

**II INTERNATIONAL SEMINAR ON
LATERITISATION PROCESSES**

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SÃO PAULO — BRAZIL**

GUIDE BOOK



PROJECT 129
International Working Group
Lateritisation Processes



IAGC
Working Group
Laterites and Lateritisation

EXCURSION I

CARAJAS AND NIQUELANDIA DEPOSITS

II INTERNATIONAL SEMINAR ON LATERITISATION PROCESSES

PART II - NIQUELÂNDIA ORE DEPOSITS

II INTERNATIONAL SEMINAR ON LATERITISATION PROCESSES

LATERITIC NICKEL DEPOSIT OF NIQUELÂNDIA, GO

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INTRODUCTION AND PREVIOUS WORKS

The following geological description and comments are derived from selected portions of the following authors: Leonardos Jr., O.H. and Danni, J.C.M. (1982) and Pedroso, A.C. and Schmaltz, W.H. (1981).

The aim of this summarized study is to place the nickel lateritic deposits of Niquelândia in a global assessment of the geologic, geographic and economic characteristics, based in the regional and local researches which have been made in the area. Niquelândia is the site of the only large nickel mine in Brazil and of a large complex of mafic and ultramafic rocks which together with the Barro Alto and the Canabrava complexes form a 700 km long lineament. The first geological descriptions were those of Morais (1935) and Leonardos (1939) who were mostly concerned with reconnaissance of the mineralization. A systematic survey was carried out by a joint war effort between the Brazilian and the American Governments (Pecora, 1944; Pecora and Barbosa, 1944). Beyond assessing the lateritic Ni-Cu-Co deposits and producing a detailed map of the ultramafics, a comprehensive account was presented in which the complex was subdivided into five units: a) basal gabbroid zone; b) peridotitic zone; c) central gabbroid zone; d) anorthositic zone; e) top gabbroid zone. Motta et al. (1972) completed the mapping of the complex and supported the stratiform interpretation of Pecora (1974) and Barbosa (1968). The rock types were interpreted as differentiated products of a tholeiitic basaltic magma chilled in what they called the marginal facies of the gabbroid zone. Other more recent interpretations have considered the complex either as part of a serpentinite belt (Almeida, 1968; Angeiras, 1968) of the Alpine-type or as a pseudo-stratiform type (White et al., 1971; Da Costa and Angeiras, 1971). Fleischer and Routhier (1970) referred to the Niquelândia complex as a differentiated massif comparable to the Stillwater complex of Montana and Thayer (1970), Figueiredo et al. (1975) and Figueiredo (1978) after

observing features common to both Alpine and stratiform types have considered the Barro Alto and Niquelândia complexes as belonging to quite a unique type.

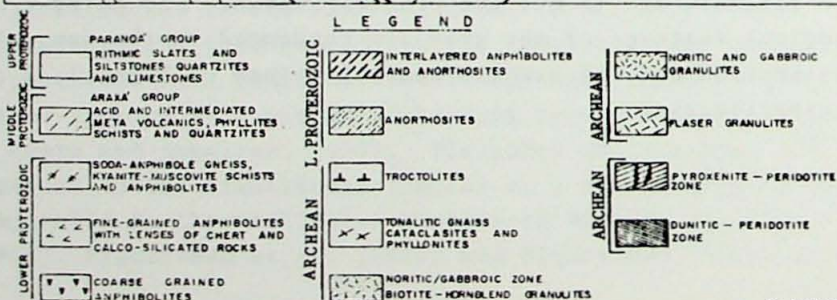
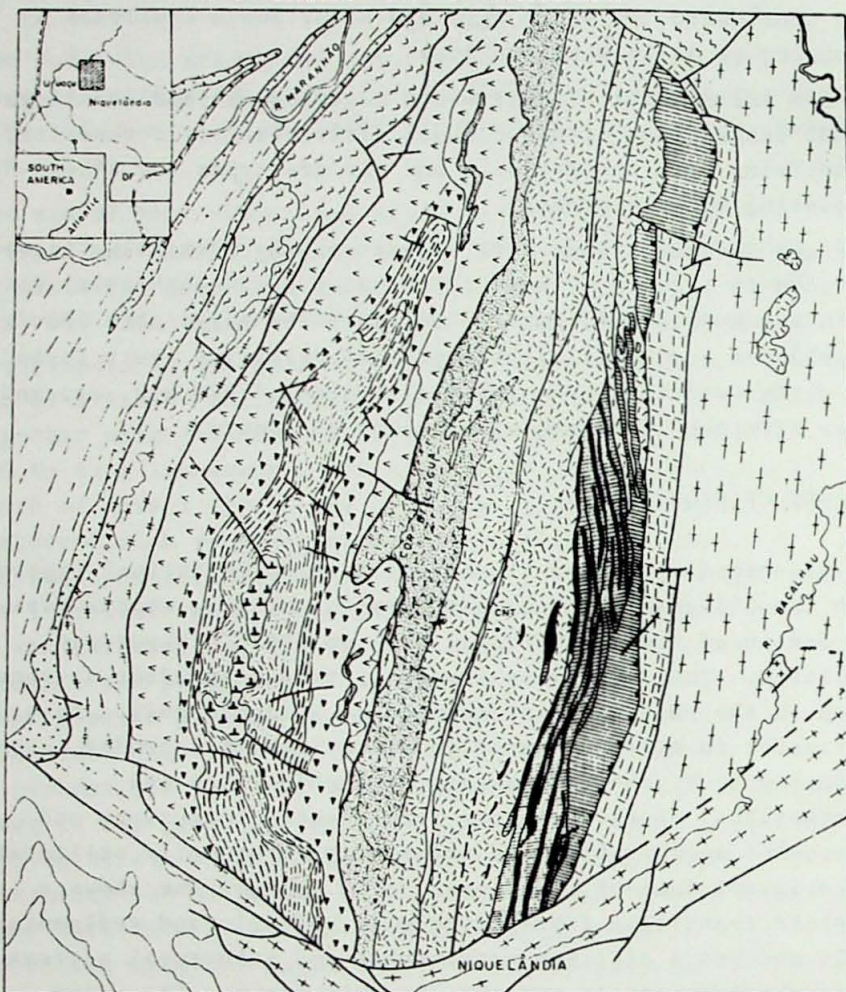
Pedroso and Schmaltz (1981) wrote a geological and stratigraphical description of Niquelândia nickel lateritic deposits, classifying both the deposits and the ore types and also discussing the ore genesis.

K-Ar age determinations with values ranging within the interval of 4,000 to 1,100 m.y. have led Cordani and Hasui (1975) to set forth and hypothesis that the rocks of the Barro Alto and Niquelândia complexes might represent primitive crust formed by the differentiation from the mantle about 4,000 m.y. ago and later affected by a complex sequence of events.

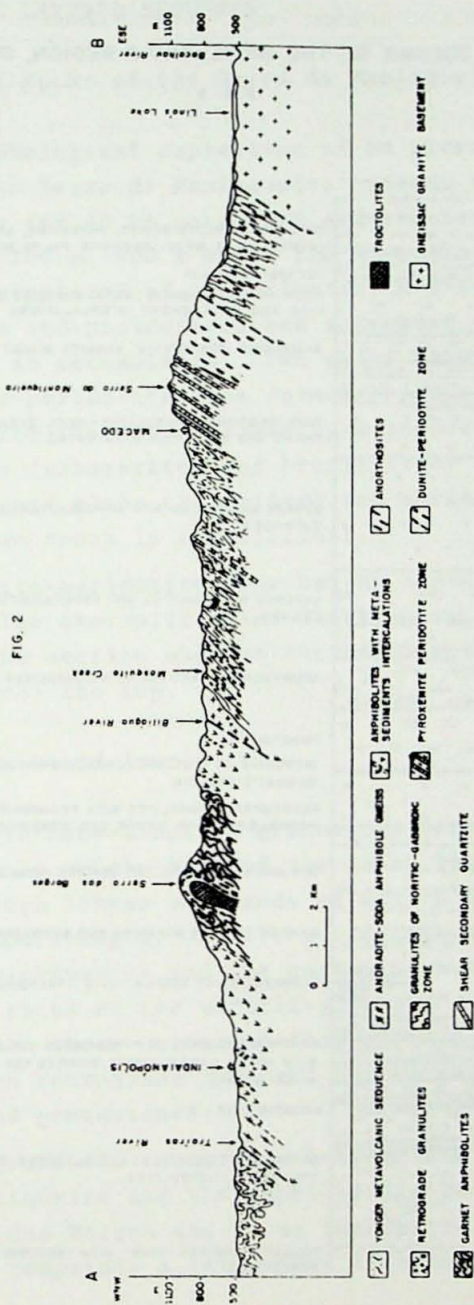
GEOLOGY OF NIQUELÂNDIA

The Niquelândia complex (former S. José do Tocantins) together with the old granitic basement forms a tectonic window within the domain of the supracrustal amphibolites, schists and phyllites. The complex is formed by two independent sequences which in the past were interpreted as a single body. An older ultramafic to mafic sequence of granulites is intruded by rocks belonging to a younger sequence of amphibolites and anorthosites. Both sequences form layered intrusions and subsequent metamorphism and deformation frequently obliterated the original igneous structures. The younger one shows a complete transition from plutonic to volcanic and sedimentary rocks and has a distinct metamorphic and structural pattern. Their absolute age is not yet properly known. The major geological features of the area are condensed in the map, the cross-section and the stratigraphical column of Figs. 1, 2 and 3, respectively.

FIG. 1 - GEOLOGIC MAP OF NIQUELÂNDIA

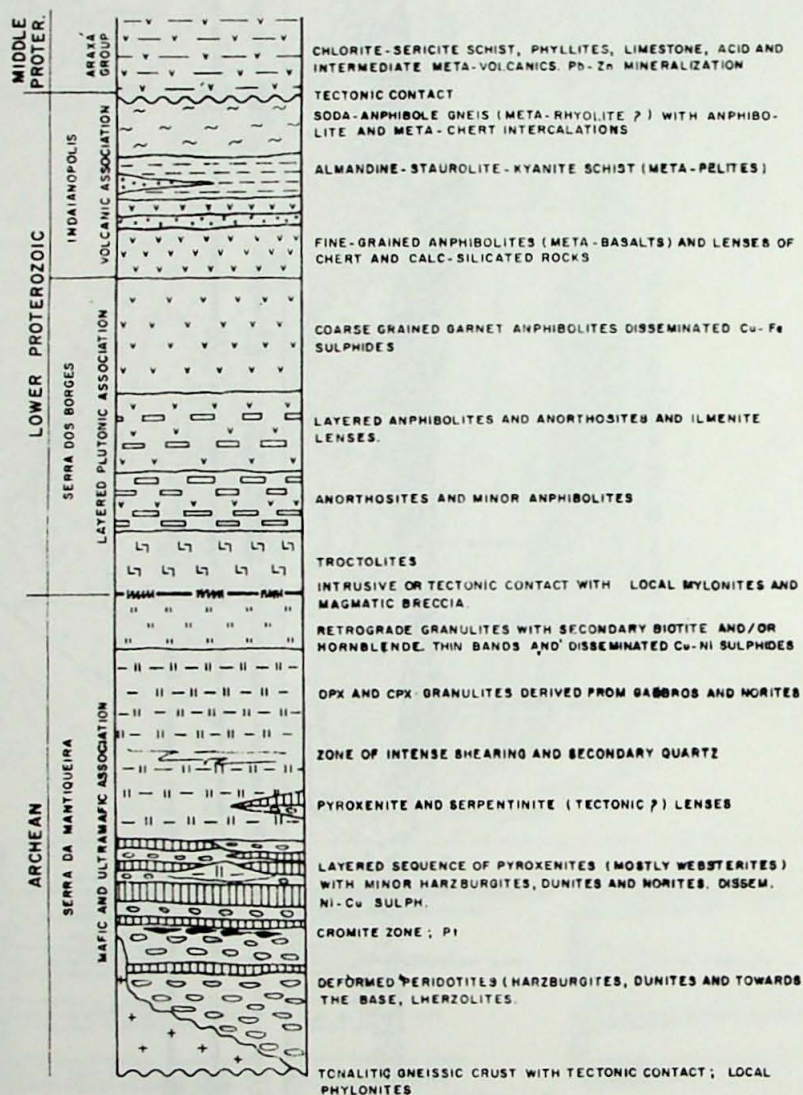


CROSS SECTION OF THE NIQUELÂNDIA COMPLEX



GEOLOGIC COLUMN OF THE NIQUELANDIA REGION, GOIAS, BRAZIL

FIG. 3



THE GRANULITIC LAYERED SEQUENCE

The Ultramafic Rocks of the Serra da Mantiqueira

As the geomorphological expression of an ultramafic pile up to 4 km thick, the Serra da Mantiqueira extends from the village of Niquelândia for 40 km northward and reaches a maximum altitude of 1,100 m, 400 m above the Niquelândia plain. It is formed by a succession of approximately N-S asymmetrical ridges of pyroxenites and peridotites and suspended valleys where the lateritic ore is accumulated. Two major units were recognized. A basal dunite-peridotite zone formed by dunites, harzburgites and minor lherzolites is followed by a perfectly layered zone of pyroxenites (websterites and bronzitites) and peridotites or serpentinites and minor troctolites and norites. The contact between the two zones is transitional.

The basal dunite-peridotite zone has an approximated thickness of 1,500 m. The lherzolites and dunites are more abundant near the base of the section whereas the harzburgites increase and dominate towards the top.

The Noritic-Gabbroid Zone

Foliated hypersthene-diopside granulites derived from norites and gabbros make up the bulk of the zone, the largest of the complex. Though lenses and bands of norite are not uncommon within the underlying pyroxenite-peridotite zone, the contact between the ultramafics and the enclosing norites is rather abrupt. The rocks of the noritic-gabbroid zone were subdivided into three units: a) the central granulite unit; b) the western retrograde zone and c) the eastern flaser granulites and greenstones.

The central granulite unit lies between the ultramafics of the Serra da Mantiqueira and the amphibolitic-anorthositic sequence of the Serra dos Borges and forms the central depression of the complex. It comprises a large N20E trending zone, 7 to 10 km

wide formed by meso to melanocratic granulites of noritic to gabbroid composition. The rocks still show the primary igneous layering as reflected by the alternation of metric to centimetric bands with slight variations in composition.

THE LAYERED AMPHIBOLITIC - ANORTHOSITIC SEQUENCE

Stratigraphy

This sequence extends in a N-S direction forming the Serra dos Borges, a drainage divisory of the Biliágua and Traíras River. It is formed by an extensive layered plutonic complex that shows a remarkable transition to a metamorphosed volcanic and sedimentary sequence. The plutonic complex is about 11 km wide in its southern part and about half of this width in its northern extreme, forming an elongated body 30 km long, geometrically arranged in an isoclinal anticline with N-S axis and an inverted eastern flank. Four main stratigraphic units were separated and these are symmetrically repeated in respect to the center of the Serra dos Borges anticline, formed by a troctolite nucleus that initiates the sequence. The troctolites are followed by a wide zone of massive to finely and regularly banded anorthosites showing amphibolitic intercalations towards the top. The anorthosites are in turn overlain by more mafic members, the amphibolite layers becoming more abundant and the anorthosite thinner until it disappears. The top of the sequence is formed by fine-grained amphibolites of volcanic origin (meta-basalts) which enclose metachert and calc-silicate rocks lenses. These are present on both flanks of the anticlinal structure; on the eastern flank the amphibolites have a tectonic contact with the retrograde granulites and in the western flank they initiate a metavolcanic-metasedimentary sequence formed by amphibolite, meta-chert, micaschist and meta-rhyolite intercalations.

THE METAVOLCANIC/SEDIMENTARY SEQUENCE

Fine-Grained Amphibolites

These are continuously exposed along the western flank of the Serra dos Borges where they form a succession of layers of different grain size with thickness varying from a metre to several tens of metres. The amphibolitic unit includes lenses of meta-cherts and calc-silicate rocks and it is interstratified with micaschists and overlain by soda-amphibole gneisses. The symmetrical fine-grained amphibolites of the eastern flank are however bounded by sheared retrograde granulites. Here, ferruginous meta-chert and calc-silicate rock lenticular outcrops are again surrounded by them. Close to the contact, local intrusive quartz-gabbros to quartz diorites contain xenoliths of both the amphibolite and meta-chert and of rocks of the granulite sequence. Such quartz diorites are clearly associated with the amphibolite-anorthosite sequence, being a late intrusive phase in its own basaltic cover. Its high quartz content seems partly related to the numerous chert inclusions which it contains.

COUNTRY ROCKS

A younger, lower grade sequence of phyllites and chlorite-sericite schists mostly derived from acid to intermediated volcanics and quartzites have been thrust over the meta-sediments and meta-volcanics that form the western and northern border of the Niquelândia complex. This volcanogenic formation is being currently investigated by METAGO S geologists who have reported the finding of well preserved tuff and ignimbrite textures and lead-zinc mineralization within the sequence.

On the eastern and southern border of the complex the mafic and ultramafic granulitic sequence is in faulted contact with quartz-sericite phyllonites and mylonites and highly cataclastic gneisses. These rocks show a gradual transition to

rather homogeneous granitic to tonalitic gneisses that in neighbouring regions form the granitic cratonic nuclei that are referred to as basement for the Archean greenstone belts. Paranoá group rhythmic slates and limestones outcrop further east lying unconformably over the gneissic basement. At the town of Niquelândia and elsewhere along the southern border of the complex the gneisses show striking mullion structures constantly dipping around 30° against the complex.

NICKEL DEPOSITS

The nickel lateritic deposits are located in the ultramafic massif (Motta et al., 1972). These deposits have been named according to local names. The most famous ore deposits, known as Jacobas, are not being currently mined, since these deposits have small reserves and a high content of silica and oxidized copper, which cause problems during the ore dressing process.

The biggest and the most important deposits of the area belong to Companhia Níquel Tocantins and also represent the total reserves which occur in the Corriola, Corrego da Fazenda, Vendinha, Angiquinho and Ribeirão do Engenho deposits.

The total nickel reserves of these deposits are 33 million tons of ore with 1,45% Ni. The total nickel reserves of the Niquelândia district is about 60 million tons of ore with 1,45% Ni.

There are two different types of nickel ore in Niquelândia; the garnieritic and the oxidized ores. The garnieritic ore is formed by the decomposition of pyroxenites which contain 0,05% Ni. The oxidized ore is formed by the decomposition of peridotite and dunites which primarily contain 0,30% Ni.

The garnieritic ore, despite having originated from rocks of lower nickel content than those which originated the oxidized ore, has a higher nickel content than the oxidized ore. This inversion of the nickel content in the garnieritic ore could be explained as a result of the contribution of dissolved nickel

from lateral water flow.

There are two types of lateritic ore deposits in Niquelândia:

1. Ore deposits of the piroxenite-peridotite subzone.
2. Ore deposits of the peridotite-dunite subzone.

The deposits of the piroxenite-peridotite subzones are in the hanging valleys, which were preserved because they were not eroded by degradation processes.

The ore deposits of the peridotite-dunite subzone were produced by weathering of the olivine rich ultramafic rocks.

In the Angiquinho open pit, where a typical deposit of the peridotite-dunite subzone occurs, the depth of supergene alteration extends about 80 m below the surface. Seven zones of supergene alteration can be recognized: "canga" (limonite-goethite zone), red grained and nodular laterite, red-brown clay, oxidized ore, garnieritic ore, jaspilite and altered peridotite.

The distribution of Ni, Co and Cu grades and their relationship to the laterite profile are illustrated in the Tables 1 and 2.

Concentrations of Cu and Co occur in laterite profiles throughout the Niquelândia area.

The copper concentration tends to grade as the nickel does, while the high cobalt concentrations occur mainly on the top of the nickel ore zone, with decreasing cobalt content at depth.

Enrichment of cobalt, which in the lateritic profile commonly appears associated with Mn oxide, forms hard concentrations of asbolan.

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TABLE 1. GEOLOGICAL AND CHEMICAL PARAMETERS OF THE NICKEL ORE OF NIQUELÂNDIA, GOIÁS
ORE OF THE PIROXENITA-PERIDOTITE SUBZONE.

ORE TYPE	AVERAGE THICKNESS VALUE	PROFILE ZONE AND PROTORE	COLOR	MINIMUM, MAXIMUM AND AVERAGE VALUE			
				Ni %	Fe %	Cu %	Co %
Silicate-Garnieritic	20 m	Clay Zone Piroxenite	Green to Brownish	.5-18.0 3.0	14.0	.01-2.00 0.40	.01-2.20 .15
Silicate-Garnieritic	1 m	Altered Piroxenite Piroxenite	Green	.05-5.0 1.5	12.0	Traces	Traces
Oxidized	20 m	Clay Zone Peridotite	Yellow Red	.3-1.50 1.20	40.0	.12	.15
Silicate-Garnieritic	1 m	Altered Peridotite Peridotite	Green Gray	.01-5.0 1.5	12.0	Traces	Traces

TABLE 2. GEOLOGICAL AND CHEMICAL PARAMETERS OF THE NICKEL ORE OF NIQUELANDIA, GOIAS
ORE OF THE PERIDOTITE-DUNITE SUBZONE.

ORE TYPE	AVERAGE THICKNESS VALUE	PROFILE ZONE AND PROTORE	COLOR	MINIMUM, MAXIMUM AND AVERAGE VALUE			
				Ni %	Fe %	Cu %	Co %
Oxidized	2.6 m	Clay Zone Peridotite-Dunite	Yellow Red	.3-1.5 1.20	40.0	.10	.01-2.0 .07
Silicate	1.0 m	Altered Rock Peridotite-Dunite	Green Brown	.01-1.20 1.0	12.0	Traces	Traces
Silicate and Oxidized	20 m	Clay Zone and Clay-Altered Rock	Green, Brown and Re- dish	1.50-10.90 2.95	20.6	.04	.11

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