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ESTIMATION OF MINERAL RESOURCES IN ANTAPACCAY MINING SITE USING DISTANCE INVERSE METHOD AND PROPER CALCULATION OF ALPHA FACTOR

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ABSTRACT

The purpose of a statistical model is to provide the mechanism to make inferences about a population based on information obtained from a sample. The probability of the observed sample is useful to make an inference about the population. In the present work we will develop the method of estimation of resources of the inverse of the distance and its dependence on the alpha parameter, which is based on a geostatistical topic using a variogram, in this particular case we will focus on the use of the method with data from the mine of Antapay to calculate and compare the method using a resource estimation program.

keywords: inverse method at distance, alfa factor choice, antapacay.

INTRODUCTION

Geostatistical estimation methods are commonly used for interpolation and estimation of different variables, in the case of inverse to distance methods are used in 2D and / or 3D local environments. An adequate estimation method is important with respect to the geometry and geological properties of the minerals.

Deposits and drilling patterns are an important issue in the estimation of resources / reserves. (David, 1970, Boisvert et al., 2008, Martins et al., 2011, Shahbeik et al., 2014). Therefore, the estimation of a precise estimation method is essential to reduce the error estimate and increase the accuracy of the evaluation of resources and reserves. (Dimitrakopoulos et al., 2007; Parhizkar et al., 2011).

The method weighted by inverse distance (IDW), have been used to interpolate polynomials and splines, to overcome the aforementioned problem that are the calculation of reserves and the lower use of resources in the field (drilling rigs and witnesses). This methods is generally used in most cases in mineral exploration and mine engineering. (Gerald van den Boogaart and Tolosana-Delgado, 2008). Using real data instead of Synthetic data has several advantages; for example, the case of the Cuajone mine. Evaluation of the distribution of the mineral element is an important parameter for the planning and design of the mine (Hustrulid and Kuchta, 2006).

PROBLEM

he great diversification of methods for the estimation of resources of mineral deposits shows different patterns to be taken into account during the calculation and depending on the type of method to be applied will entail a certain expense to the company; however, the inverse to distance method is a mathematical method of interpolation that uses an inverse function of distance and assumes that the samples have different weight depending on the distance from the center, this method also reduces costs and it allows to have data of the local geology with greater reliability since the reserve is estimated with a high level of trust based on details of law and distance.

OBJECTIVES

- find the value of the alpha parameter based on data from drillhole assays and the inverse distance method.
- perform the reserves estimation using the technique of the inverse distance weigthing for antapaccay.

1 GENERAL

1.1 Location

The mine is located at:

District: Yauri

Province: Espinar

Department: Cuzco

Height: 4,000 m s.n.m.

To reach the mining camp is by air Lima - Arequipa, then travel approximately 250 kilometers along the Arequipa - Tintaya Espinar highway. Another access is via the Lima - Cuzco air route and by land, Cuzco - Espinar - Tintaya, at an approximate distance of 260 km. Also it can be accessed through the Arequipa - Espinar area, in an approximate time of 30 minutes, using the Yauri heliport, which was built by Tintaya. The UTM coordinates of the administrative offices of the Tintaya mining camp are:

NORTH: 8,355,155.05   EAST: 250,409.76

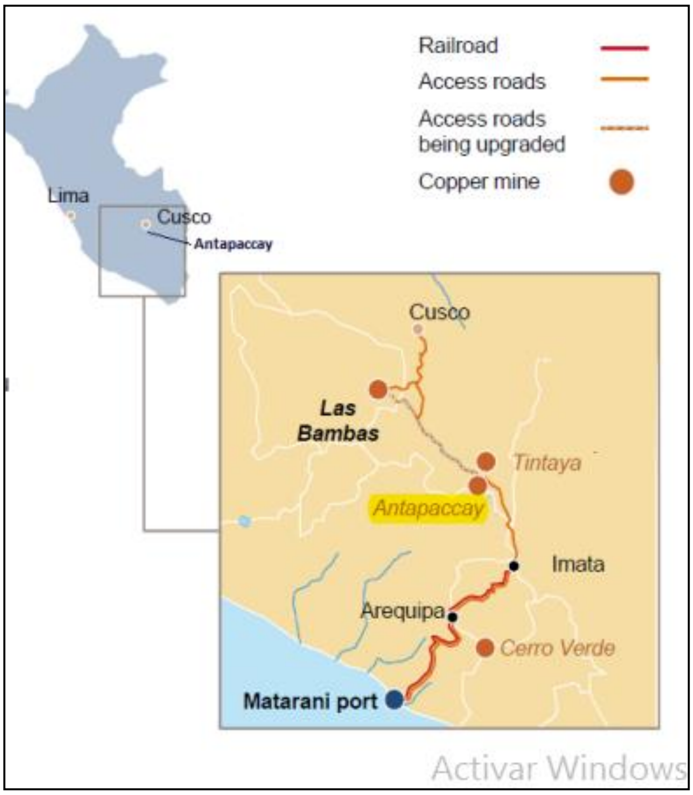


Ilustración 1. Access Antapaccay mine

Tintaya is located between the geographical coordinates 14º 55 '-14 ° 54' south latitude and 71º 20 '- 71º 19' west; between 4000 and 4100 m levels and corresponds to the district of Yauri, Espinar province, Cusco department.
It is the Urcos-Yanaoca-Yauri-Tintaya route travel approximately 252km; It is also connected to the port of Matarani, 444km by road or rail 600km South passing Sicuani and is connected by road to Tintaya.

1.2 Geology

1.2.1 Regional Geomorphology

The geomorphology, the relations with the conglomerates, the typical ones of the Puno Group, the observations towards the north, the oriental chains, the great extensions, the volcanos and fluvioglaciares, the covers until the argillaceous soil. , which is observed to the south, in the western chain.

1.2.2 Regional Stratigraphy

The Tintaya deposit is included in the Sicuani and Ocogate quadrants. The oldest rocks are the Copacabana Group that belong to the Permian (lower-middle), limestones and black limonites, and the Upper Permian to the Triassic continental, the red and andesitic volcanic layers of the Mitu Group (Klinck et al., 1991; Mendívil y Dávila, 1994), located north and east of the Andahuaylas-Yauri belt. The mesozoic units include the Hualhuani orthocuarcites, the quartz-rich conglomerates-Huancané, and the red and lutite sandstones of the Murco formation (Dávila, 1988).

In the area five magmatic pulses are recognized in the Andahuaylas-Yauri batholith. The first is a unit of gabor-diorite-quartz diorite- (it represents 80% of the intrusive rocks in the area). The second is for the small occurrences of gabro-monzogabro-monzogabro quartz. The third is an intrusion of porphyritic monzonite quartz. The fourth pulse is a porphyritic monzonite located south of the monzonite quartz. To the southwest of the Tintaya porphyry, a dacitic porphyry is placed as the fifth and last pulse of the batholith, contemporary with the Miocene and Pliocene volcanics.

The Andahuaylas-Yauri batholith intrudes a sedimentary sequence, which extends from the Upper Jurassic to the Middle Cretaceous. The oldest are the prayers of the Hualhuani (Neocomian) formation of the upper part of the Yura Group. They are superimposed by a conglomerate rich in quartz that correlates with the Huancané formation, from the Jurassic to the Lower Cretaceous. It is a sequence rich in faith of red sandstones and shales, probably belonging to the Murco Formation. The limestones of the Ferrobamba Formation, of the Cenomanian-Turonian Formation, were deposited after the clastic sequence. It is 300 to 800 meters thick and deposits in an environment of internal carbonated platform. The Ferrobamba Formation correlates with the Arcurquina Formation of the Arequipa basin and the Ayavacas limestone of the Lake Titicaca basin. To the north, discordantly overlying the Ferrobamba limestones, the Yauri Formation is deposited, consisting of tuffs, silty sandstones and sandstones of higher Pliocene age. To the south it is overlain by siliceous volcanic rocks (porphyritic rocks) of the

Barroso group of Pliocene and Pleistocene age. The most recent formations are glacial-fluvial Pleistocene sediments and alluvial-fluvial sediments of the Holocene.

Regionally, the Tintaya mine is located in an elongated belt of Mesozoic sedimentary rocks that extend for more than 300 kilometers from Andahuaylas in the Northwest, to Yauri in the Southeast. Legal Framework

1.2.3. Regional Petrology

Greenstone.

Its main characteristic is its content of mafics that can reach up to 25%. It presents a greenish gray to dark gray color, of medium to fine grain, of faneritic texture. It consists essentially of plagioclase, hornblende and augite and little biotite. They are distributed in the surroundings of the sites and have very similar textural and compositional characteristics in their different outcrops.

Granodiorite

It is light gray in color and is medium-grained, consisting mainly of plagioclase, with partially chloritized hornblende and biotite, quartz and orthoclase. Distributed in the surroundings of the deposits, it presents some diorite xenoliths that clearly indicate its later location.

Monzonite

Associated with the formation of skarn is presented as dykes and stocks. It is light gray, generally porphyritic, phenocrysts of plagioclase and orthoses with some hornblende and biotite in an aphanitic matrix of quartz-ortosa.

Andesite, Latita and Riodacita

They are the later events and are mainly constituted as dykes.

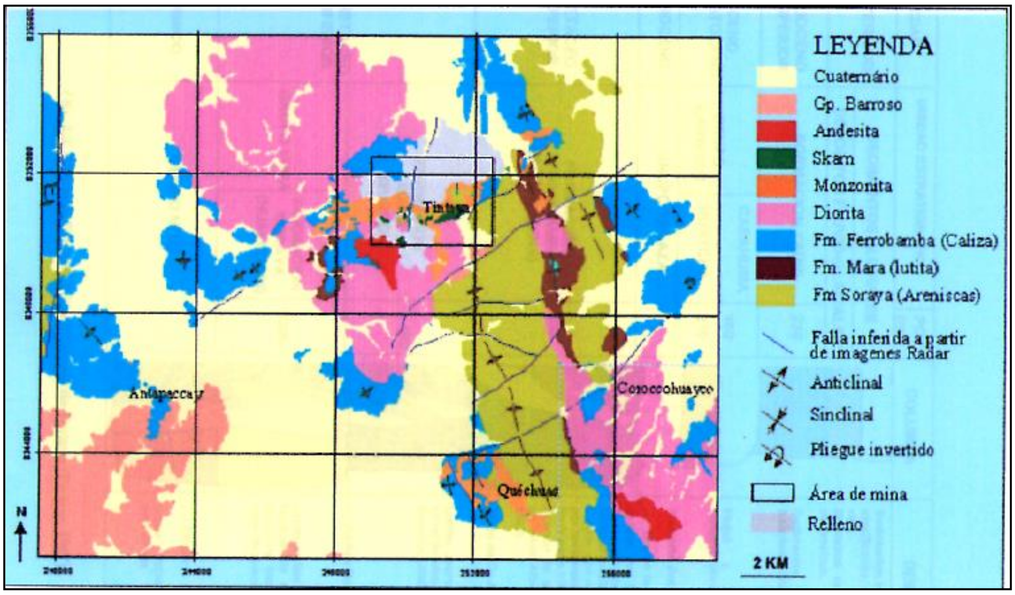


Ilustración 2. Regional Petrological reasoning of the Antapaccay mine.

1.2.4. Climate and meteorology

The area of the Tintaya mine is characterized by a cool and humid climate, with rainy and dry periods. The average annual total evaporation is 1,599.7 mm. The average temperature of the area is 7.3 ° C; The month of June reaches the lowest temperatures, oscillating between 0 ° C and 9.9 ° C.

The average relative humidity of the zones is 55.2%. During the year it remained at 61.2% (January) and 50.2% (September), as a monthly average.

The presence of rain in the basin marks two seasons, the first rainy season that begins in November and ends in April and the second dry season from May to October, with July being the driest month with 55% persistence with 0.0 mm. The average annual average is 762.3 mm, based on the historical record, the maximum value in the year 1984 is 1291.7 mm and the minimum is 417.6 mm in the year 1983.

The winds have predominant directions that from NNE to NNW with frequencies of up to 35% for wind N in the station located in the north of Huinipampa and 20% in camp 2., of 15% for wind NW in Camp 2 and less than 10 Near of the dam of Ccamacmayo.

1.2.5. Air quality

The air quality in the area of operations development is preimpacted by the mining activities in current development, so that the increase of potential of atmospheric pollutants, especially in the pertinent to the concentration of particles in suspension, is a factor that it has been considered within the mitigation plans implemented and optimized by Tintaya, associated with the development of operations so as not to deteriorate the existing basic conditions.

1.2.6. Surface water courses

The Tintaya mining unit is located in the river basin of the Salado River. The Salado River is a tributary of the Apurímac River, which will form part of the Ucayali basin and eventually form the great Amazon River. The Tintaya River and the Ccamacmayo Stream, whose waters run from south to north, flow into the Salado River. The Quebradas where the mining activities take place correspond to the Tintaya and Ccamacmayo micro-basins. There are also mining activities in the Coloyomayo micro-watershed, which is a tributary to the Cañipia River. The Cañipía River joins the Salado River before reaching the Apurímac River. The water courses that could be directly affected by the operations are: Tintaya river, streams: Chullumayo, Ccamacmayo, Yanamayo, Shangrilla, Paccpaco, Huinipampa because they are streams bordering mine operations. The Salado and Canipia rivers would be considered indirectly. The current uses of water are mainly:

- For irrigation and animal drink; Y
- For use of mine operations. Potential uses:
- For agricultural activities (for irrigation and animal drink);
- For human consumption; Y
- For activities related to the industry.

1.2.7. Groundwater courses

With regard to flows, groundwater flows vary depending on the period of low water and floods, being of the order of 120 l / s for the first case and 160 l / s for the second approximately. In general, we have two aquifers, one of which consists of glacial fluvial cover whose contributions are mainly in the flood season, below which is located another aquifer constituted by pre-quaternary rocks (monzonites and limestones) which is the main aquifer.

Groundwater is monitored in the Tintaya and Huinipampa micro-watersheds.

At present:

- The quality of groundwater is controlled, they do not have any use. And if these outcrop are used for irrigation and animal drink.
- For human consumption there are water springs that are distributed to the camps.

1.2.8. Life zones

According to the Ecological Map of Peru and its Explanatory Guide (INRENA, 1996) the area corresponding to the mining activities of Tintaya S.A. (Tintaya river, Camacmayo effluent - Salado river receiving body, and Huinipampa tailings dam - Cañipia river receiving body) correspond to the life zone: Very wet paramo - SUBTROPICAL SUBALPINO (pmh - SaS); that in the Explanatory Guide of the Ecological Map of Peru, refers the following basic information.

1.2.9. Flora

The analysis of flora information allows us to affirm that the specific diversity is moderate to moderately high since it is represented by 65 species belonging to 54 genera, 30 families, 23 orders, 8 subclasses, 3 classes and 2 divisions.

1.2.10. Wildlife

The specific diversity of amphibians is very low and is composed of 5 species that correspond to 3 families and 4 genera. The specific diversity of the faunal group of birds is the largest that occurs in the area of the mine, including the Tintaya and Ccamacmayo micro-basins.

1.3 LOCAL GEOLOGY

1.3.1 GEOMORPHOLOGY

Locally, the mining deposit of Tintaya, is determined as the flatness of Yauri, with shallow valleys, hills of little elevation, concave geometry and smooth slope. The mountains in general have a moderate elevation with respect to the Altiplano, such as Condorsayana (4575 masl), and some with higher elevation such as Condoroma, to the north, La Raya mountains, to the SE, where the terrain presents strong and soft slopes, typical of the erosion of glaciers.

The drainage is controlled by the structures of the area, such as the NW line of the Salado River, whose tributaries (Pallatamayo, Alpacomaña, Huichuma, Calzada, etc.) take the NW line, showing a straight drainage. Only the Tintaya, Ccañipía and Salado rivers maintain their flow throughout the year, while the rest of the rivers have their flow in times of coming. Locally, the Tajo Tintaya area is located on the slopes of the Huancaruma and Condorsayana hills that form the ravine through which the Chullumayo River flows, which are covered by morphine and fluvioglacial material.

1.3.2 STRATIGRAPHY

The Cretaceous stratigraphic sequence comprising the Soraya, Mara and Ferrobamba Formations is incomplete. The substratum and consequently the discordance of the base of the Soraya Formation do not surface. The passage from the Mara Formation to the Ferrobamba Formation is through a marked disagreement. The Ferrobamba Formation is not overlain by formations of the Upper-Tertiary Cretaceous so its top is eroded.

The thicknesses and lithofacies vary from one place to another due to the tectonic presence without-sedimentary and erosions. For example, in the Ferrobamba formation we found a thickness of 500m in Chabuca Este to be reduced to a thickness of less than 50 m NE of Zona Nueva.

1.3.2.1 Soraya Formation (200-500m).

It correlates with the Huallhuani Formation of Upper Jurassic age. It is constituted by yellow to white quartzites of fine to medium grain with small intercalations of red to gray shales (Jenks, 1948). The contact of the roof is generally progressive to the Mara Formation (decrease of quartzose sandstone in the Soraya Formation giving way to an increase of shale from the Mara Formation).

The Soraya formation consists mostly of monotonous sequences of recrystallized quartzose sandstone ("quartzite") of varied grain sizes (coarse to fine). Locally there are intercalations of lenses (channels) of intraformational conglomerates with predominantly quartzite and erratic clasts of andesite coming from the erosion of the substratum volcanic sequences (Grupo Mitu), as well as thin strata (<10cm) of intraformational conglomerates. The top of the Formation consists of alternating layers of quartzose sandstone with shale. Soraya quartzite shows weak conditions to store economic mineralization due to the low porosity and permeability (very good cementation). However, this rock has strong secondary permeability, due to strongly fractured and failed areas, so it may have conditions to house moderate weak concentrations of oxides and sulphides mineralization of the stockwork type.

1.3.2.2 Mara Formation (50-300m).

It correlates with the Murco Formation of the lower Cretaceous. The contact relations with the underlying formation is not defined as previously described, but with the overlying formation (Ferrobamba) it is through a marked disagreement (E. Cordova, 2000). The Mara Formation in "complete" outcrop consists of 3 members: A, B and C. Member A consists mostly of massive layers of brown and greenish shale with intercalations of lytic and feldspathic sandstone lenses with friable tendency. Member B contains laminated and massive quartzite layers well cemented, similar to Soraya quartzite. Member C consists mostly of reddish shale interbedded with limonite and fine-grained feldspathic sandstone. The litofacies of the Mara Formation show moderate conditions for storing economic mineralization due to the good porosity and permeability of the lithic and feldespathic sandstone, the shale acting as a seal rock.

1.3.2.3 Ferrobamba Formation (50-70 m).

It correlates with the Arcurquina Formation of the Middle Cretaceous. The relations of contact with the Underlying Mara Training is through a marked disagreement. The roof is eroded because there are no overlying Cretaceous-Tertiary formations. The sequence is incomplete and presents different thicknesses in different outcrops. There is no lateral continuity due to the anticlines and synclines in the Soraya and Mara formations (eroded Ferrobamba) and on the other hand the sequence is cut by the numerous bodies. According to the last classification, it was divided into 3 members: the lower one that has an approximate power of 300m, is it is constituted by breached marl, and powerful massive limestone; and the upper one that has a power of 170 m, and is formed by massive layers of limestone with abundant chert nodules interspersed with dolomitized limestone (Jenks, 1951).

1.3.2.4 Yauri Training.

It appears in the whole Yauri pleneplanicie. Lacustrine sediments with tufa sands and fluvial conglomerates, tentatively from the upper Pliocene. The Yauri formation with unknown floor (does not appear) and eroded roof has an approximate power of 230 m.

1.3.2.5 Fluvial Deposits - Glaciers.

Constituted by clasts and volcanic, sedimentary and igneous rocks in smaller proportion, variable size and granular matrix, it is covered by a layer of humic soil of 0.50 to 1 meter thick.

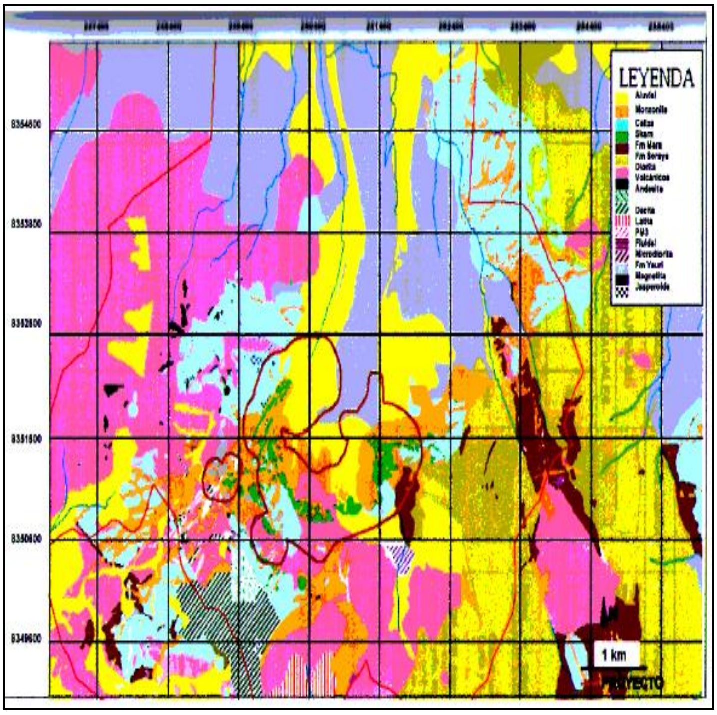


Ilustración 3. Antapaccay local geology

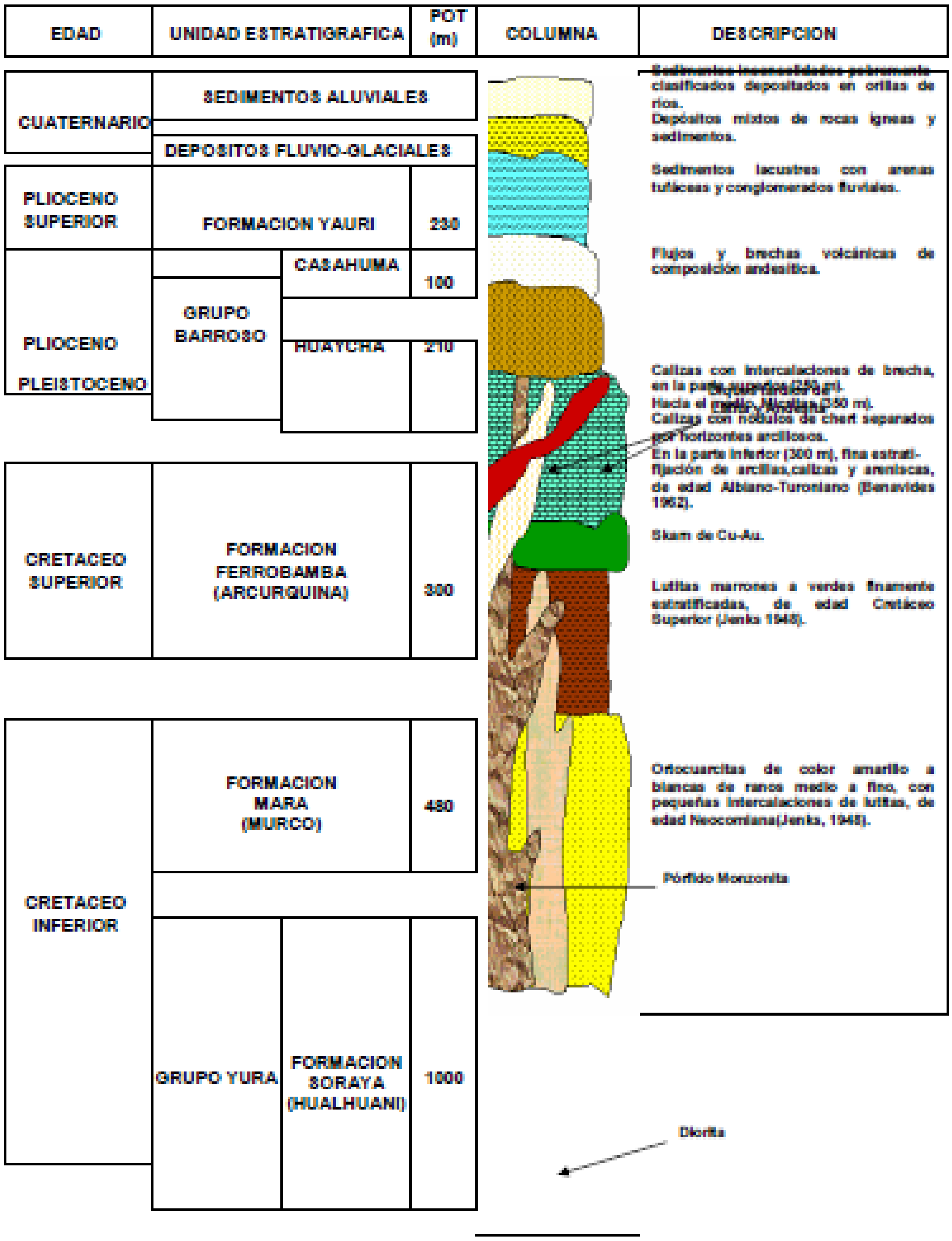


Ilustración 4. Stratigraphy of the Antapaccay mine.

1.4 Local Petrology

1.4.1 Diorite (FLUIDAL)

It has a fluidic porphyritic texture, where the plagioclase phenocrysts are elongated and aligned. They do not present quartz. The ratio of phenocrysts: matrix is 65:35. In contact with the sedimentary rocks this rock only forms endoskarn, with mineralization of pyrite and chalcopyrite disseminated and in spots. It is assumed that it extends from the Tintaya Tagus to the Chabuca Sur zone.

1.4.2 Diorite.

It is characterized by its fine grain phaneritic texture, rich in hornblende, and whose magnetite content is greater than 1.5%. The amount of magnetite is greater than the rest of the intrusive rocks present. Within the Tintaya area it occurs mainly as sills. In contact with carbonate rocks, diorite forms centimetric pyroxene skarn bodies.

1.4.3 Monzonitic Porphyry.

It is the main mineralizing porphyry, and it is after the site of the diorite. This type of monzonite occupies the largest significant volume with respect to the other monzonites within the Tintaya area.

It has a medium grain porphyritic texture, characterized by its higher content of quartz crystals (> 7%), and euhedral crystals of biotite 3-6 mm wide, of broad-leaved habit (> 5%), tabular hornblende (> 5%) . As accessory minerals it has spheena, pyrite and magnetite, all within a feldspathic-siliceous aphanitic matrix whose quantity varies based on the time of crystallization and the cooling history of the magma. In general there is a phenocrystal relationship: 80:20 matrix. This monzonite is cut by numerous veins of qz-cpy-py, and qz-cpy-py-mo with halos of kspar, veins of quartz and ortosa. The PM1a porphyry in contact with the Ferrobamba limestones forms mineralized garnet and pyroxene skarn bodies, due to the consecutive events of hydrothermal fluids coming from the same magmatic pulse.

1.4.4 Latita.

This type of rock corresponds to the last monzonite porphyry event, and is equivalent to the PM3. It contains abundant plagioclase (80%), hornblende (6%), biotite (4%) and rare eyes of quartz and alkali feldspar together with larger grains of biotite. The latitas cut the monzonitas and skarn in Chabuca Norte and Chabuca Sur and TajoTintaya. Latita does not contain hydrothermal veins, and represents the youngest post-skarn dike. Towards the area of Chabuca Este and Chabuca Sur, the canyon is NW and dip NE, located parallel to major faults that affect the area. The latite dikes are late and sterile in Cu sulphides. Latita is the fourth intrusive activity event in Tintaya. It has a width of 10-40m, and a length of approximately 600m. cut by quartz veins with pyrite and traces of cpy. The age of this type of rock is weak. The site of this dam was post-mineral. However, the presence of chlorite-pyrite microfractures indicates that it is a late dyke of monzonites emplaced before the cessation of the hydrothermal hypogenic system. In contact with sedimentary rocks this rock does not form endoskarn.

1.4.5 Porphyry Andesite.

It has a porphyritic texture with medium to fine grain plagioclase, elongated tabular hornblends (4%), and with magnetite accessories within a siliceous-feldspathic matrix. It has a relationship fenos: matrix of 65:35. This porphyry lacks biotite. The origin of this rock is subvolcanic, it represents a late pulsation so it is cutting skarn, monzonitas and latita. These dams have a predominant orientation NS, N-NW, N-NE, and were controlled by faults. It has a power of 15-30m.

Figure 4: shows the main types of rock from the Antapaccay mine.

1.5 STRUCTURAL GEOLOGY

Regarding the fault, the mining district of Tintaya is differentiable 3 systems of main structural guidelines. From the oldest to the youngest we have: the normal EW faults, with dip to the north; the NW and NE faults; and the NS faults. These were generated during the Peruvian and Inca tectonic phases. Which have been reactivated and probably rotated during the successive tectonic periods. Due to the structural complexity presented in Tintaya due to the super imposition of several tectonic events, it is difficult to make a rigid classification, however the tentative classification could be: the NW and NE faults are the oldest faults, followed by the EW faults and finally the NS faults. The structural behavior of this region indicates a compressive stress direction E-NE that gives rise to N-NW orientation folds. The EW faults contain ca-cl-py-cpy, cut the programed skarn, and were important controls in the distribution of retrograde alteration. The dike of PM2, was located thanks to the failures NW NE.

The folds have a NNW tendency in quartzites, NW in limestones, which correspond to the Peruvian and Inca tectonic phase. The difference between the courses of the folds in the quartzite as well as in the limestones is possibly due to a difference of behavior to the deformation. Local efforts caused by intrusions within the Ferrobamba seem to be causing more deformation locally.

On a general scale the district of Tintaya is characterized by a large anticline that is exposed by the Soraya formation, open and symmetrical, approximately 5 km wide or wavelength, and 16 km long south (covering the Quechuas area) north (to the south of Tintaya) with a NNW heading. The transition area between the anticline and syncline is cut by normal faults NE and NW. Through these normal faults the sedimentary layers of the Ferrobamba limestones are sliding, exposing the layers of Soraya quartzites, which constitute the structural highs of the district

1.6 DEPOSIT

Since 2006, Xstrata Copper, the fourth largest copper producer in the world, acquired the Tintaya deposit, the production capacity of this mining unit was increased to 85 thousand tons of Cu in concentrates, 35 thousand in cathodes and 30 thousand ounces of gold, developing in parallel a broad program of social responsibility in the Cusco communities adjacent to the operation.

It is a copper deposit type skarn consisting of Cretaceous sedimentary rocks invaded by monsoon plutons, with bornite, calcantite, calcosine and copper oxides as the main minerals bearing Cu.

The Probable and Probable Mineral Reserves include 10 million tons with 1 percent of sulfides and oxides collected for their treatment during the remaining life of the mine. This estimate is based on a Resource Block Model that was constructed using ordinary Kriging interpolation within the geological limits and taking into account the historical data of tests that comprise approximately 651 thousand meters of diamond drilling and reverse circulation.

In Tintaya, copper appears to be mostly linked to sulfides, although it is also found associated with oxidized minerals. These two types require different production processes, but in both cases the starting point is the same: the extraction of material from the mine to an open pit that, in the form of rocks, is transported in trucks to the crushing plant, to continue there the productive process.

1.7 PROCESSING FACILITIES

1.7.1. Sulfide Plant

The current treatment capacity in the Tintaya Concentrator Plant is 18 kpd with a head grade of 1.4% CuT, whose annual fine copper production is 85,000 MT.

For the extraction of the metal, a pyro metallurgical process is used, eliminating impurities such as sulfur, iron and insolubles. The main sulphide minerals of the deposit are 90% chalcopyrite, bornite and calcosine, approximately 10%.

The Antapacay flotation circuit consists of five cells of 100 m3 capacity, Rougher circuit; 12 Outukumpo cells of 38 m3, Escavengher circuit; and in the Cleaner circuit it has three Svedala cells of 130 m3 capacity, a Wemvo cell of 130 and column cells of 10 m high by 2.5 m in diameter with a vertical mill of 200HP to release the mixed minerals floating in the Cleaner circuit. increase the grades of concentrate.

The recovery obtained through this process is usually in the range of 88% with concentrate grade higher than 32% copper.

1.7.2. Oxides Plant

Oxidized ore from the Tintaya mine is reduced in size by crushing and stacked on permanent fields to be irrigated with a weak solution of sulfuric acid, in different concentrations where oxidized copper dissolves.

The fine mineral product of the crushing is subjected to the process of leaching in agitation and backwashing (CCD). Copper dissolved in the ionic state is part of the charged solution (PLS). In the solvent extraction plant, the ionic Cu is concentrated and purified, and then deposited in the electro-winning stage by means of a continuous current, thus producing pure metallic copper of "A" quality. The purpose of the solvent extraction circuit is to concentrate and purify the ionic copper in solution. It uses an organic reagent that has a high selective affinity for Cu ions, leaving the impurities in the liquid phase. It consists of two stages: one of extraction (E-1 and E-2) and another of reextraction (S-1 and S-2). Antapacay produces pure copper cathodes (99.999% Cu), by electrolytic deposition of the mineral for five days. The electrolyte that enters the electrowinning ship deposits the copper in metallic form in cathodes, which constitutes the final product. During the operation time of the Oxides Plant the production was 100% "A" grade.

1.7.3. Mineral Resource

The mineral resource is the natural concentration in situ or the occurrence of mineralization within a geologically defined zone (Illustration N ° 1), it has characteristics of quantity, degree and continuity; which are partially known, estimated or interpreted from evidence. The presence of mineralization is inferred without a scheduled verification framework and cutoff concept. The main emphasis is the estimation of the inventory of low confidence resources made during the early exploration stage or around the outer periphery of the economic concentration. The economic viability is premature and is established after the advanced stages of exploration. The form, quantity and grade indicate intrinsic future interests and reasonable prospects for eventual profitable extraction.

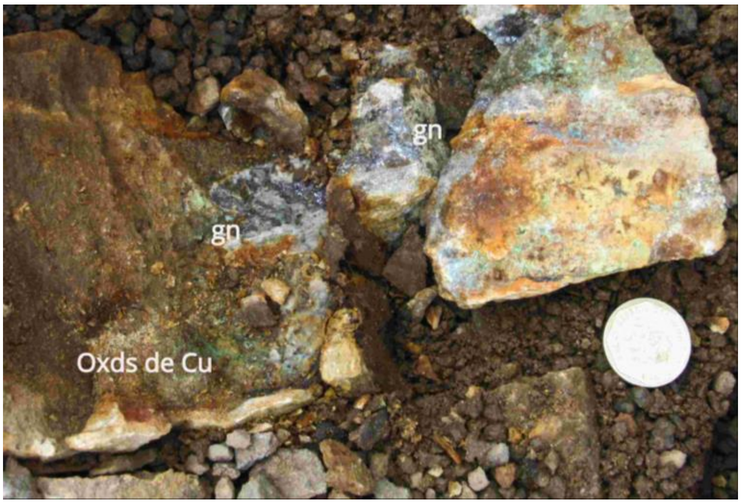


Figure 5. Vein with mineralization, which will undergo a Cut off calculation process.

1.7.4. ORE DEPOSIT

Since in 2006, Xstrata Copper, the fourth largest copper producer in the world, acquired the site Tintaya, the production capacity of this mining unit increased to 85 thousand tons of Cu in concentrate, 35,000 in cathodes and 30 thousand ounces gold, parallel developing a comprehensive program of social responsibility in adjacent communities cusqueñas operation.

It is a copper deposit skarn consisting of chalky sedimentary rocks invaded by monsoon plutons bornite, chalcanthite, chalcocite and copper oxides as the main bearing minerals Cu.

Mineral Reserve Proven and Probable include 10 million tons with 1 percent of sulfides and stockpiled for treatment during the remaining lifetime of the mine oxides. This estimate is based on a model of resource blocks to be built using ordinary Kriging interpolation within geological boundaries and taking into account historical test data comprising approximately 651,000 meters of diamond drilling and reverse circulation.

copper appear linked in Tintaya mostly sulfides, although it is also found associated with oxide ores. These two types require different production processes, but in both cases the starting point is the same: the extraction of material from the open pit mine that shaped rock is trucked to the crushing plant to continue there the production process.

1.7.4.1. Sulphides

The current treatment capacity in the Concentrator Plant Tintaya is 18 kpd head grading 1.4% CuT, whose annual production of fine copper is 85.000 TM.

To extract the metal pyro metallurgical process used, removing impurities such as sulfur, iron and insoluble. The major sulphide minerals chalcopyrite reservoir are 90%, bornite and chalcocite, 10% approximately.

The Tintaya flotation circuit consists of five cells of 100 m3 capacity, Rougher circuit; 12 cells Outukumpo of 38 m3, Escavengher circuit; and the Cleaner circuit has three cells Svedala 130 m3 of capacity, Wemvo cell 130 and column cells 10 m high and 2.5 m in diameter with a vertical mill 200HP to release the mixed ores float in the Cleaner circuit and increasing concentrate grade.

Recovery obtained through this process is typically in the range of 88% grading to 32% higher copper concentrate.

1.7.4.2. Oxides

The oxidized ore from Tintaya mine is reduced in size by crushing and stacked permanent fields to be irrigated with a weak solution of sulfuric acid in different concentrations where the oxidized copper is dissolved.

The fine ore crushing product is subjected to the leaching process and backwash agitation (CCD). The dissolved copper in the ionic state is part of the pregnant solution (PLS). In the solvent extraction plant, the Cu ion is concentrated and purified and then be deposited in the electrowinning stage through a continuous stream, producing pure metallic copper quality "A". The solvent extraction circuit is designed to concentrate and purify the ionic copper solution. It employs an organic reagent having high affinity for selective Cu ions, leaving impurities in the liquid phase. It consists of two stages: extraction (E-1 and E-2) and other stripping (S-1 and S-2). Tintaya produces pure copper cathode (99.999% Cu), by electrolytic deposition of mineral for five days. The electrolyte entering the electrowinning ship, copper deposited in metallic cathodes, which constitutes the final product. During the operation time Oxides Plant production has been 100% grade "A".

1.7.5. PRODUCTION

1.7.5.1. Copper mine Tintaya

In southern Peru, is on track to reach production of 90,000t as was budgeted for this year, he told BNamericas.com the mine president Jaap Zwaan. Its financial year ends this month, on par with the Australian financial year which owns 100% of the deposit is governed. The rate of mine production was 2,700t less than budgeted for the period from January to March, because of the heaviest rainfall than usual, besides the fact that the wet season was longer than normal.

TINTAYA PRODUCTION: Production of Tintaya in the last 5 years was as follows:

TINTAYA	2007	2008	2009	2010	2011
Copper (mtf)	119540	110770	107233	93015	95262
Silver (kgf)	35,880	29,982	29.061	25,645	27,051
Gold (kgf)	1,206	1.139.7	1,167	935.5	1,058

Ilustración 5. Tintaya production

1.7.6. METHODS OF EXPLOITATION:

Tintaya is an important copper mine. As mines as Cuajone and Toquepala Tacna Moquegua it is operated under the open pit system, ie by blasting the soil is removed, and the removed material, rich in copper processing becomes.

1.7.6.1. OPEN PIT

Surely we have heard mentioned more than once a mine is open pit and another is tunneled, but we have not become aware of the operational implications of each of these options and above all the importance of its determination within planning of a mining project. Given the importance of this aspect it is that in this Information Fortnightly, we seek to explain and indicate the characteristics of each. The previous analysis after the place where the mineral (with the processes of prospecting and exploration) we proceed to carry out the feasibility study which will determine, according to various parameters, if the mining project is viable been located (feasible) or not.

The feasibility study therefore also analyzes the most efficient way to extract the ore deposit you have, and depending on that choice determines infrastructure, human capital, tools and machinery that requires minimizing the costs required for this purpose throughout the life of the project. So how it is that mining will take place will be a key point in the feasibility study, and finally affects the volume of possible production and cost structure of the mine. So, you will need to analyze two alternatives: Open Pit or Socavón. Open Pit and Socavón What are they? Open pit and the tunnel are two methods for mining mineral extraction, and commonly referred to as operating methods. There are basic criteria, primarily technical, allowing you to choose the method of exploitation of minerals. Among them we can find: shape, size and spatial position of the orebody (grain) or content and distribution thereof. Physical and chemical or mineral and the surrounding rock properties. or economic factors and ease of transport. or safety conditions, environmental and government regulations.

As seen, the decision regarding the method of operation to be performed will depend on economic, geological and environmental factors.

Figure 6. Open pit operation

The mining (exploitation) or Open Pit opencast is performed when the deposits are large, have a regular shape, and are located on the surface or near it. This is an efficient process to the extent that the cost of extracting the ore (including the mobilization of non-commercial material covers), is less than the trading price of the mineral to be extracted. The open pit looks like a big bowl and this is built in so far as the operation progresses, both laterally and in depth. As will locking, an amphitheater is generated (by the stepped shape) whose shape can be changed to the extent that the operation proceeds. While the concept of an open pit mine is very basic, conception and development involves a complex and costly planning. It should be noted also that many mining operations often begin as open pit and when they reach a point where the cost of extracting the ore does not cover the cost of removal of surrounding rocks start using adit mining methods.

How open pit mine exploited?

Before starting drilling is important to take into account a fundamental element in their planning: the angle of the slope (pit), which determine both safety and the profitability of the mine. Once determined the slope you start with the withdrawal of rocks to reach the mineral. Extraction begins with drilling and blasting rock, processes that start blocks concrete rock into smaller pieces that are loaded onto trucks with large electrical or hydraulic shovels or bulldozers, to be removed and classified in heavy trucks . As the pit is growing form what are called banks, which are like "stairs" around which the ore is exploited and are connected by ramps between them and toward the surface.

Ilustración 6. Open pit mine exploited

1.8. PRODUCING MINERAL TYPES

Since in 2006, Xstrata Copper, the fourth largest copper producer in the world, acquired the site Tintaya, the production capacity of this mining unit increased to 85 thousand tons of Cu in concentrate, 35,000 in cathodes and 30 thousand ounces gold, parallel developing a comprehensive program of social responsibility in adjacent communities cusqueñas operation.

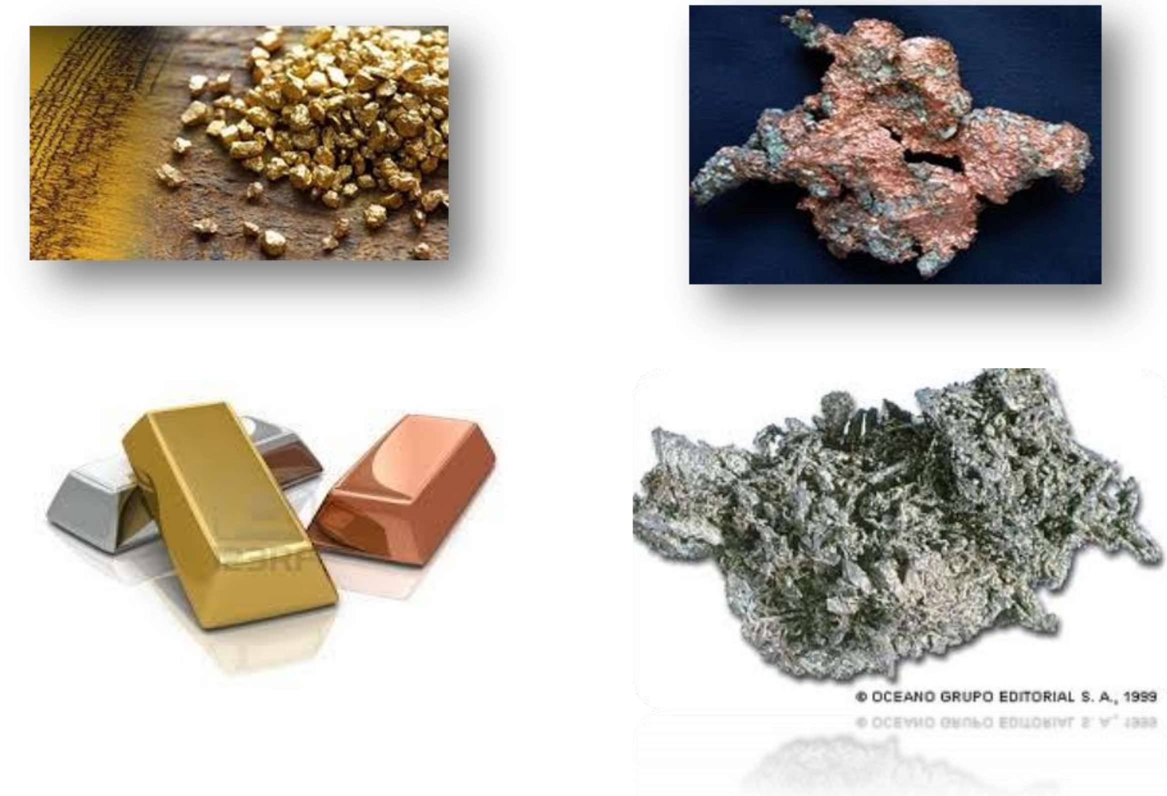


Ilustración 7. Producing mineral types

1.9. MINERAL DISTRIBUTION

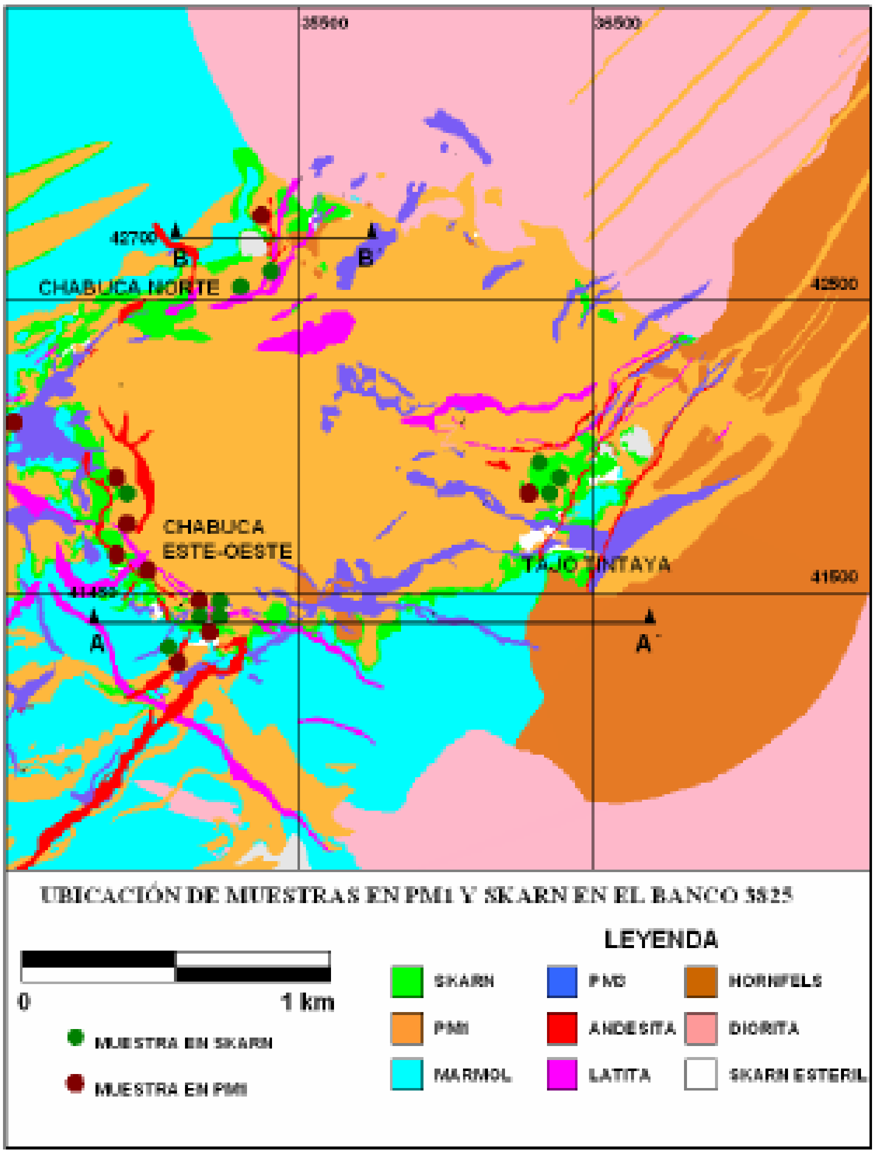


Ilustración 8. Mineral distribution

1.9.1. Cu

Cu values in Intrusive reach up to 0.8% with an average of 0.127%. These high values are observed at higher levels of Chabuca East-West. At their lower levels go down in value by an average of 0.47%. In contrast, Edge Tintaya also exhibit anomalous zones 0.8% but at their lower levels. At their upper levels of Cu values fall to less than 0.1%. Chabuca North has the lowest values below the average. On the other hand, in the samples in skarn, high values reach almost 10.6%, and mostly concentrated in the banks means higher. North Chabuca in this case has its highest values in the average levels. Tajo Tintaya and Chabuca East West present their laws Cu higher at higher levels.

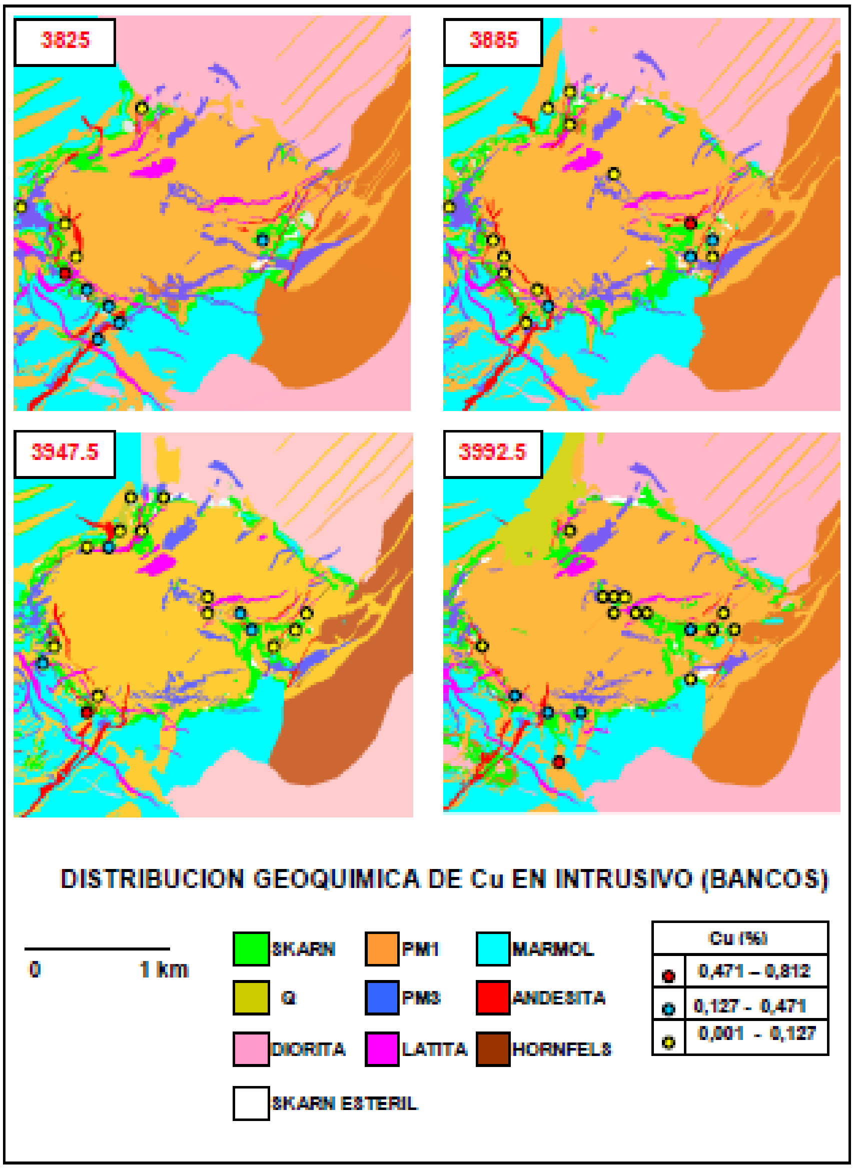


Ilustración 9. Copper distribution

1.9.2. Au

Au values in the intrusive have an average of 35 ppb, to maximum levels of 536 ppb. Chabuca East West and Tajo Tintaya have high values of Au, but deep areas of the site. Au values can reach 536 ppb levels of 3885. Chabuca North below shows poor values of Au in samples taken intrusive, unlike other areas

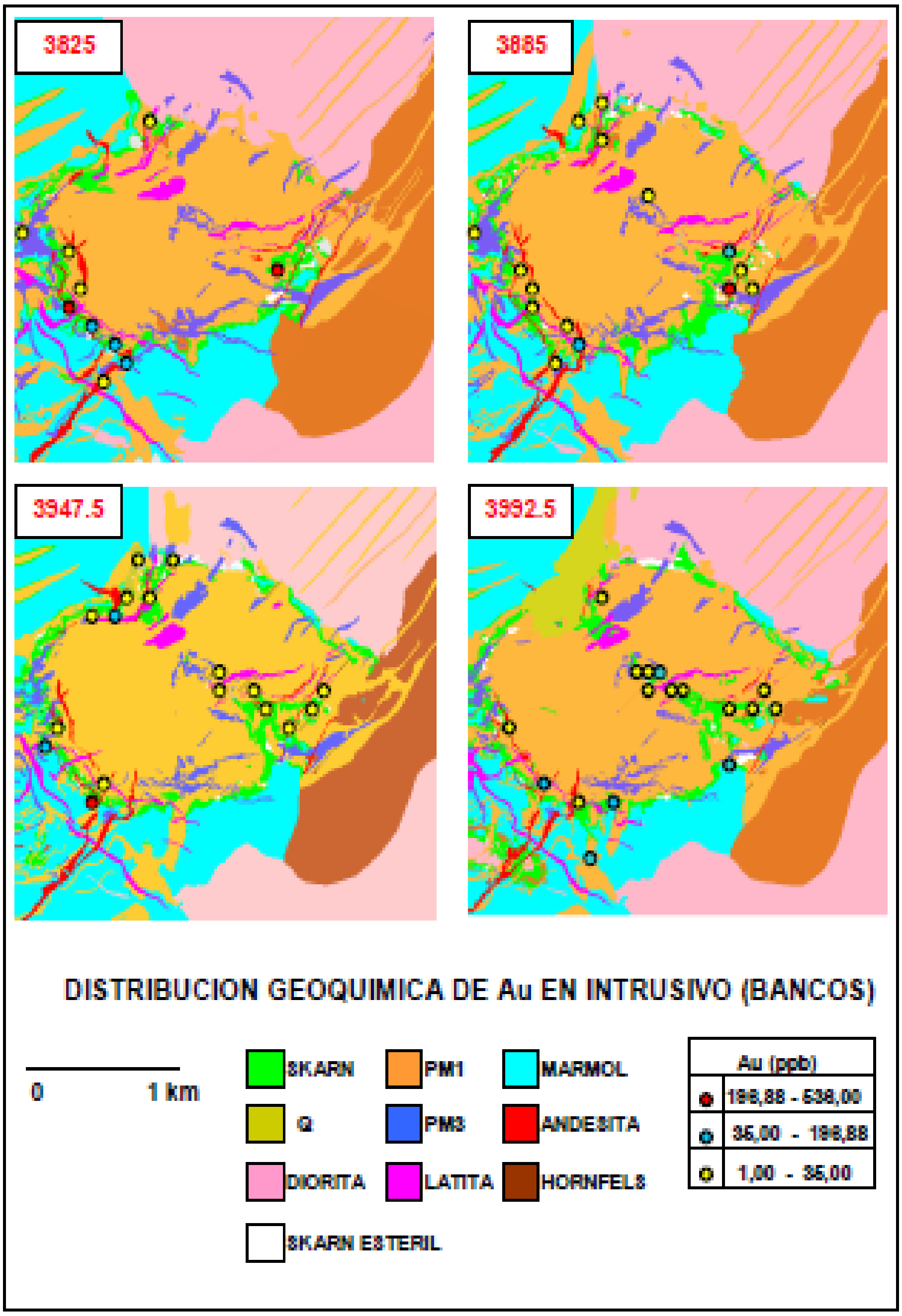


Ilustración 10. Gold distribution

1.9.3. Mo

Mo abnormal areas for this work are considered that are above 290 ppm and in some cases up to 784, for samples intrusive. Only Chabuca East West has these laws in their intermediate levels 3947.5 and 3992.5. Other areas show only laws do not exceed 300 ppm and are located in below average levels. It is noted that Mo values fall as one moves to the other levels, focusing on the middle levels.

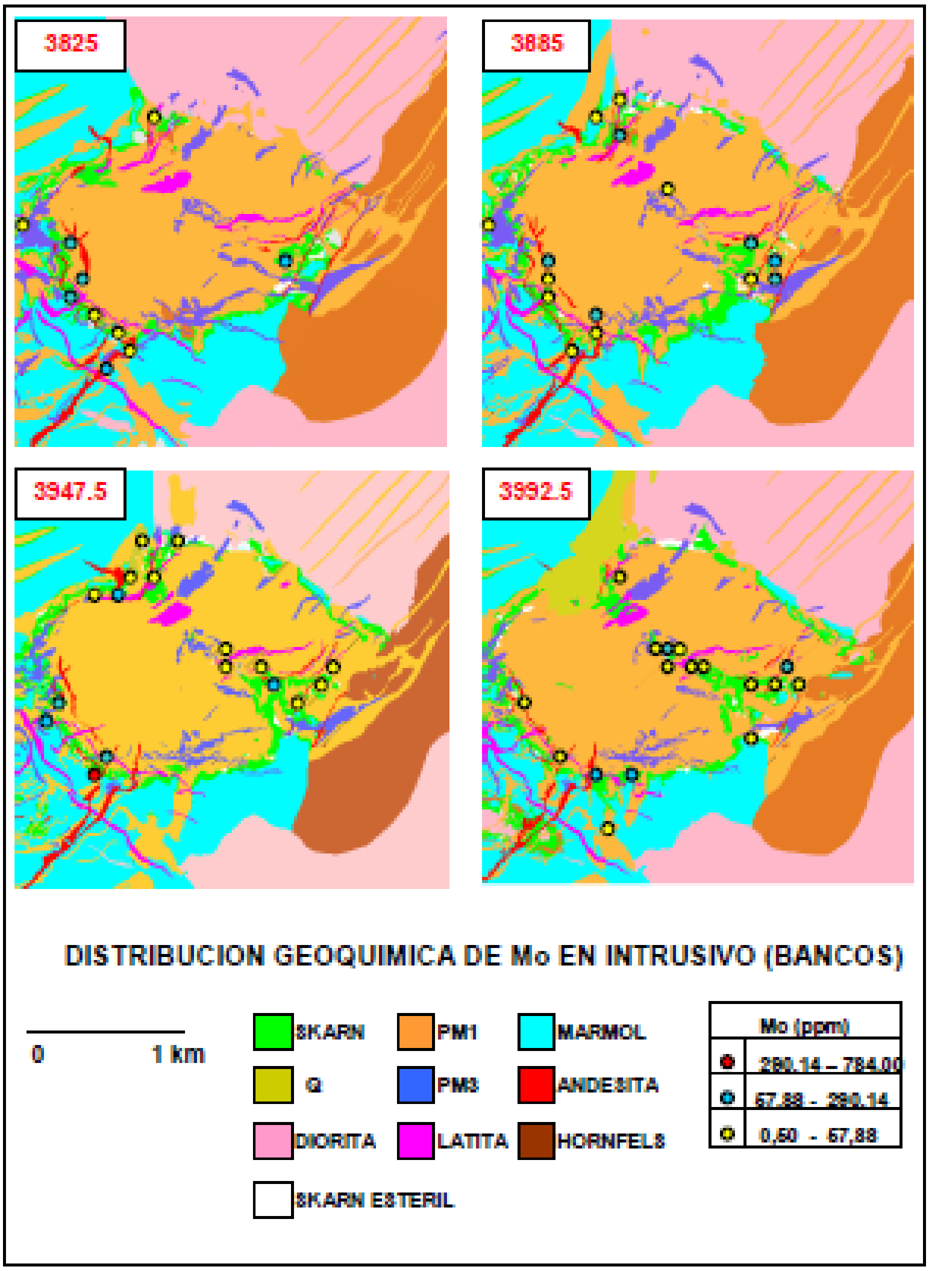


Ilustración 11. Mo distribution

1.9.4. Ag

The values Obtained from the analysis values reach an average of Ag intrusive 0.40 and peaks up to 7 ppm. It is further NOTED That Chabuca East West Ag Their highest values reach results. Can be seen in as the following drawings, in this area, the values of Ag in deep zones Between 0.40 and 2.21 Have ppm ranges, but in the upper parts, from bank 3947.5 7.00 ppm values upward reach. The Tintaya pit has to like behavior, laws, showing areas, Although up to 7 ppm Ag, especially to the lower intermediate portions. The northern part of the site, Chabuca Norte, has the lowest values, Which are Between 0.05 and 0.40 ppm.

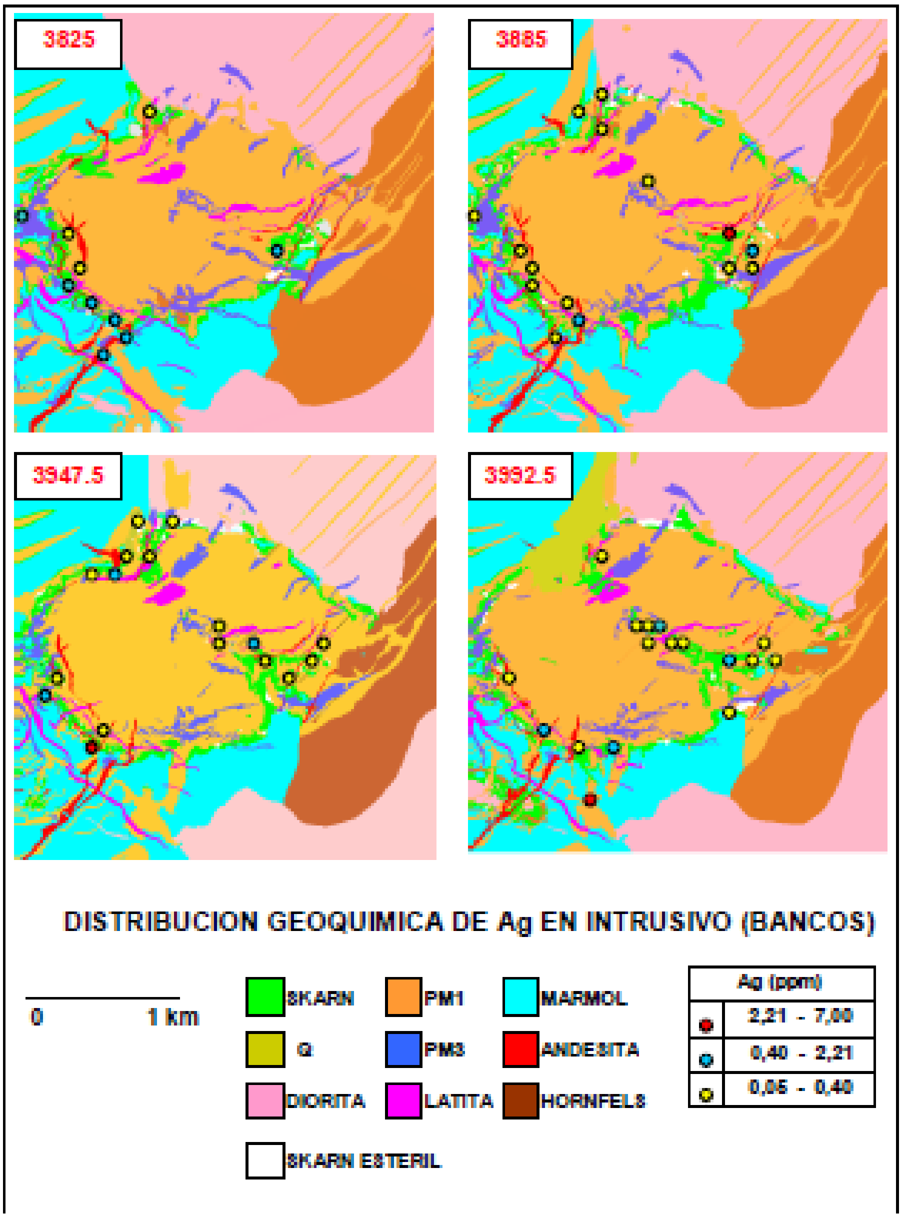


Ilustración 12. Argentium distribution

1.10. Mineral Reserve

The defined part of the deposit is named with a specific cutoff after completion of the detailed scan. The reserve is estimated with a high level of confidence based on details and reliable information, this based on the locations of the sample are spaced close enough to confirm the geological and / or grade continuity.

This reserve must be technically viable economically. The geological characteristics must be so well established to support production planning. The deposit can be extracted and marketed with a profit before a metallurgical, prefeasibility / scope study or feasibility report is prepared to make an investment decision. It also includes mine planning, financial analysis including losses associated with the closure. of mine.

1.10.1. Geological probes

Drilling or drilling is the culmination of the mineral exploration process through which the third dimension of a prospect and its geometry in the subsoil is defined. Drilling provides most of the information for the final evaluation of a prospect and will ultimately determine whether the prospect is economically exploitable. The chemical analyzes of core samples are the basis for determining the mean grade of the mineral deposit. Careful recording of drill core samples helps to delineate the geometry and calculation of ore volume and provides important structural data. The two main types of drilling are diamond (DDH) and those of reverse air or reverse circulation (RC).

Diamond drilling uses a diamond drill bit, which rotates at the end of the drill rods (or tubes). The opening at the end of the diamond drill bit allows the cutting of a rock solid core. (Illustration 2) .. The basic standard sizes are 7/8 inches (EX), 13/16 inch (AX), 1 5/8 inches (BX) and 21/8 inches (NX). Most drill rods are 10 feet long (3,048 m). After the first 10 feet of drilling, a new tube section is screwed into the upper end and so on.

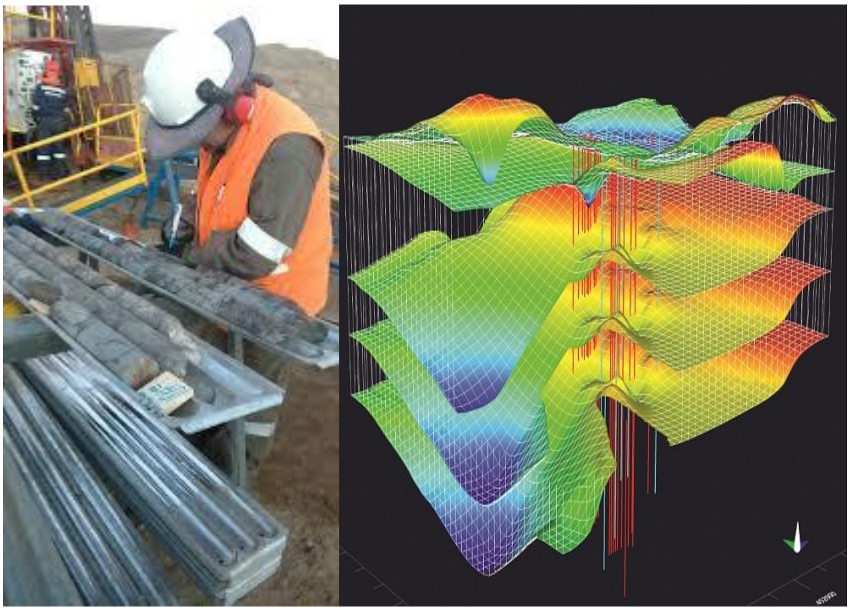


Ilustración 13. Right: lots of drill core, Left shows a 3D model of the holes in a mineralized zone.

1.11. Assay y Composites

The calculation of the "Composites" of a drilled hole involves the calculation of samples at regular intervals along a drilling hole from the original data of the drillhole "Assay". The calculation of the compounds can be thought of how to cut the core of the drill in pieces of equal length. This is necessary so that the samples have the same weight or influence when used to calculate the block values. The pre-processing of drilling hole data in composites of equal length is necessary before block modeling using the Reverse Distance or Kriging methods to calculate the block values.

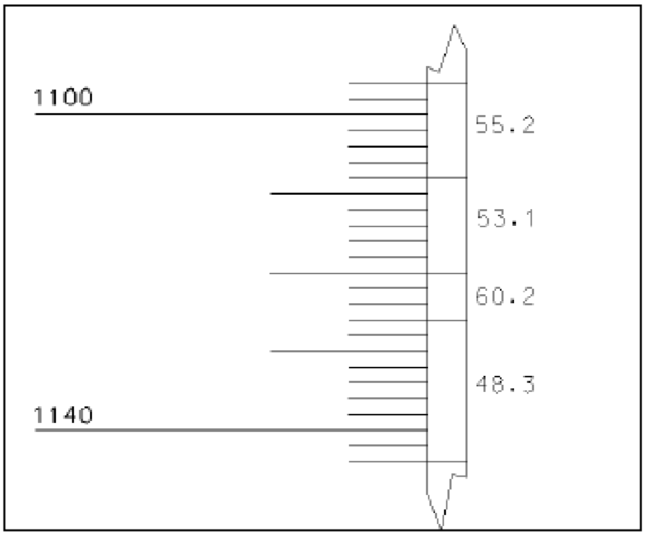


Ilustración 14. El cálculo de composite de banco.

The realization of the calculation of the composites on the basis of the assays is carried out by means of a weighted average with the lengths and the values of grades

$$C = \frac{\sum Ai * Li}{\sum Li}$$

Where C is the value of the composite, Ai is the value of the assay i, and Li is the length of the assay i.

The composite value of 40 feet in height from elevation 1100 to 1140 in Figure 8.2 is calculated as follows: C = [55.2 * 8 + 53.1 * 12 + 60.2 * 6 + 48.3 * 14] / 40 = 52.9

If indefinite assays are found, they are ignored. For example, if the last assay in this example was not defined, the composite value of 40 feet would be calculated as follows: C = [55.2 * 8 + 53.1 * 12 + 60.2 * 6] / 26 = 55.4

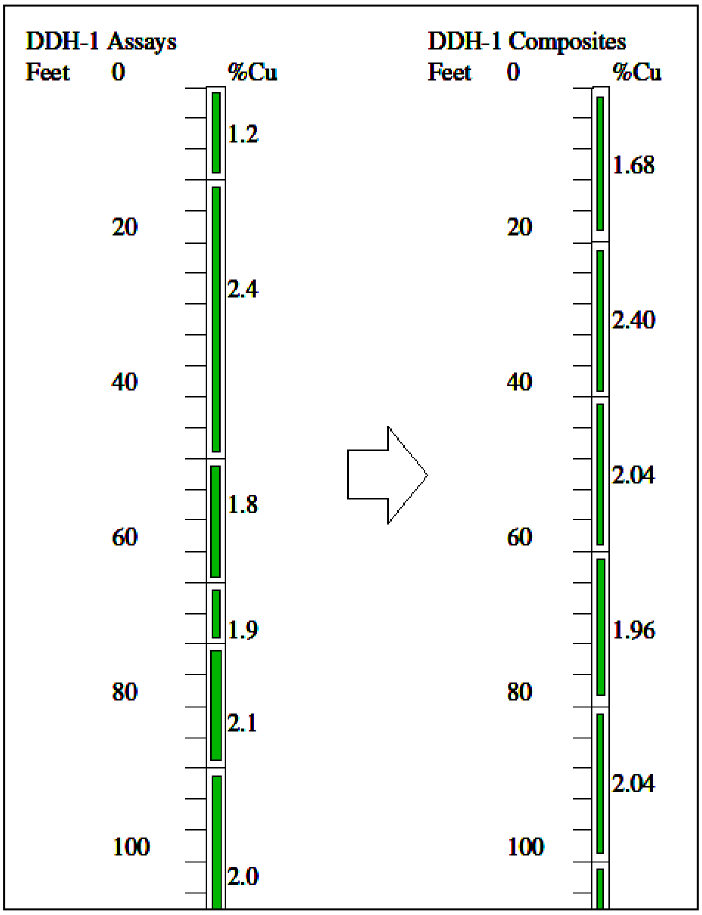


Ilustración 15. Regular composites calculated from the test data along a drill.

1.12. Oore control and Digitalization

Pray control is the process that constitutes the fundamental basis of geological exploration and care must be taken in its preparation, its use must be given to highly trained people. It consists of the geotechnical and lithological compilation in condensed form by means of the use of abbreviations, colors, numbers, that serve to describe a mineral deposit, in such a way that they can be used in the study and modeling in the most approximate form.

Digitization consists of passing all data written on paper now to the computer in order to perform different computational processes such as modeling, calculation of reserves and more, for this purpose different soft-path tools are used.

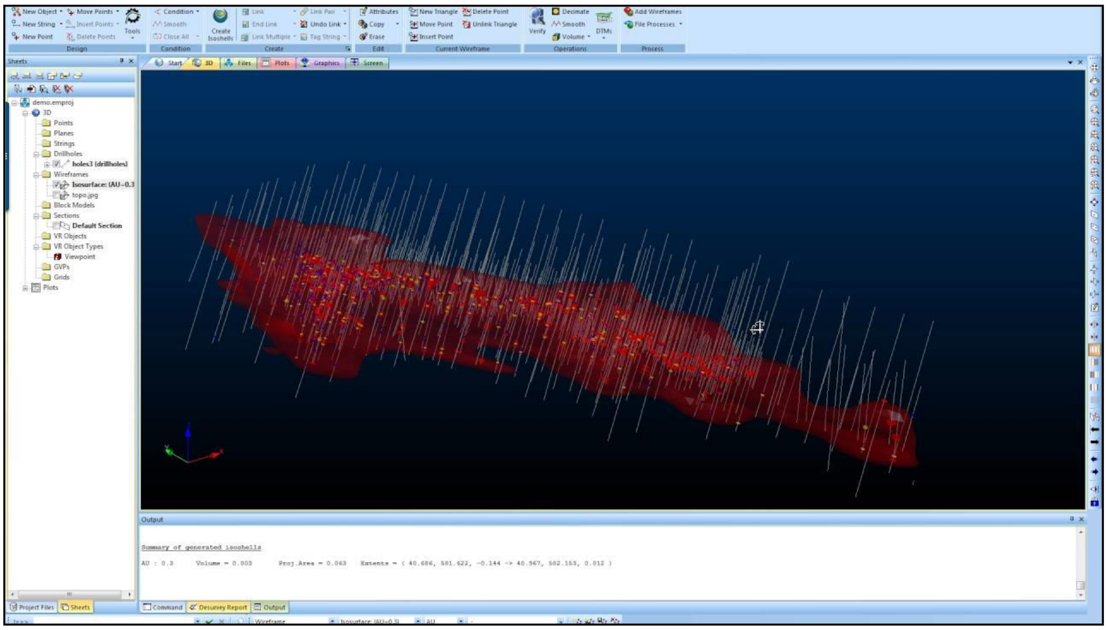


Ilustración 16. The use of the MineSigh program for the digitization of data is done.

2. THE DISTANCE REVERSE METHOD

The inverse distance method is based on assigning greater weight to nearby samples and less weight on samples that are far away from the area. This method also assigns an inversely proportional value of the distance to the site where the estimate is to be made, if the assigned value is low then the distance raised to that power is 1 and then all the data are assigned the same value, if on the contrary the assigned value is very high, the values raised to that power will become very small and the it will become the nearest neighbor FIGURE 6. So it is recommended for cases of estimation of mining resources to use a power factor of 2. It is necessary to select only those samples that are within the zone of influence corresponding to mineralogical behavior (function of continuity) of the population. Mathematically it is expressed as:

$$Z^*(x) = \frac{\sum_{i=1}^{n}\left[\frac{1}{(d_{0i})^{\alpha}} Z(x_i)\right]}{\sum_{i=1}^{n}\frac{1}{(d_{0i})^{\alpha}}}$$

Where:

d_{0i} :Distance between the location to be estimated and the location of the sample i.

$Z(x_i)$: Attribute which is being treated (known values).

$Z^*(x)$: It is the value to predict.

α: It is an exponent defined by the user (usually 2).

The inverse distance square (IDS) method can be used to calculate the values of a regular grid of block data from irregularly spaced sample data, usually in the form of drill hole test compounds. The composite values are weighted by the inverse of the square of the distance from the center of the compound to the center of the block. FIGURE 7. The basic idea of the method is that samples near the center of a block influence the degree of the block more than samples that are further away.

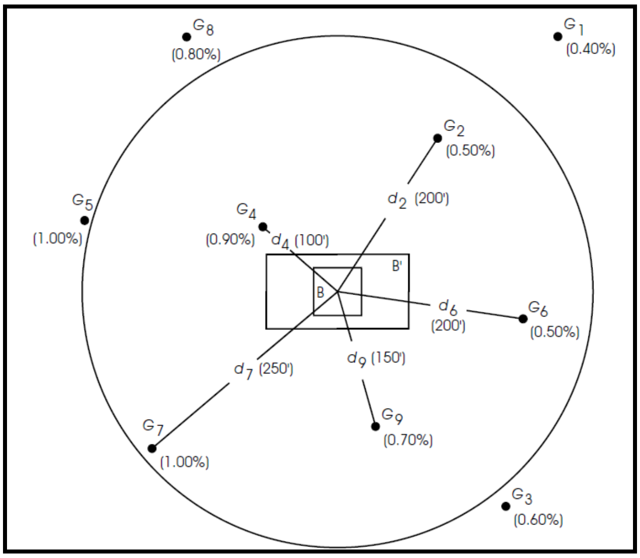


Ilustración 17. Graphic representation of the inverse method of distance. Taken from Applied Mineral Inventory Estimation (Sinclair, 2002)

Sample	Cooper (%)	d^b	$1/d$	$1/d^2$	$1/d^3$
G1	0.4	360			
G2	0.5	200	0.005	0.000025	0.125 × 10-6
G3	0.6	290			
G4	0.9	100	0.01	0.0001	1.0 × 10-6
G5	1.0	275			
G6	0.5	200	0.005	0.000025	0.125 × 10-6
G7	1.0	250	0.004	0.000016	0.064 × 10-6
G8	0.8	320			
G9	0.7	150	0.0067	0.000044	0.195 × 10-6
Sum			**0.0307**	**0.00021**	**1.609 × 10-6**
[b]Estimated block grade			0.74	0.77	0.81

[a] Nearest-neighbor grade estimate = 0.9; local average (five nearest grades) = 0.72.
[b] Distance to block center.

Table 1 Degrees, distance and weights used for estimation by the inverse to the distance of the previous block.

In this way it is possible to perform the modeling of the entire mineral deposit, as is logical this will require a lot of data and a great processing of them.

2.1 CHOICE OF THE FACTOR

The choice of α factor depends on how much influence you want to give to your near or far samples, the method of estimating resources by inverse of the distance is for local estimates, because the alpha factor influences a lot in the distance of the data, whether you do it for isotropically or anisotropically distributed data, the style that is closest to the real thing is the anisotropically, since the values are not found equidistantly as in anisotropic, but are more varied in the axes "x", "and " and Z".

$$Z_{V(x)}^{V} = \frac{\sum_{i=1}^{N} \frac{Z_i}{d_i^{\alpha}}}{\sum_{i=1}^{N} \frac{1}{d_i^{\alpha}}} \quad , \qquad \alpha > 0$$

- If α=0
  If the alpha value was 0, there would be a similarity or distance value according to equity, ie a distant sample would have the same influence as a distant, and this can be shown in the formula.

$$Z_{V(x)}^{V} = \frac{\sum_{i=1}^{N} \frac{Z_i}{d_i^{0}}}{\sum_{i=1}^{N} \frac{1}{d_i^{0}}}$$

$$Z_{V(x)}^{V} = \frac{\sum_{i=1}^{N} \frac{Z_i}{1}}{\sum_{i=1}^{N} \frac{1}{1}}$$

$$Z_{V(x)}^{V} = \frac{\sum_{i=1}^{N} Z_i}{N}$$

With this we can show that when the value of α = 0 the equation becomes the arithmetic mean method.

Arithmetic average:

This method is based on the estimation of an average grade of a set of values and averaging them giving an equal significance to each sample

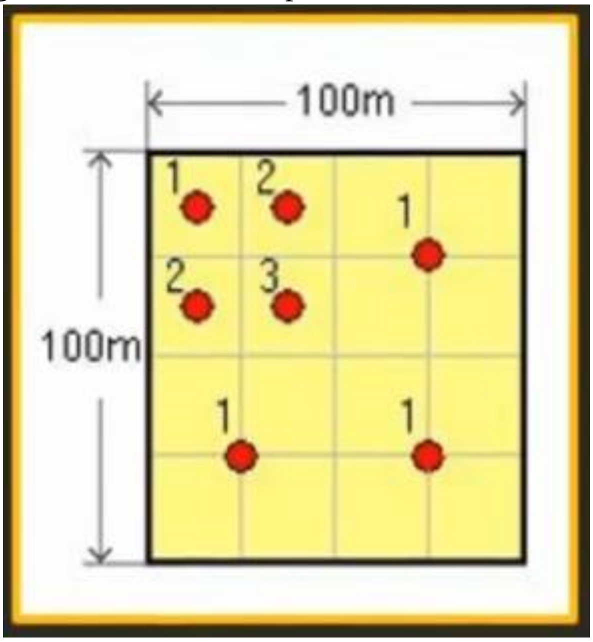


Ilustración 18. Square with 7 samples inside

In this case, you are only attributed a division of values with the number of elements.

$$Z_{V(x)}^{V} = \frac{1+1+1+2+3+2+1}{7}$$

$$Z_{V(x)}^{V} = 1.57$$

- If α>0
  In order to provide a more accurate value regarding the distance presents the exhibition center block is not granted to him, with this we reduce the error produced by the above method. The tendency of importance to the values near or far, depending on the grades that you have to give them more importance.
  Example:

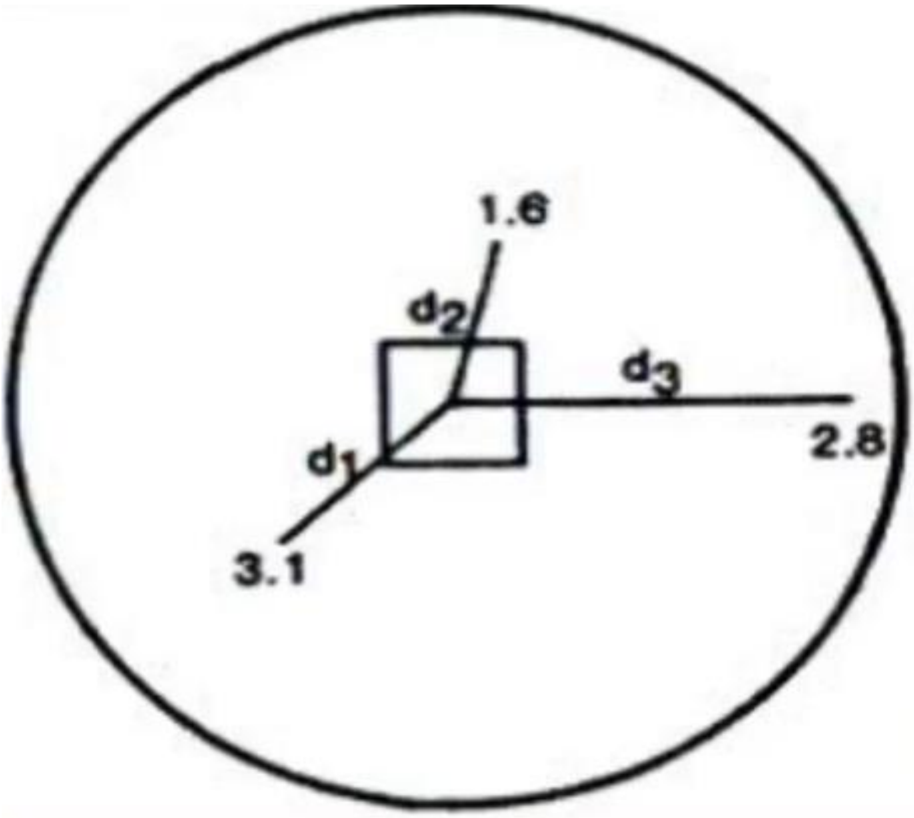


Ilustración 19. Weighting inverse distance method using a circular neighborhood search.

Sample weights (%)				Estimated Block Grade
ω	1.6%	3.1%	2.8%	
1	44.8	34.7	20.5	2.37
2	55.2	33.2	11.5	2.34
3	64.0	29.9	6.1	2.12

Coordinates of the samples:

Grades	Coordinates
1.6	(10,40)
2.8	(90,0)
3.1	(-4.,-35)

As shown in the table, the value of lower weight and distance, while increasing the gains relevance α, and this is contrary sample with a sample having good weight but greater distance, relevance is lost with increasing α.

As explained above, almost always the value given to α is 2, because this value is the one giving a smaller error in most cases, giving an appropriate influence each sample by distance, is why sometimes or in some texts is called "method of inverse distance squared."

As explained can give a graph indicating the influence of α.

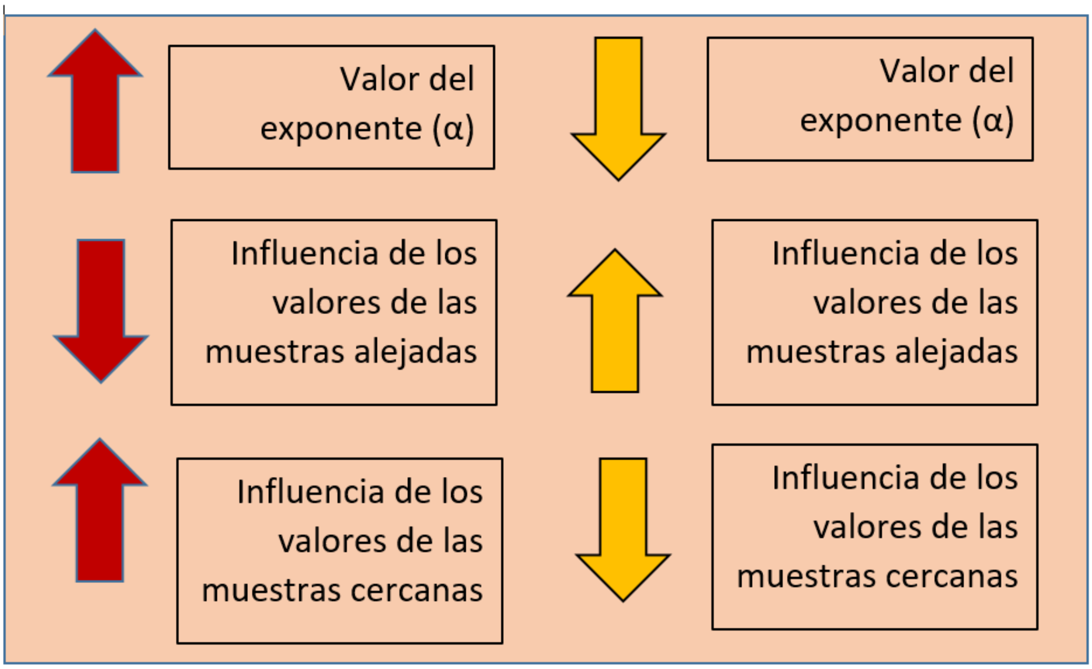


Ilustración 20. Influence increases or decreases according alpha

3. VALIDATION CRUSADE

3.1. Kriging estimate

The Kriging estimator defined as such is a combination of random variables and therefore a random number and is defined as:

$$z^*(\mathbf{x}_0)=a+\sum_{\alpha=1}^{n}\lambda_\alpha z(\mathbf{x}_\alpha).$$

It should be noted something important, when the Kriging was used was speaking neighborhood when all data is preserved, however, and except for some cases their influence will be very low, in an intuitive way a distant data does not provide too much information to the site to estimate and it will be affected by a weighting of Kriging.

The neighborhood where the Kriging estimation is performed on a mobile vicinity when the data are close to the site to estimate and generally what is sought is to make estimates on all nodes of the grid covering block and should define the shape and size of the neighborhood will depend on the variogram and data available and how is based on the anisotropy of the variable.

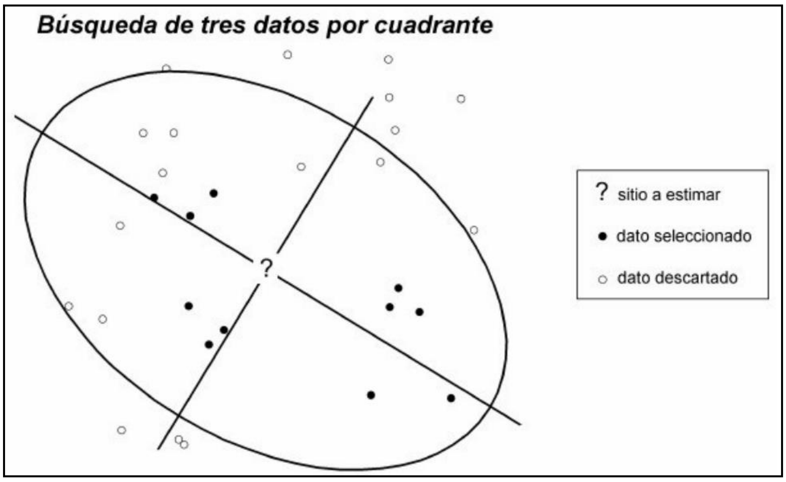


Ilustración 21. Graphical representation of a neighborhood. Geostatistical taken from notes. X. (Emery).

The estimator Kriging is a linear estimator, that is, estimates the value of the regionalised variable from a weighted sum of the data. Unlike traditional estimators, consider not only their geometric configuration, but also considers its spatial continuity, based on the variogram. Another important aspect is that quantifies the accuracy of the estimate from the variance is known as Kriging, which is the variance of the error.

The estimator is a weighted linear combination of data and, therefore, the problem of Kriging is reduced to calculate the values of the weights that allow to obtain an unbiased estimate and with the best possible accuracy. The Kriging is performed under the following restrictions:

- Restriction linearity: the estimator is a weighted linear combination of data located in the neighborhood.
- Insesgo restriction: the expected value of committed error should be zero.
- Constraint optimization: The goal is to minimize the variance of the error in the estimate.
- The dispersion of the estimated values is less than the actual data, this results in an overestimation or underestimation of the regionalised variable values high grade and

low grade respectively. In addition, the Kriging is unable to reproduce the occurrence of extreme values and produce a bias in the estimation of functions involving a cutoff grade.

- The weights and Kriging variance does not depend on the value of the data; This results in the failure to consider the greater variability in areas of high values and that is why the method downplays this source of uncertainty

3.2. Cross-validation

Cross-validation is used to verify the adequacy between the data and the parameters adopted, which would be the variogram model of Kriging and neighborhood. The principle is to estimate successively by Kriging, each data, considering the remaining data. This way you can calculate the estimation error at each site with data and perform a statistical analysis of the mistakes made at all sites with data.

To be valid cross-validation should try to satisfy at least two of the following criteria:

- The mean errors and standard errors should be close to zero.
- The error variance, which measures the accuracy of the estimator should be minimal.
- The variance of standardized errors should be close to 1.
- The correlation coefficient between estimated values and data values should be as close as possible to 1.
- The estimated number of bad data should be as small as possible, to fix ideas, this number can be considered satisfactory if it represents less than 5% of the data.

4. APPLICATION IN MINING

4.1. CASE STUDY: MINA CUAJONE - Southern Peru Copper Corporation

Study gradess belong to the primary blasting holes (holes blast).

Banks have a height of 15 meters.

Study data belong to a period of operation of 27 years, since the beginning of operations of the mine until 1987

Copper grades were obtained by two methods:

- weighted average of individual trials
- sampling bank

First population: 400x400 square prism and 75mts high.

Second population is an extension of mined volume

4.2. ESTIMATE OF COPPER BY GRADES TO REVERSE THE DISTANCE TO THE NTH POWER

With this method gradess was assigned to 15x15 square blocks.

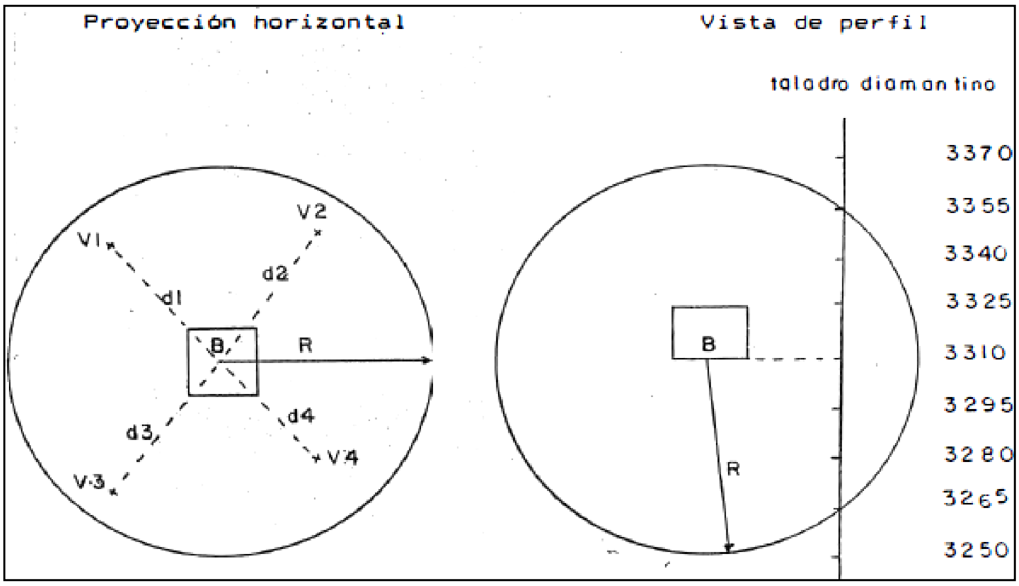


Ilustración 22. Graphical representation

Where:
R = Radius of influence
Vi = grades of diamond drill holes
di = distance drill*i* the center of block
α = exponent distance
8 = grades assigned block

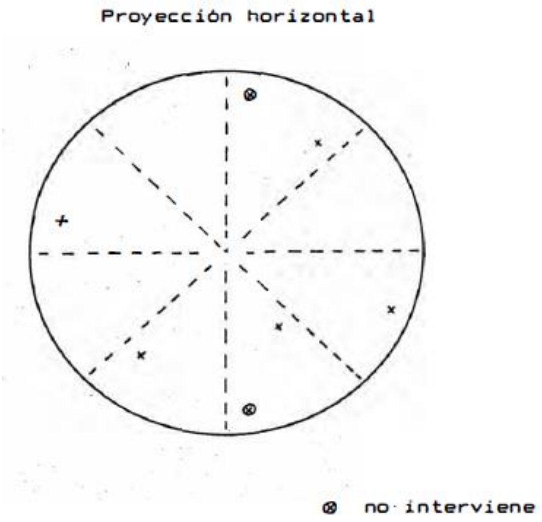
4.3. PARAMETERS FOR

4.3.1. RADIO INFLUENCE ESFERICO

Limit is the distance to which gradess can intervene diamond drill holes in the grades to block assignment. For the case study examined radios from 60 to 180 meters, obtándose for optimum radius of 80m.

4.3.2. RESTRICTION ANGLE

Has been applied an angular constraint 45 degrees in the horizontal, this is that if two or more holes adamantine fall within a circular sector of 45 degrees on a level, is considered for the assignment grades block which is closest the center of the block.



4.3.3. RESTRICTION GEOLOGICAL

It is to do. gradess intervene diamond drill holes having the same type of mineralizaci6n and / or lithology (geol6gicas areas) that the block to be allocated grades.

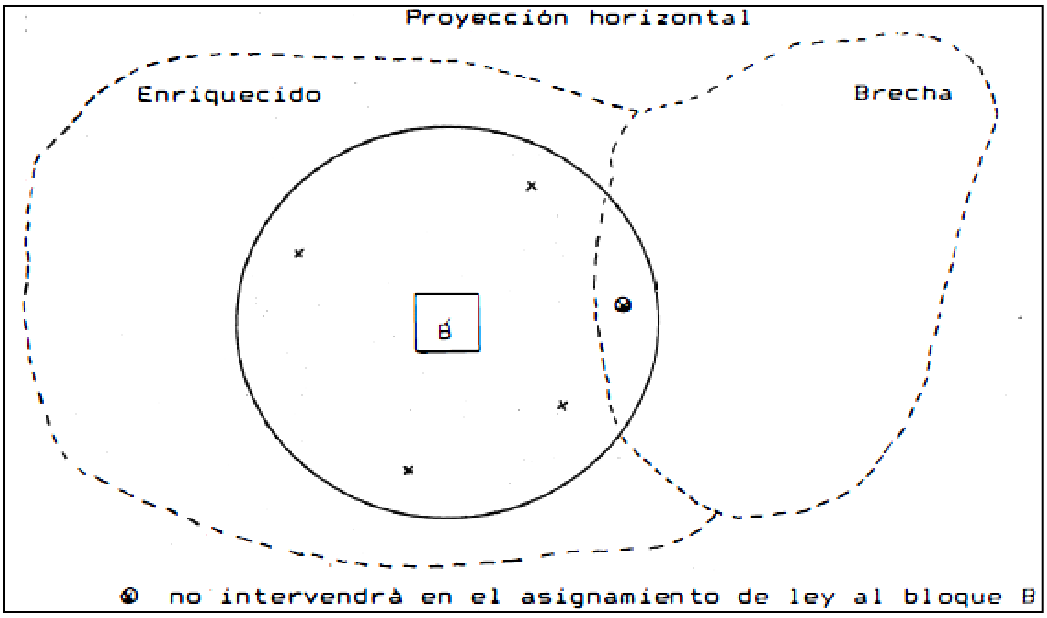


Ilustración 23. Graphical representation restriction geological

4.4. CRITERIA FOR OBTAINING OPTIMUM Exponent DISTANCE: MINIMUM VARIANCE ERROR

$$S = \frac{(V_i^* + V_i)^2}{N}$$

Donde:

$S = varianza\ de\ error\ promedio\ por\ bloque$

$V_i^* = ley\ estimada\ del\ bloque\ i$

$V_i = ley\ real\ del\ bloque\ i$

$N = número\ de\ bloques$

The optimum exponent minimize the accumulated error variance product average error per block.

4.5. RESULTS COMPARISON

A comparison was made between blocks of 20x20 for the proposed without actual geological restriction blocks, and then the comparison was made with the geological constraint for 20x20 and 25x25 blocks method.

- *UNRESTRICTED GEOLOGICAL*

PARAMETERS:

$radio\ esferico\ de\ influencia = 80\ mts$

$restriccion\ angular = 45°$

$exponente\ optimo\ para\ el\ metodo\ IDW = 2.4$

Tabla 1 VARIANZA MINIMA DE ERROR

Dimensión bloque	Número Blqs. comparados	Varianza de error	Desviación estandar
20x20	1986	0.161	0.4013

Tabla 2 TONELAJES Y LEYES

cut-off = 0.55 %

Tipo de bloque		Tons. mineral	%Cu	Porcentaje de error Tons	Porcentaje de error Ley
Real	20x20	28 357 350	1.151	--	--
I.D.	20x20	29 255 700	1.120	3.2	-2.7

cut-off= 0.45 %

Real	20x20	29 611 650	1.123	--	--
I.D.	20x20	31 069 890	1.083	4.9	-3.6

I.D. = inverso de la distancia

Porcentaje de error $\frac{(ley\ asignada - ley\ real)*100}{ley\ real}$

- *RESTRICTED GEOLOGICAL*

PARAMETERS:

$radio\ esferico\ de\ influencia = 80\ mts$

$restriccion\ angular = 45°$

$exponente\ optimo\ para\ el\ metodo\ IDW$
$= 1.8\ para\ bloques\ 20x20/25x25$

Tabla 3 VARIANZA MINIMA DE ERROR

Dimensión bloques	Número Blqs. comparados	Varianza de error	Desviación estandar
20x20	1974	0.147	0.383
25x25	1263	0.132	0.363

Tabla 4 TONELAJES Y LEYES

Cut-off= 0.55 %

Tipo de bloque		Tons. mineral	% Cu	Porcentaje de error Tons	Porcentaje de error Ley
Real	20x20	28 357 350	1.151	--	--
	25x25	28 735 546	1.138	--	--
I.D.	20x20	28 425 250	1.162	0.2	1.0
	25x25	28 417 736	1.164	-1.1	2.3

Cut-off= 0.45 %

Real	20x20	29 611 650	1.123	--	--
	25x25	29 847 890	1.114	--	--
I.D.	20x20	29 764 200	1.132	0.5	0.8
	25x25	29 715 470	1.134	-0.4	1.8

4.6. DETERMINATION OF OPTIMUM EXPONENTS OF THE DISTANCE BY GEOLOGICAL ZONES

With the criterion of the minimum variance, the optimal exponents of the distance for blocks of 20x20 are determined.

Tabla 5

Zona geológica	Nº Blqs. analizados	Niveles	Var estimac	Exponente óptimo
Brecha	529	3295 a 3490	0.0660	1.0
Enriquecido	1899	3430 a 3475	0.3664	1.0
Oxido	1089	3460 a 3520	0.7869	1.0
Post-mineral	71	3475 a 3520	0.6644	0.0
Primario-trans	7564	3295 a 3460	0.1327	1.8

Tabla 6 CUADRO COMPARATIVO DE VARIANZAS DE ESTIMACION POR DISTINTOS METODOS

Metódo	Zona geol	Ley media	V.E.exper	Var disp	Coef co
Geoestadístico	Brecha	0.376	0.0677	0.0450	0.8369
	Enriquecid	1.664	0.3832	0.5019	0.9359
	Primario	1.069	0.0705	0.0401	0.9687
	Total	1.046	0.1270	0.2362	0.9508
Inverso de la distancia	Brecha	0.368	0.0713	0.0378	0.8268
	Enriquecid	1.392	0.5214	0.3790	0.9088
	Primario	1.125	0.0851	0.0648	0.9674
	Total	1.054	0.1497	0.1914	0.9418
Poligonal	Brecha	0.376	--	0.1243	--
	Enriquecid	1.612	--	0.9974	--
	Primario	1.151	--	0.1444	--
	Total	1.110	--	0.3818	--

Tabla 7 DETERMINACION DE ESTIMADOR DE LA MEDIA CON 95% DE PROBABILIDAD

Descripción del método	Ley media estimada			Ley media real 20X20		
	Brecha	Enriquecido	Primario	Brecha	Enriquec	Primar
Geoestadistico	0.376±0.024	1.664±0.083	1.069±0.011	0.400	1.581	1.059
	total 1.046±0.021			1.043		
Inverso de distancia	0.368±0.022	1.392±0.064	1.125±0.013	0.400	1.581	1.059
	total 1.054±0.019			1.043		
Poligonal	0.376±0.151	1.612±0.417	1.161±0.072	0.400	1.581	1.059
	total 1.110±0.099			1.043		

Tabla 8 PORCENTAJE DE ERROR DEL TONELAJE Y LEY DE MALLAS ASIGNADAS Y REALES

Nivel 3385

cut-off	Geoestadistic		Inverso de Dis		Poligonos	
	Tons	ley	Tons	ley	Tons	ley
0.40	4.1	-5.1	3.2	1.5	-14.6	9.8
0.45	5.7	-6.0	2.4	2.0	-12.8	8.4
0.50	3.3	-4.9	-0.6	3.6	-13.5	9.0
0.55	3.4	-5.1	-2.2	4.5	-11.9	8.0
0.60	3.2	-5.1	-1.0	4.0	-10.1	7.2

Nivel 3400

0.40	-0.3	2.9	1.4	11.5	-8.2	7.4
0.45	0.3	2.6	1.1	11.7	-6.9	6.5
0.50	-1.2	3.4	-0.9	13.1	-6.8	6.6
0.55	-2.1	3.9	0.0	12.7	-4.3	5.2
0.60	2.6	2.0	5.8	10.1	-5.4	6.0

Nivel 3415

0.40	1.4	4.0	1.4	8.4	- 8.5	6.3
0.45	1.7	3.9	1.7	8.3	-6.9	5.2
0.50	1.5	4.0	1.2	8.8	-8.9	6.6
0.55	2.4	3.5	0.6	9.1	-6.1	5.0
0.60	3.5	3.1	4.2	7.5	-2.1	3.1

Nivel 3430

cut-off	Geoestadistic		Inverso de Dis		Poligonos	
	Tons	ley	Tons	ley	Tons	ley
0.40	-6.2	3.8	-7.0	4.8	-11.2	15.3
0.45	-5.2	3.2	-6.4	4.3	-9.3	13.7
0.50	-3.7	2.1	-7.1	4.9	-7.3	12.3
0.55	-2.0	1.3	-7.0	4.9	-6.2	11.8
0.60	-3.0	1.7	-6.5	4.6	-4.8	10.9
Nivel 3445						
0.40	0.5	-4.4	-3.8	-11.8	-17.0	14.3
0.45	-1.4	-3.1	-5.0	-11.0	-16.0	13.4
0.50	-1.7	-2.9	-5.3	-10.9	-17.0	14.4
0.55	-1.1	-3.3	-4.0	-11.7	-14.8	12.5
0.60	-2.0	-2.8	-5.5	-11.0	-14.1	11.8
De nivel 3385 a 3445						
0.40	-0.2	-0.2	-1.1	1.3	-11.9	10.4
0.45	0.1	-0.4	-1.3	1.4	-10.4	9.3
0.50	-0.4	-0.2	-2.6	2.2	-10.7	9.5
0.55	0.1	-0.4	-2.6	2.2	-8.7	8.3
0.60	0.8	-0.7	-0.8	1.3	-7.4	7.6

5. METHODOLOGY

We used the Point Validation tool (p52401), we selected the ordered composite file (in our case: uni09.dat)

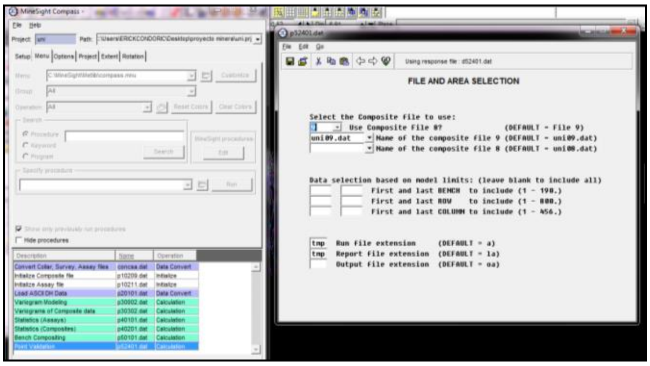


Ilustración 24. File selection.

We choose the metal which we are going to compare (in our case Cu, restricted to a domain). This procedure always compares with kriging, however we will only focus on the IDW with a different alpha factor.

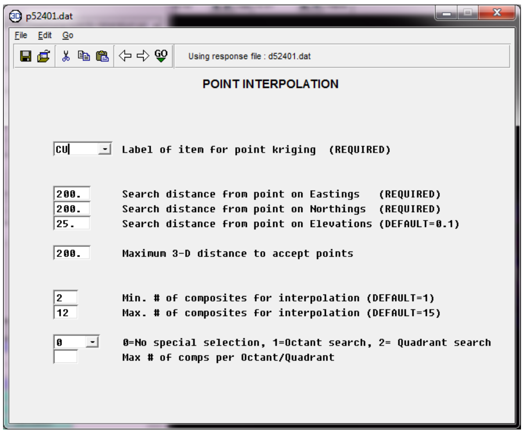


Ilustración 25. Choice of metal

The variogram of the metal (Cu) can be created with the procedures p30002 and p30302. We include this in optional parameters.

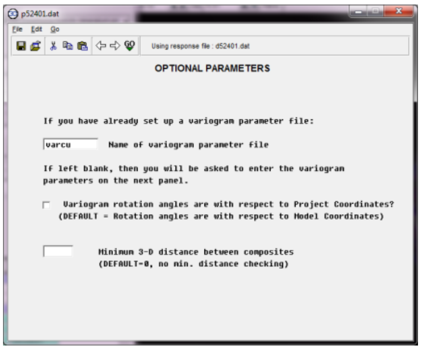


Ilustración 26. Inclusion of the variogram

In the next window we choose the exponent that the IDW will use for the interpolation. We choose the powers: 1, 2, 3, 4 and 5, which are placed in the blanks. Finally we choose the power of the IDW with which the analysis of the data is made. This was done for each of the powers.

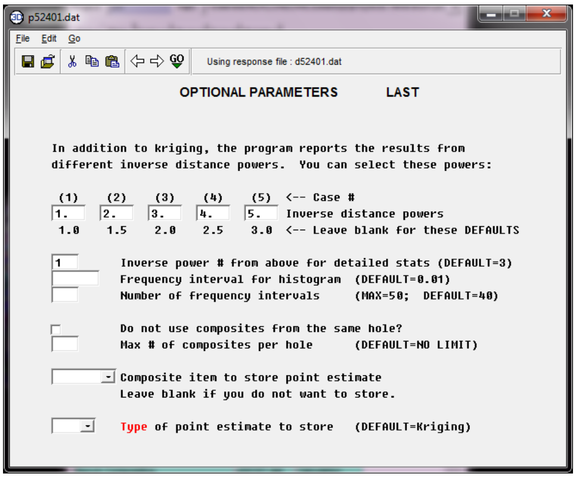


Ilustración 27. : choice of powers for IDW

Reports will be generated for each case, we save each one, to make the comparison.

Variable : CU

Statistics of each input item

	ITEM	MEAN	STD. DEV.	MINIMUM	MAXIMUM	MEDIAN	SKEWNESS
1.	ACTUAL	0.315	0.493	0.001	7.196	0.118	3.361
2.	1ST IDW	0.321	0.353	0.001	2.746	0.207	1.752
3.	2ND IDW	0.316	0.385	0.001	3.894	0.175	2.094
4.	3RD IDW	0.315	0.408	0.001	4.538	0.159	2.339
5.	4TH IDW	0.315	0.421	0.001	5.289	0.152	2.486
6.	5TH IDW	0.315	0.429	0.001	5.937	0.148	2.577
7.	KRIGING	0.317	0.375	-0.022	3.704	0.183	1.986
8.	KRG-VAR	0.117	0.008	0.089	0.176	0.118	0.899

Ilustración 28. Sample report sheet.

6. APPLICATION IN ANTAPACCAY CASE

7. RESULTS

7.1. CREATION OF THE GEOLOGICAL MODEL

Experience has shown that the main problem in estimating resources is not directly related to the estimation method used, but rather to the correct application of geological principles. The core issue to be resolved before estimating resources properly is to establish the continuity of the mineralization and the law within the deposit. A representative sampling, reliable analysis and a coherent geological interpretation are the main components of resource estimation (Arseneau and Roscoe, 1997).

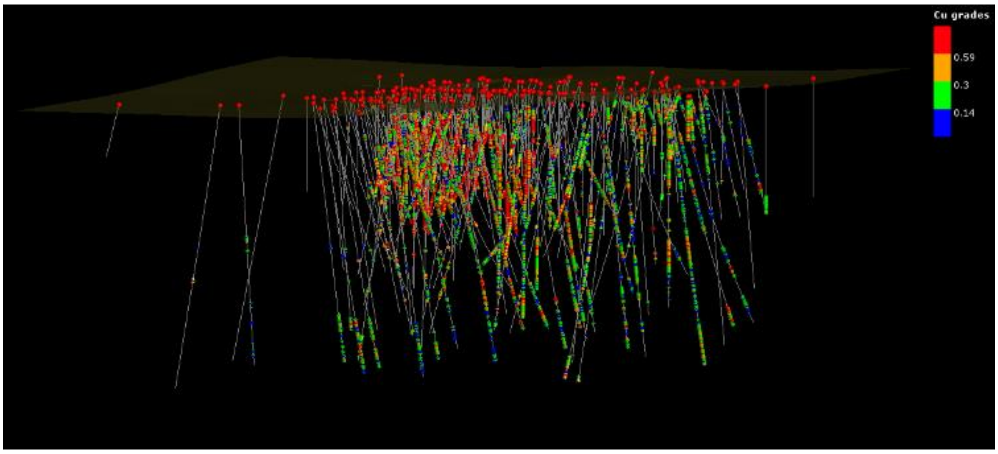


Ilustración 29. 3D view of the diamond drill holes.

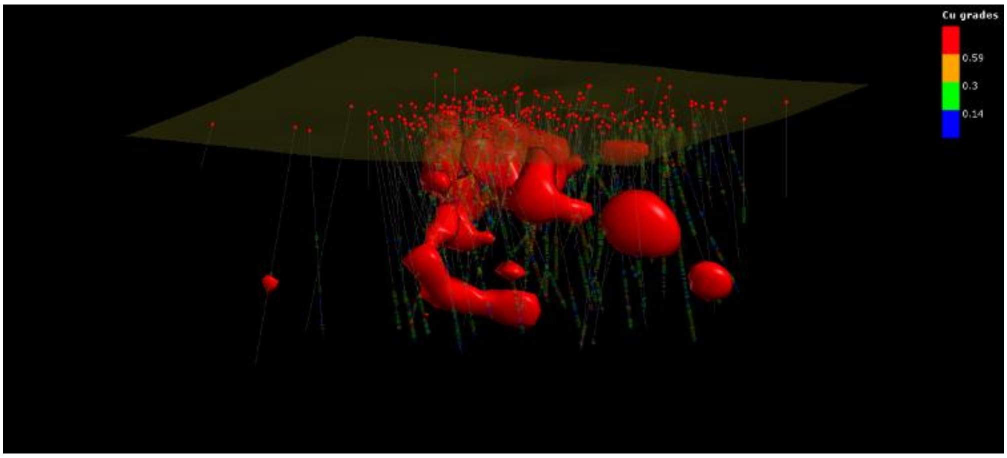


Ilustración 30. isovalorous bodies of high law zone of isovalue.

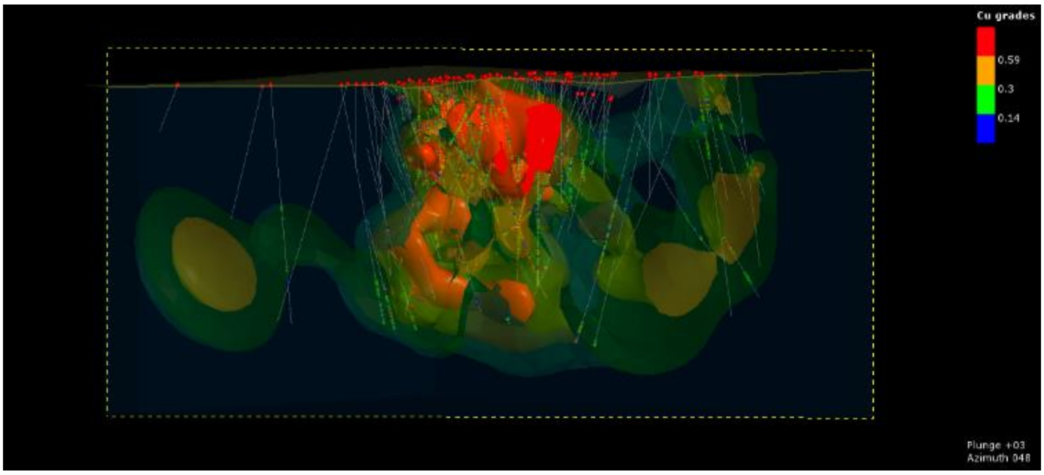


Ilustración 31. copper iso-values.

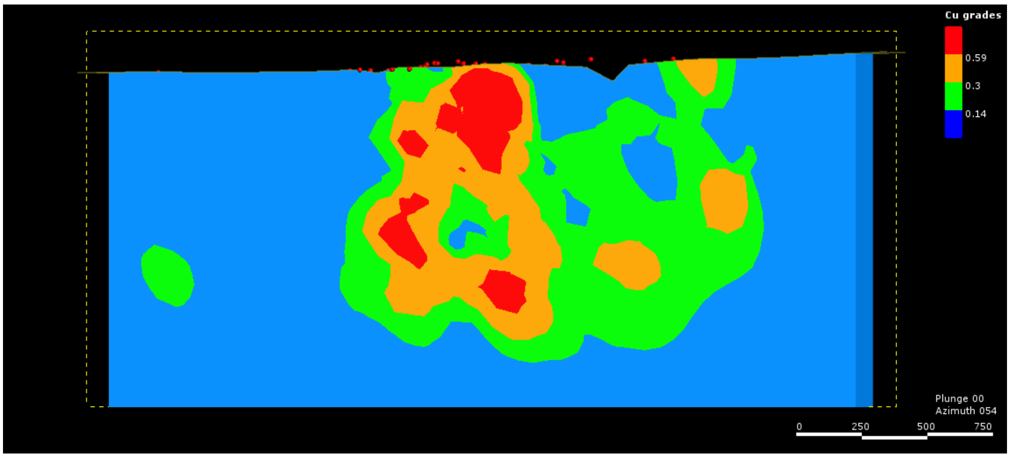


Ilustración 32. 2d outline.

CONCLUSION

- ✓ It is important in the use of the method of the inverse to the distance the choice of the alfa factor, in our case the alpha factor that we used was 2.
- ✓ It is important to use the inverse distance method with alpha factor due to the reduction of costs in the exploration part and to have data of the local geology with greater reliability since the reserve is estimated with a high level of confidence based on details and reliable information, this based on the locations of the sample are spaced close enough to confirm the geological and / or grade continuity.
- ✓ The use of the method is applicable in real situations such as cuajone.

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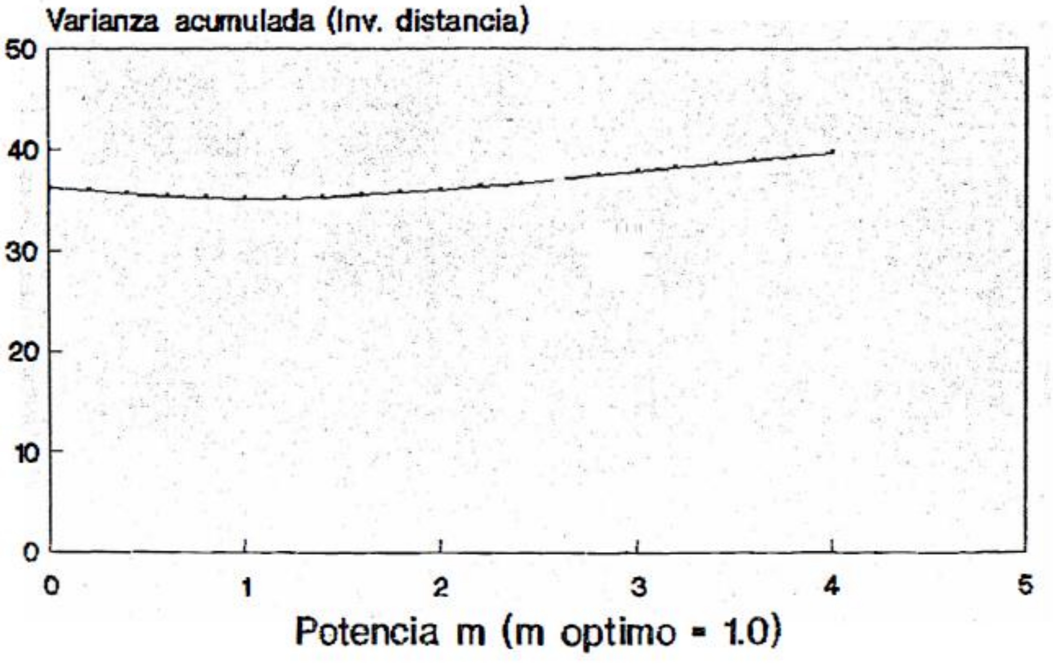
- Dimitrakopoulos, R., Martinez, L. and Ramazan, S. (2007) 'A maximum upside/minimum downside approach to the traditional optimization of open pit mine design', *Journal of Mining Science*.

ANNEXES

VARIANZA DE LEY Cu. DE Nv. 3295 A 3490
AREA: 539800,85400,540250,85700
RADIO ESFERICO DE INFLUENCIA = 80 m



BLOQUES : 629 - 20x20 - ZONA DE BRECHA
VARIANZA ACUMULADA MINIMA = 35.182
DESVIACION STANDAR = 0.2579

Fig. N° 1

PICTURE OF TONELAJES AND LAWS MEDIA OF CUT-OFF 0.40-0.60%, BY METHODS GEOESTADISTICO, IDW, POLIGONAL.

NIVEL 3385

CUT-OFF	MALLA REAL 20x20		GEOESTADISTICO		INV. DISTANCIA		POLIGONAL	
0.40	5'773,186	0.994	6'009,120	0.943	5'958,409	1.009	4'930,361	1.091
0.45	5'655,426	1.006	5'975,686	0.946	5'788,909	1.026	4'930,361	1.091
0.50	5'554,192	1.016	5'740,166	0.966	5'519,065	1.053	4'805.585	1.107
0.55	5'453,377	1.025	5'639,313	0.973	5'333,462	1.071	4'805,585	1.107
0.60	5'251,052	1.042	5'419,419	0.989	5'198,748	1.084	4'719,193	1.117

NIVEL 3400

0.40	5'937,879	0.963	5'920,867	0.991	6'022,544	1.074	5'452,209	1.034
0.45	5'853,764	0.971	5'870,017	0.996	5'920,844	1.085	5'452,209	1.034
0.50	5'802,364	0.975	5'735,307	1.008	5'751,980	1.103	5'405,842	1.039
0.55	5'633,372	0.989	5'515,974	1.028	5'633,923	1.115	5'390,751	1.040
0.60	5'295,384	1.015	5'431,520	1.035	5'600,362	1.118	5'007,455	1.076

NIVEL 3415

0.40	5'924,134	1.008	6'008,513	1.048	6'008,486	1.093	5'420,169	1.071
0.45	5'822,561	1.018	5'923,923	1.056	5'923,736	1.103	5'420,169	1.071
0.50	5'754,761	1.024	5'839,469	1.065	5'822,163	1.114	5'242,464	1.092
0.55	5'584,668	1.040	5'721,116	1.076	5'619,485	1.135	5'242,464	1.092
0.60	5'329,318	1.062	5'517,716	1.096	5'551,854	1.142	5'218,515	1.095

NIVEL 3430

CUT-OFF	MALLA REAL 20x20		GEOESTADISTICO		INV. DISTANCIA		POLIGONAL	
0.40	6'274,038	1.092	5'884,182	1.133	5'833,253	1.144	5'566,277	1.259
0.45	6'138,438	1.107	5'816,382	1.142	5'748,503	1.155	5'566,277	1.259
0.50	6'002,838	1.121	5'782,525	1.145	5'579,045	1.176	5'566,277	1.259
0.55	5'816,345	1.140	5'697,775	1.155	5'409,630	1.196	5'456,920	1.274
0.60	5'731,553	1.149	5'562,175	1.169	5'358,780	1.202	5'456,920	1.274

NIVEL 3445

0.40	6'227,906	1.480	6'260,826	1.415	5'989,669	1.306	5'171,534	1.691
0.45	6'160,106	1.491	6'074,885	1.445	5'854,577	1.327	5'171,534	1.691
0.50	6'041,456	1.511	5'939,285	1.467	5'718,977	1.347	5'014,607	1.729
0.55	5'887,677	1.537	5'820,635	1.486	5'651,177	1.357	5'014,607	1.729
0.60	5'836,827	1.546	5'719,189	1.503	5'515,577	1.376	5'014,607	1.729

DE NIVEL 3385 A 3445

0.40	30'137,143	1.111	30'083,508	1.109	29'812,361	1.125	26'540,550	1.227
0.45	29'630,295	1.123	29'660,893	1.119	29'236,569	1.139	26'540,550	1.227
0.50	29'155,611	1.134	29'036,752	1.132	28'391,230	1.159	26'034,775	1.242
0.55	28'375,439	1.151	28'394,813	1.146	27'647,677	1.176	25'910,327	1.246
0.60	27'444,134	1.170	27'650,019	1.162	27'225,321	1.185	25'416,690	1.259

View of the Antapaccay mine.