

IVAN JURKOVIC

SOME GEOCHEMICAL ASPECTS ABOUT THE GENESIS OF THE NICKEL DEPOSIT LOMA DE HIERRO (VENEZUELA)

With 1 annex

The author discusses the conditions under which – during lateritization and serpentinization of the peridotite – there occurred a geochemical separation of the constituting elements and the formation of the nickel-silicate deposit at Loma de Hierro.

According to the program made by the Dirección de Geología of the Ministerio de Minas e Hidrocarburos for the one month visit of the author, as the consulting engineer of the company GEOISTRAZIVANJA, Zagreb, Yugoslavia, to some Venezuelan ore deposits, the author visited Loma de Hierro on May 4th, 1962. He was accompanied by H. Lavié and A. Galavis, the geologists of Dirección de Geología and A. Ferenčić, M. E. & geologist, head of the geological team of GEOISTRAZIVANJA in Venezuela. Due to the limited time, it was not possible to study the nickel ore deposit and the method of exploration in detail. Nevertheless, we shall try to resume some geological aspects of this deposit, particularly from the geochemical point of view.

The nickel ore deposits of Loma de Hierro is situated about 50 km SSW from Caracas (Estados Miranda y Aragua); it is connected with ultrabasic (peridotite) rocks. More or less serpentinized peridotite (auto-metamorphic serpentinization prevails) has the shape of elongated sill ($22 \times 0,7$ to 5 km). It strikes in the ENE direction (see geological map).

It can be seen from the geological map by R. J. Smith (1951) and by R. Shagan (1957) [revised by H. Lavié (1961)] that the peridotite sill is accompanied by its WSW side by gabbro and is situated (intruded) between »Formación Tucutunemo« on the NNW contact and »Rocas volcánicas de Tiara« on the E and ESE contact. There is a diorite intrusion within the formación Tucutunemo. Peridotite is bordered by the »Los Naranjos« formation on its extreme West. The surrounding rocks and peridotite are of Mesozoic (Cretaceous) age.

The intensity of serpentinization varies, but is relatively mostly expressed along the contacts of the peridotite sill.

Peridotite is covered in the WSW (7 km. long and 0,15 to 1,0 km. wide) area by nickeliferous laterite. Laterite is particularly well developed along the ridges, plateaus and – mild slopes, while it is thinner or disappears along the steep slopes. Obviously, the concentration of laterite depends on the morphology of the terrain, on the surface of the peridotite sill.

According to the morphological type of the nickel deposit in Loma de Hierro, the most adequate and the cheapest way of exploration of the deposit – the shallow exploration pits and drilling – was applied. Some pits are too shallow and stopped in ore and therefore it should be carried out until the fresh unmineralized rock. We suggest that some of the drill holes pre-drilled in several meters into the fresh rock so that the distribution of nickel in this zone, the bottom and the form of the mineralized area can be followed. These are very important data for the future excavation method, delimitation of economically interesting parts as for the evaluation of ore reserves.

The eastern part of the deposit is not included in the exploration program, but we expect further ore reserves in this region.

Geological mapping and sampling of the explorations pits and drill holes were carried on which is enough for the evaluation of ore reserves and for the distribution of nickel in the deposit. The average content of nickel in the deposit is 1.5%.

Further, more complete chemical analyses are in progress or planned (SiO_2 , Al_2O_3 , Fe_2O_3 , Mn, Co, Ni, MgO, CaO, Cr_2O_3 , Cu, P). Such analysis enables the construction of the isoelement lines and the distribution of the elements. It also gives a deeper information about the genesis of ore and the specific characteristics of the Loma de Hierro deposit.

The study of mineralogy and the study of chemical composition of the minerals, their structure and texture, the degree of dispersity would greatly facilitate the selection of the most adequate ore dressing of technological method.

The most appropriate method is applied for the calculation of the ore reserves – the method of parallel profiles. The exact determination of the average unit weight is in progress. For obtaining the industrial reserves (or commercial reserves) industrial tests of a representative sample of the Loma de Hierro ore are to be performed.

The Loma de Hierro nickel ore deposit belongs to the large nickel silicate deposits. Its advantage consists in the easy accessible position, the ore can be excavated by open pit mining and can be transported gravitationally.

For the design of development and exploitation of the mine the isopach maps, the bottom relief maps and the isoelement maps are to be prepared.

Discussion about genesis

The Loma de Hierro nickel deposit was formed by the alteration of peridotite in the superficial conditions. Peridotite seems to be of the harzburgite type (olivine-pyroxene variety). Nickel originates from this mother rock.

During the differentiation of magma nickel concentrates within the rocks of early stage of liquid-magmatic differentiation (ultrabasic rocks). The ionic radius of Ni^{2+} is very close in size to the ionic radius of Mg^{2+} and both elements mutually replace each other in early magmatic silicate minerals.

As the lattice energy of the silicates where Mg^{2+} and Ni^{2+} are built in is the highest one, both elements enter into olivine $(\text{Mg})_2\text{SiO}_4$ of the magnesium type. In the further sequence of crystallisation of the ultrabasic magma Fe^{2+} ($r = 0,83 \text{ \AA}$), Co^{2+} ($r = 0,82 \text{ \AA}$), Mn^{2+} ($r = 0,91 \text{ \AA}$), Ca^{2+} ($r = 1,06 \text{ \AA}$) enter in the structure of the femic silicates, gradually as their lattice energy decreases – which is proportional to the increase of their ionic radius. Consequently, the sequence of entry of these elements in the magmatic silicates is as follows: $\text{Ni}^{2+} \rightarrow \text{Mg}^{2+} \rightarrow \text{Co}^{2+} \rightarrow$

→ $\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} \rightarrow \text{Ca}^{2+}$. It is obvious that Ni can enter into the earliest magmatic silicates of the liquidomagmatic stage. As nickel in these silicates is not only in ionic bond but partly in covalent bond besides its entry into olivine (Mg-type) nickel enters to certain amount in orthorhombic pyroxenes, particularly enstatite. The ratio between NiO : MgO varies from 1 : 30 to 1 : 500 in the ultrabasic rocks.

Nickel occurs also within the sulphide minerals: $(\text{Fe}, \text{Ni})_9\text{S}_8$ - pentlandite, Ni_3S_2 - heazlewoodit and as nickel arsenide.

For a further study of the deposit of Loma de Hierro and clarification of its genesis in detail the following additional investigations should be carried out:

- a) to determine the distribution of the different lithological types of peridotite.
- b) to determine the degree of serpentinisation.
- c) to determine the paragenesis of metal minerals in fresh peridotite, i. e. nickel-sulphide or arsenide as segregation products by ore microscopy.
- d) to determine by spectrography or polarography (or by precise quantitative chemical analyses) the amount of Ni, Co, Mn in (1) peridotite (2) in individual silicate minerals of peridotite.

During the alteration processes in the region of Loma de Hierro the geochemical separation and migration of the constitutional elements develops (Mg^{2+} , Fe^{2+} , Ni^{2+} , Co^{2+} , Mn^{2+} , Si^{4+} , Fe^{3+} , Al^{3+} , Ca^{2+}). While during the magmatic differentiation the geochemical separation is based mainly on the lattice energy

$$U = \frac{N. A. z_a. z_k}{r} \left(1 - \frac{1}{n} \right)$$

by geochemical weathering processes the fundamental roll plays the Goldschmidt's law on the ionic potential $\left(\frac{Z}{r} \right)$ i. e. charge divided with ionic radius.

All the elements with the ionic potential $\frac{Z}{r}$ below 3,0 alter by desintegration of the main silicate minerals (as cations) into the aqueous solutions, and as such are being transported; they are Mg^{2+} , Fe^{2+} , Ni^{2+} , Mn^{2+} , Ca^{2+} , Co^{2+} . Elements of $\frac{Z}{r}$ below 10 and above 3 by weathering at first alter into ionic stage (as cations) but soon they associate with the hydroxile groups (OH) forming thus positively or negatively charged hydrosols. They can be transported for a certain time as hydrosols, but they mostly precipitate as hydrogels for several reasons: partial evaporation of solution, absorption, mutual precipitation of differently charged sols (neutralization of sols), entry of electrolite into the system. In our case the elements are: Si^{4+} , Ti^{4+} , Al^{3+} , Fe^{3+} .

During our short visit to Loma de Hierro two types of alterations were noted: a) serpentinisation of peridotite, b) lateritisation. While lateritisation is obvious and can be easily limited in the field, serpentinisation is sometimes hard to be discerned. Particularly difficult is to determine the degree of serpentinisation. According to H. Lavić, this phenomena is under investigation. We consider the study of various kinds of peridotite very important. The limitation of serpentine and the intensity of serpentinisation should also be studied. It is of particular interest to know which types of peridotite underlie the laterite blanket.

It has not yet been studied where and in what degree the superficial serpentinisation had developed (besides the autometamorphic, which probably prevails). Such investigation is conducted by detailed laboratory analyses of the antigorite structure (α - or β -form). Through the serpentinisation process (either intramagmatic autohydration or the superficial hydration), olivine, containing high Ni content, is first attacked, and is altered into the α or β antigorite ($H_4Mg_3Si_2O_{10}$) or the nickeliferous antigorite ($H_4(Mg, Ni)_3Si_2O_{10}$). Pyroxene (enstatite) persists and partly serpentinized peridotite is formed – which is the often case in Loma de Hierro. If pyroxene is metamorphosed entire serpentinisation is reached.

It is important to determine the degree of serpentinisation as by the superficial alteration (lateritization) serpentine and peridotite react differently according to their different physico-chemical properties. The speed of alteration and the products obtained are different for the two rocks.

Completely serpentinised peridotite usually contains little nickel (below 1%) The present market condition requires 1,5% of nickel in silicate ore as minimum, therefore, the nickel-bearing serpentine, with the exception of a few cases, does not come into consideration as a commercial ore. Nevertheless, the recent development of technological processes for beneficiation of the nickel silicates has greatly improved, especially on the eve of World War II, when the commercial ore had to contain at least 5–6% of NiO. Gradually this tenor diminished and is nowadays around 1,5% of Ni. It is supposed that by constantly improving the technology and by a steady demand, even lower nickel tenor will be considered as commercial. Therefore we propose at least a preliminary investigation of the nickel bearing serpentine zones in Loma de Hierro.

Under special circumstances the cementation nickel silicate deposits can be formed along the contact of serpentine. They are sometimes rich in nickel but usually of small dimensions.

The process of nickel concentration and forming of the deposit in Loma de Hierro are connected with the lateritization of peridotite and partly with the serpentinisation of peridotite. The kind of the laterite here clearly indicates that the primary rock was rich in iron and poor in alumina. The iron laterite derives from peridotite under tropical weathering with sharp changes between the dry and the rainy season.

The percolation waters have rhythmically changed their pH characteristics as the seasons interchanges, being below 7 during the rains and above 7 during the dry period. Besides the mechanical factors which enabled and improved the percolation of waters, another important factor in favour of alteration was the chemical dissolving of silicates from peridotite and / or from partially serpentinised peridotite. Due to the differences in ionic potential among the constitutional elements in peridotite geochemical separation took place. The separation was stimulated by seasonal changes of the pH and redox potential as well as by the concentration of the elements in solutions.

The underground percolation waters penetrate into peridotite through the system of diaclasis. These waters carrying their aggressive components dissolve the magnesium, iron-magnesium and nickel-magnesium silicates. Besides the diaclasis the percolation waters penetrate through numerous jointing planes. Both kinds of mechanical alterations were noted in the Loma de Hierro peridotite.

Magnesium is dissolved as bivalent ion (Mg^{2+}) and because of its low ionic potential (3,0 eV) value the percolation waters leach it and take it away from the rock. Exceptionally, if pH reaches 10 to 11, magnesium partially precipitates as $Mg(OH)_2$.

Silica also transforms into the ionic stage but because of high ionic potential (9,5 eV) silica soon associates with the hydroxyl groups, forming thus $Si(OH)_4$ hydrosol. This hydrosol precipitates under very low pH (acid medium) and its stability increases with the increase of pH. This is the reason why SiO_2 precipitates only in part while in a greater part it is leached out as $Si(OH)_4$ hydrosol and as such is transported farther on.

Successively the rock remains poorer and poorer in Mg and Si, porous and of diminished unit weight. These circumstances enable further accelerated penetration of the waters.

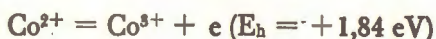
Iron is dissolved in ionic stage as Fe^{2+} but under positive redox potential it is converted in Fe^{3+} .



$Fe(OH)_2$ hydrosol precipitates as hydroxide gel under very low redox potential and under $pH = 5$. Such conditions seldom accompany the decomposition of peridotite and because of positive redox potential $Fe(OH)_3$ hydrosol is usually formed. Under $pH = 3$ or $pH = 7$ to 8, it easily precipitates as iron hydroxide (goethite). $Fe(OH)_3$ once precipitated becomes very difficult for dissolving because pH below 3 or pH above 8 are required, which seldom happens in the nature. Hence, peridotite enriches in iron »in situ«.

Cobalt is soluble and forms Co^{2+} ions under the ionic potential 2,8 eV and pH below 7 (rainy season).

Co^{2+} is stable in water solution characterised by pH below 7 as by this condition high E_h is necessary for its oxidation in Co^{3+} .



therefore, this process does not take place. Under pH above 7 (dry seasons) Co^{2+} transforms according to the equation:

$\text{Co}^{2+}(\text{OH})_2 + \text{OH}^- = \text{Co}^{3+}(\text{OH})_3 + e$, under $E_h = +0,7$ to $+0,2 \text{ eV}$. In such a way cobalt hydroxide precipitates under alkalic conditions »in situ« and enriches its parent rock.

Aluminium is soluble as $\text{Al}^{3+} \left(\frac{Z}{r} = 5,9 \text{ eV} \right)$. Aluminum quickly associates with the hydroxyl groups altering into $\text{Al}(\text{OH})_3$, absorbing by the way the the remaining hydrosols and hydrogels. Thus aluminum also concentrates during the weathering of peridotite. A small amount of Al^{3+} can enter into the lattice of the nickel silicates.

The same happens with $\text{Ti}^{4+} \left(\frac{Z}{r} = 5,9 \text{ eV} \right)$

Calcium turns into $\text{Ca}^{2+} \left(\frac{Z}{r} = 2,0 \text{ eV} \right)$ and in the form of bicarbonate is leached out from the rock. The content of Ca in dunite and harzburgite kinds of ultrabasic rocks as primary component, are very small and consequently, this process seldom happens.

Manganese turns as bivalent Mn^{2+} into the solution. The oxidation of Mn^{2+} into Mn^{3+} cannot happen if pH remains below 6, for this process requires high redox potential.



While during the rainy season (pH below 6) manganese is leached out and turned into the ionic stage, during the dry season (pH above 6) it oxidises as Mn^{3+} , associates with the OH groups and precipitates as $\text{Mn}(\text{OH})_3$ hydrogel. That is why manganese is also concentrated within the residum of peridotite.

Nickel turns, after the attack of the aggressive underground waters, into ion $\text{Ni}^{2+} \left(\frac{Z}{r} = 3,0 \text{ eV} \right)$. According to Goldschmidt's law, nickel is one of the quickest elements to leave the crystal lattice. The oxidation of Ni^{2+} in Ni^{4+} or the transition of $\text{Ni}(\text{OH})_2$ in NiO_2 are practically impossible in the nature, because these processes require higher potentials than encountered in the water solutions.

Consequently, nickel does not concentrates as NiO_2 , in laterite. Without such special conditions all nickel (Ni^{2+}) in dissolved stage as $\text{Ni}(\text{OH})_2$ or $\text{Ni}(\text{HCO}_3)_2$ would be transported and evacuated from

peridotite. Nevertheless, by dissolving of peridotite, sometime complicated hydroreactions occur between $Mg(OH)_2$ or $Mg(HCO_3)_2$ and $Si(OH)_4$ hydrosol and $Ni(OH)_2$ or $Ni(HCO_3)_2$ and nickel-magnesium hydratised silicate are formed. Which of the nickel silicates will be formed depends on pH and concentration. Earlier ideas considered only the antigorite structural types possible, but recent investigations show that 3 types of nickel magnesium silicates are formed:

1. garnierite with the structural lattice of antigorite.
2. schuckardite with the structural lattice of chlorite.
3. pimelite with the structural lattice of montmorillonite.

The pH characteristic of the environment and the concentration of particular components control which of the 3 types will be formed.

The general formulas of these silicates are:

antigorite	$H_4Mg_3Si_2O_9$	$Mg : Al : Si = 3 : 0 : 2$
chlorite	$Mg_{10}Al_2(Si_6Al_2)O_{20}(OH)_{16}$	$Mg : Al : Si = 5 : 2 : 3$
montmorillonite	$Al_4(Si_4O_{10})_2(OH)_4 \cdot nN_2O$	$Mg : Al : Si = 0 : 1 : 2$

Nickel replaces isomorphically either Mg^{2+} or Al^{3+} .

Usually by the chemical decomposition of peridotite optimal concentration of Mg^{2+} and Si^{4+} are present within the leaching solution and forming of nickel antigorite (garnierite) takes place and therefore this mineral can be encountered in the beginning phase of the concentration of nickel »in situ«. Later on, by descendent enrichment, when a conspicuous roll plays also Al^{3+} , the other nickel silicates are formed.

It is of major importance for the technological treatment of nickel silicate ore to have an exact knowledge of the mineralogical composition of the nickel silicate ores. The above mentioned 3 types of Ni-Mg-silicates have different structural lattices, different chemical composition, different physical properties (e. g. the minerals of the montmorillonite group swell and have the property of »cations exchange«, etc.). Pimelite (Ni-montmorillonite) has the most complicated chemical composition because it can contain in the molecule besides Al^{3+} and Si^{4+} , also Mg^{2+} , Co^{3+} , Ni^{2+} , Fe^{2+} and Mn^{2+} .

So far the mineralogy of the Loma de Hierro deposit has not been studied. We consider that the following investigations should be done:

- a) identification of the Ni-Mg-hydrosilicates.
- b) distributions of each one of the silicates (quantitative ratio) within (1) the zone of partially altered peridotite, (2) the zone of impregnations and intensely altered peridotite and (3) the zone of lower laterite.

A separate problem presents the investigation of the dispersed nickel minerals. The nickel silicates are mostly finely crystallised (crypto to microcrystalline). The study of the dispersity is also important for the technology, and we propose corresponding investigations.

On the basis of the exposed chemical laws, intense separation of the constituent elements occurred during the attacks of peridotite by the underground aggressive percolation waters. Mg^{2+} , Si^{4+} , Ca^{2+} are leached out and the rock is gradually impoverished in these elements and relatively enriched in Fe^{3+} , Al^{3+} , Mn^{3+} , Mn^{4+} , Ti^{4+} , Co^{3+} , Ni^{2+} etc. »in situ«.

Thus peridotite, turns into a very porous and water permeable peridotite relatively rich (1,5%) in nickel.

Further on, during the process of weathering in Loma de Hierro, complete leaching of Ca^{2+} , Mg^{2+} and Si^{4+} from the spongy peridotite takes place and a *laterite blanket* covering peridotite is formed. The lower part of laterite is very porous. Here, is in course further separation of the elements. Particularly important is the separation of Fe^{3+} from Mn^{4+} (Mn^{3+}) and Co^{3+} on one side and Fe^{3+} from Ni^{2+} on the other side.

Separation of iron from manganese and cobalt is caused by their different redox potentials at the transition from the lower ionisation stage to the higher ionisation stage. The speed of the oxidation decreases from Fe^{2+} , to Mn^{2+} and to Co^{2+} . While for Fe is sufficient pH above 4, Mn requires pH = 6 and Co requires pH = 7,5. A higher redox potential is necessary to equal proportion. Therefore iron easily precipitates as $Fe(OH)_3$, while manganese is still dissolved in this condition and precipitates only by an elevated redox potential as MnO_2 . Similarly as manganese cobalt behaves. That is why cobalt is often encountered within the manganese rich parts of laterite (asbolan).

In several places in Loma de Hierro porous laterite rich in Mn and Co were noted. According to information, no study about the distribution of the two elements has been carried out in Loma de Hierro.

Descendent migration of nickel takes place within laterite. The separation of nickel from iron depends on many factors, particularly the climatic factor and morphology. Nickel is soluble in acid environment and goes into the solution as Ni^{2+} . It can again be precipitated from the solution by the partial evaporation of the solution. Which hydrated Mg-Ni-silicate will precipitate depends on the content of Mg^{2+} , Al^{3+} and Si^{4+} in the solution. Relatively high Al content in the solution enables the development of the chlorite and montmorillonite structural types of nickel silicates. Descendent precipitation is controlled by diacclasis, micropores and fissures of the altered peridotite. If the precipitation takes place mainly in pores, then the impregnation type of the deposit is formed; if it takes place in fissures and fractures, the stockwerk deposit is formed. Usually both types occur jointly.

It is characteristic of the Loma de Hierro deposit that the descendent migration of nickel had developed within the lower portion of laterite, but only partially, and the migration is still in progress; in this respect Loma de Hierro is different from similar deposits in New Caledonia. This is at the same time the reason why the Loma de Hierro nickel

deposit contains relatively low quantities of nickel (1,5 to 2,0%) not only within the lateritic zone but also within the zone of altered peridotite.

The upper part of the laterite in Loma de Hierro is characterised by gradual dehydration which is more and more intense towards the surface. The amorphous and cryptocrystalline masses of $\text{Fe}(\text{OH})_3$ turn, by dehydration, into concretions and pisolites, which are of microcrystalline granular or fibrous texture and typical colloidal structure.

Locally (over a relatively small surface) in Loma de Hierro intensely dehydrated areas within the upper part of laterite can be encountered. This is the so called *limonitic crust*; it is the cellular crust with a high iron content, composed of goethite and hydrohematite, quartz and the individualised minerals from the clay group.

The remnants of the limonitic crust indicate that the erosion activity after the lateritisation destroyed a significant part of the laterite blanket in Loma de Hierro. The comparatively intensive erosion was another reason for the relatively limited development of the descendent nickel enrichment.

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I. JURKOVIC

NEKI GEOKEMIJSKI ASPEKTI GENEZE NIKALJNOG LEŽIŠTA LOMA DE HIERRO (VENEZUELA)

Silikatno nikaljno ležište Loma de Hierro nalazi se oko 50 km SSW od glavnog grada Caracasa. Vežano je na manje ili više serpentinizirani peridotitski sil (22×0,7—5,0 km) koji se pruža u ENE smjeru (vidi geološku kartu).

Peridotit je pokriven u WSW dijelu sa 7 km dugim i 0,15–1,0 km širokim nikaljonosnim lateritom. Laterit je naročito razvijen uzduž grebena, platoa i blagih padina, dok je tanji ili nestaje na strmim pristrancima.

Nikaljno ležište je stvoreno alteracijom peridotita u površinskim uvjetima. Za vrijeme alteracije nastupila je geokemijska separacija i migracija konstitucionih elemenata: Mg, Fe, Ni, Co, Mn, Si, Al, Ca. Proces koncentracije niklja i stvaranje nikalnog ležišta Loma de Hierro vezano je na lateritizaciju peridotita, a djelomice i na serpentinizaciju peridotita. U članku se razmatraju uvjeti pod kojima je došlo do geokemijske separacije konstitucionih elemenata i formiranje pojedinih zona u rudništu: limonitske kore (dehidratizirani gornji dio laterita), nikaljonosnog laterita te »spužvastog peridotita«.

Rudište je velikih razmjera, a sadrži u prosjeku 1,5% Ni.

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GEOGRAPHICAL POSITION OF LOMA DE HIERRO NICKEL DEPOSIT
 SCALE 0 10 20 km
 GEOGRAFSKI POLOŽAJ RUDIŠTA LOMA DE HIERRO.

GEOLOGICAL SKETCH OF LOMA DE HIERRO REGION

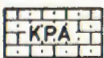
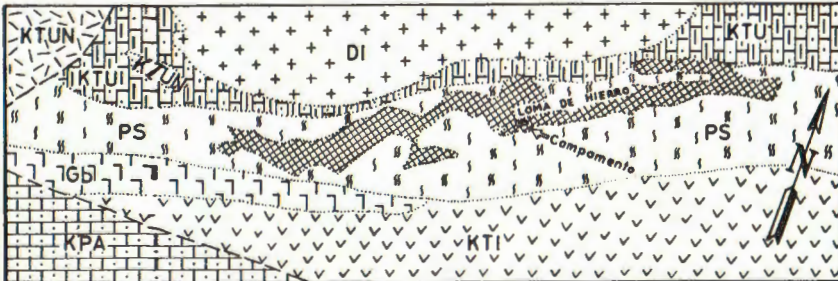
By H. LAVIÉ, 1961

Sc. 0 1 2 3 km

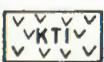
GEOLOŠKA SKICA PODRUČJA LOMA DE HIERRO

Izradio H. LAVIÉ, 1961

0 1 2 3 4 km



FORMACIÓN PARACATOS: Sandstoneous limestone, conglomerate.
Pješkoviti vapnenjaci, konglomerati;



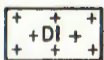
ROCAS VOLCÁNICAS DE TIARA: Aplite-basalte and submarine volcanic rocks.
Aplitski bazalti i submarinski vulkaniti;



FORMACIÓN TUCUTUNEMO: Finegrained black limestone, feldspathic-quartz-conglomerate, carbonaceous phillite.
Crni vapnenjaci finozrnati, feldspatsko-kvarcni konglomerati, ugljeviti filiti;



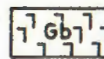
MIEMBRO LOS NARANJOS: Metabasalte, metaphillite.
Metabazalti i metafiliti;



DIORITE SERPENTINIZED PERIDOTITE
Diorit Serpentinizirani peridotiti



LATERITA NIQUELÍFERA: Nickeliferous laterite.
Nikaljonosni lateriti;



GABBRIO
Gabro