Aija-Ticapampa and San Luis. All this structures with strong economic potential. There is not that discard the presence the other structures of this type that can not be easily recognizable for a strong erosion.

Ocros is an area that is inside a structure kilometric subvolcanic, which is characterized because has a great quantity of geochemistry anomalies. Until the moment has not been a deposit of great importance, being limited to polymetallic veins and small porphyry subvolcanic body non economic. The study of the thin sections highlights as main rocks related to the mineralization to the quartz porphyries, dacite with quartz, diorite and tourmaline breccia.

The high-level stocks in the surroundings of the Ocros structure seem to be related genetically to Cordillera Blanca batholith and they are interpreted to be small apophysis of Cordillera Blanca batholith.

The regional structural control has strong evidences of strike slip fault, that can control the direction of structure more small as veins. Is possible that the direction NE of the veins in the Huaraz – Recuay is related to sinistral regional fault (Romero, 2008). The different lithology that cut a fault can origin deflexion zones, which origin rich zone in ore (bonanza veins) as San Luis deposits.

The geochemistry anomalies (sampling regional stream sediment) show a strong potential in metals base, existing little presence of anomalies of gold, that which reaffirms the character polimetalic of the Cordillera Negra. By means of the interpretation of the geochemistry anomalies and the control field we could recognize an contamination product of the environmental passive located in the High Mountain of the Cordillera Negra. These values is along the Aija river should be taken with much care for the interpretation of the geochemistry maps.

The Cordillera Blanca presents high values in Mo, W, U. The high concentrations of these elements are confirmed by some mines and occurrences located outside of the reserve area of the Cordillera Blanca example: Pasto Bueno (W greissen), Jacabamba (Mo porphyry).

The Cordillera Blanca presents a magmatism very differentiated related to enrichments in uranium, but we can indicate that there is not a direct relationship among the enriched granites in uranium and the economic mineralization of uranium. Metamorphic Processes is necessary to produce economic mineralization.

The Jacabamba prospect is located in the Cordillera Blanca Batholith and is maybe the only mineral occurrence recognized in the Peru like porphyry of Mo. This porphyry has better developed its mineralisation inside the sandstones of the Chicama Formation, while in the argiligy facies the economic mineralisation is almost null, maybe due to its low permeability and fracturamiento of the rock that it didn't facilitate the migration of the fluids.

By means of a study of thin section has been able to recognize an association to numerous intrusive phases highlighting among them the tonalite, diorite and granodiorite. Until the moment, the studies that have been carried out in Jacabamba have not been able to determine with clarity an area of supergene enrichment with high value of Cu. The present discovery and the exploration carried out in the California-Centauro prospect (Mo) toward the northwest of Jacabamba suggests that a change in the philosophy of the exploration would be very profitable.

According to the study of the thin sections it is suggested clearly that the stock of high-level of Corpanqui which surrounds the subvolcanic structure of Ocros has a classification monzogranite with a granude texture; while the stocks that are inside the subvolcanic structure have a tendency to a classic porphyry texture. This can be interpreted as a magmatic evolution due to a bigger differentiation or as well as due to different magmatic pulses that happened in different times.

The areas of more interest in the Cordillera Negra are related to subvolcanic rocks of porphyry texture, which could be related genetically to the Cordillera Blanca batholith or to Coast batholith.

When observing to microscope the thin sections of the Coast batholith, high-level stocks of the Cordillera Negra and Cordillera Blanca batholith, a great difference exists for the textures of the stocks of the Cordillera Negra with respect to both batholith. The texture of the stocks of the Cordillera Negra presents a mass of fine grain to very fine, that which suggests a genetic relationship to a subvolcanic emplacement, while the thin sections of both batholith show a classic granude intrusive texture with some phenocryst.

A bigger quantity of plagioclase exists for the thin sections of the Coast Batholith in relation to Cordillera Blanca batholith, that which would be related to a magmatism with smaller magmatic differentiation. The plagioclase sometimes presents zonally that which suggests a continuous magmatic feeding.

Finally the study zone has a older mining, but currently the private mining company is discover new interesting zone, therefore the mining potential is eve very big.

RECOMENDATION

To recognize the different grades of magmatic differentiation (trace elements and REE), as well as the interpretation petrogenetic among the different types of intrusions in the study area would be an important tool that would allow to recognize the different magmatism types, suggest this way their possible economic potential.

REFERENCES

ATHERTON M.,WARDEN V. & SANDERSON L.M.(1985) The Mesozoic marginal basin of central Peru:a geochemical study of within plate-edge volcanism. In: Magmatism at a Plate Edge: The Peruvian Andes, p. 47-58, Blackie, Glasgow .

ATHERTON M., PITCHER W. & WARDEN V. (1983) The Mesozoic marginal basin of Central Peru. In: Nature, 305, p. 303-305.

BENAVIDES, V.(1956) Cretaceous System in Northern Peru. In: Bull. Amer. Mus. Nat. Hist.108, p. 252-494.

BONDELOS A. & ERICKSEN G. (1979) Tuco Chira. En: El Perú Minero. Tomo 4, vol. 2, p. 831-837.

CABOS R. & TUMIALAN P. (1975) Geología económica del distrito minero de Ticapampa-Ancash. En: Boletín de la Sociedad Geológia del Perú, Tomo Nº47, p. 31-56.

CARRASCAL R. & SAEZ J. (1990) Stratabound polymetallic ore deposits of the Santa metallotect in the Huanzala and Pachapaqui mining areas in Central Perú. In: Stratabound ore deposits in the Andes. Special publication Nº 8 of the Society for geology applied to mineral deposits, p. 554-568.

COBBING, E. J; PITCHER, W,S; WILSON, J.J; BALDOCK, J.W; TAYLOR, W.P; McCOURT, W. J; SNELLING, N. J. (1981) The geology of the western Cordillera of the north Peru. In: Institute of geological Sciences. Overseas, memoir, N° 5. 154 p.

COBBING E.J.(1973) Geología de los cuadrángulos de Barranca, Huaral y Canta. En: Serv. Geol. Bol. 26.

COBBING, E. J. AND PITCHER, W. S. (1972) The Coast batholith in the central Peru. In Journal Geol. Soc. London, Vol. 128, p. 421 – 460.

COSSIO A. & JAEN H. (1967) Geología de los cuadrángulos de Puemape, Chocope,Otuzco, Salaverry y Santa. En: Serv. Geol. Bol. 17.

HARRISON J.V. & WILSON J.J. (1960) Geolgía de la región comprendida entre Huacho y Vinchos. Soc. Geol. Peru, 35 p.

IMAI H. ET AL. (1985) Mineralization and Paragenesis of the Huanzalá Mine, Central Perú. In: Bulletin of the Society of Economic Geologists. Vol. 80, p. 461-477

JONES P.R. III (1981) Crustal structures of the Peru continental margin and adjacent Nazca Plate, 9 S latitude. In: Kulm, L.D. et al. eds. Nazca Plate. Geol. Soc. Amer. Mem.154, p. 423-443.

LIPTEN E. & SMITH S. (2005) The geology of the Antamina copper-zinc deposit, Perú, South América. In: PGC Publishing, Adelaide, vol. 1, p. 189-204.

LUJAN R. (1997) Geología del yacimiento polimetálico de Pachapaqui. En: Resúmenes extendidos de la Sociedad Geológica del Perú. Vol. 1, p. 83-88.

LYNAS B. & BENNETT J. (1983) Jacabamba molybdeum prospect, Ancash, Perú. In: Institution of mining and metallurgy. Transation section "B", Applied earth sciences, p. B42-B45.

MAMANI F. & RODRIGUEZ W. (1983) Informe geológico del área de reserva de "OCROS". In: Archivo técnico Ingemmet, 11p.

MEGARD F. (1984) The Andean orogenic period and its major structures in central and northern Peru. In: Geol. Soc. Lond. Jour. 141, p. 893-900.

MEGARD, F. (1973) Étude gélogique d´une transversal des Andes au niveau du Pérou central. These de l´Academie de Montpellier (Unpublished).

MYERS J.S. (1974) Cretaceous stratigraphy and structure, western Andes of Peru between latitudes 10° and 10° 30' S. In: Bull. Amer. Assoc. Petrol. Geol. 58, p.474-487.

NOBLE D.C, MCKEE E.M., MOURIER T. & MEGARD F. (1990) Cenozoic stratigraphy, magmatic activity, compressive deformation, and uplift in northern Peru. In: Geol.Soc. Amer. Bull. 102, p.1105-1113.

OLIVO G. & GIBBS K. (2003) Paragenesis and mineral chemistry of alabandite (MnS) from the Ag-rich Santo Toribio epithermal deposit, Northem Perú. In: A journal of mineral sciences. Vol. 67, Nº 1, p. 95-102.

PETFORD N., ATHERTON M.P. & HALLIDAY A.N. (1996) Rapid magma production rates, under-plating and remelting in the Andes: isotopic evidence from northern-central Peru (9 -11 S). Jour. South. Amer. Earth Sci., 9, p. 69-78.

REDWOOD S. (2004) Geology and development history of the Antamina copper-zinc skarn deposit, Perú. In: Society of economic geologists. Especial Publication 11, p. 259-277.

ROMERO, D., Carlotto, V., Tassinari., C. & Quispe, J. (2008) Los depósitos de la cuenca Maastrichtiano-Daniano: relación con los yacimientos tipo sulfuros masivos volcanogénicos de Pb-Zn-Cu; Perú central. Resúmenes extendidos XIV Congreso Peruano de Geología, en Revisión.

ROMERO, D. (2008) The Cordillera Blanca fault system as structural control of the Jurassic-Cretaceous basin in central-northern Peru. In: 7th International Symposium on Andean Geodynamics (ISAG 2008, Nice), Extended Abstracts: p. 465-468.

ROMERO, D. (2007) La cuenca Cretácico superior-Paleoceno del Perú central: un metalotecto para la exploración de SMV, Ejemplo Mina Maria Teresa. Tesis de maestría Programa ALFA, pp. 100.

SAMAME B. (1979) Katanga. En: El Perú Minero. Tomo 4, vol. 1, p. 264-284.

SANCHEZ A. (1995) Geología de los cuadrángulos de Chimbote, Casma, y Culebras. En INGEMMET, Bol.59.

VELA C. (1997) Nueva concepción estratigráfica de la sudcuenca de Lima. En: Soc. Geol. Peru. Vol.Esp.1, p. 409-412.

VIZCARRA J. & LINARES S. (1997) Modelo estructural del Yacimiento de Huinac, Ancash. En: Resúmenes extendidos de la Sociedad Geológica del Perú, vol. 1, p. 225-230.

VOLKERT D. et al. (1999) Pierina Au-Ag deposit, Cordillera Negra, north-central Perú. In: Mineria, año 46, Nº 259, p. 17-20.

WILSON D. (1985) The deeper structures of the Central Andes and some geophysical Constraints. In: Magmatism at a Plate Edge:The Peruvian Andes (W,S.Pitcher elt al. Eds.). p. 13-18. Blackie, Glasgow.

WILSON, J. J. (2002) Structural development of the Northern Andes of Peru. In**:** X Congreso Peruano de Geología, Lima- Perú.

WILSON J.J., Reyes L. & Garayar J. (1967) Geología de los cuadrángulos de Mollebamba, Tayabamba, Huaylas, Pomabamba, Carhuaz y Huari. In: Serv. Geol. Bol. 16.

WILSON J.J. (1963) Cretaceous stratigraphy of Central Andes of Peru. In: Bull. Amer. Assoc. Petrol. Geol. 47, p. 1-34.

ANNEXES