CHROMITE POTENCIAL OF THE VALE DO JACURICI

SUPERINTENDÊNCIA DE GEOLOGIA E RECURSOS MINERAIS

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ABSTRACT

The chromite production of Brazil is almost exclusively restricted to the State of Bahia. It comes from the two important districts of Campo Formoso and Vale do Jacurici, each of which produces about 50% of the total.

The Government of the State of Bahia, through its Geological Survey (Superintendência de Geologia e Recursos Minerais-SGM), has conducted a series of studies on the Vale do Jacurici district, including aerophotogrametric survey, detailed geological investigation and drilling, aimed at delineating its full chromitiferous potential.

As a result, potential reserves of 28.000.000 tons of chromite have been estimated in this district, significantly improving the Brazilian position as a supplier of Fe-Cr alloy.

INTRODUCTION

The Secretariat of Mines and Energy of the State of Bahia, through the Superintendence for Geological and Mineral Resources - SGM, has, all through its history, taken several actions aimed at fomenting the development of the mineral sector in the State. Such actions have included, among others, supporting implantation of new mining projects, improving infra-structural conditions of traditional mining centers and preparing and publishing geologic and metalogenetic maps which hopefully will point to the most favourable exploration areas.

In 1983 a Geology of Mining Districts Program was created within SGM with the purposes of producing detailed geologic maps and of defining the potential reserves of the State's main mining districts. The Program, which involves integration of the available data, aerophotogrametric surveys, field mapping, and drilling, was initiated with the Jacurici Project on the chromite-bearing Vale do Jacurici District that encompasses areas of the Senhor do Bonfim, Itiúba, Monte Santo and Uauá Counties and yields about half of the State's chromite production (Fig. 1).

Chromite is presently the first item in the mineral tax revenue of the State (25%) and occupies the third place in total mineral production (15% in value). In 1984 total production of lump and concentrated ores reached 312,000 tons. In that same year 125,000 tons of Fe-Cr alloy were produced, 53,000 tons were exported, and 81,000 tons were sold to the internal market.

Chromite extraction in the State of Bahia began in 1917, but only after the creation of FERBASA in 1962, has its importance really increased, with the production of Fe-Cr alloys.

Up to 1973 all the production came from an area near to the town of Campo Formoso. After 1970, when a geological exploration project, including deep drillings, was carried out by the Federal Government, through its National Department of Mineral Production (Departamento Nacional da Produção Mineral-DNPM), larger mineralised area was defined which later became the Chromitiferous District of Campo Formoso. Approximately 30 millions tons were then estimated for this district. In spite of the production intensity of the operating mines, the chromitiferous potencial of this district, is still enormous. In addition, continuity of orebodies under the Jacobina Group quartzites has been observed suggesting the possibility of large underground but minable chromite reserves. More agressive prospection activity should certainly lead to more favourable results.

Extraction from Vale do Jacurici started in 1974. The economic significance of this new district has increased since, and it is responsible today for 50% of the chromite production of the State.

The main distinguishing feature of this district's deposits as opposed to the Campo Formoso ones is their large thickness which frequently reach 8 to 10 m. In addition, they show no significant lateral thickness variation, exhibiting also great constancy in their mineralogical characteristics, textures chemical and physical properties.

Their lateral continuity is only tectonically perturbed, a factor that has caused some difficulties in the exploitation of the bodies. This, however, does not strongly affects the highly favourable cost/benefit relation of this prospection, considering the high award represented by the discovery of so thick mineralized bodies.

The potential of the Vale do Jacurici and Campo Formoso districts places the country in a comfortable situation, not only with respect to the internal Fe-Cr alloy supply but also to the generation of significant exportable excedents. From the international view point, these Brazilian deposits can and should acquire a rising importance. In this context, it should be taken into account that in spite of the enormous reserves of the Great Dyke, the high production costs of its narrow ore bodies (20-30 cm) have greatly inhibited exploitation. In fact, the economically more feasable deposits of Zimbabwe are exactly those geologically similar to the Vale do Jacurici ones.

Also in Bushveld, South Africa, despite the large reserves, thicknesses of the ore bodies (0,90 m) are far from comparing with those of the Vale do Jacurici or even Campo Formoso.

CHROMITIFEROUS DISTRIC OF THE VALE DO JACURICI

HISTORY OF THE DISTRICT

The history of this district is relatively recent. The first chromite samples of the region were collected by local prospectors, around 1968 from what would later became the Medrado Mine (Mina de Medrado).

A geological mapping project developed by the Federal Government in 1970-71 identified occurrences along the same trend.

FERBASA demonstrated its interest with relation to these new types of chromite deposits, associated with Archean rocks, when in 1972 it constituted a subsidiary directed to the prospection and evaluation the Valley.

The result of the first year activities was exceptional: in addition to finding new occurrences, it madeit possible to define the thecnical and economic exploitation feasibility of the principal deposits of the region. In 1974 the first mine of the District - the Medrado Mine - became operational.

Since then, interest concerning the region has considerably increased, leading FERBASA, through the Vale do Jacurici Mining Co., to greatly augment its investments in research, mining and ore dressing, with the state government providing continued support, particularly as for the infra-structural needs.

Although the initial activities were naturally concentrated on outcropping deposits, at the present time the emphasis has changed to non-outcropping bodies and localization of important chromite deposits has been achieved thanks to new geological and geophysical prospection techniques, and drilling.

ECONOMIC SIGNIFICANCE

This district is presently responsible for approximately 50% of the State's chromite production.

From 1974 to Dec/1985, over one million tons of ore have been extracted, corresponding to 400,000 tons of Fe-Cr alloy, and amounting to US$160 million. In 1985 alone, 170,000 tons of lump concentrated ores were produced, amounting to Cz$87 million.

The climatic conditions of the region and the geometric characteristics of the deposits have permitted a high degree of regularity in the production whose flowoff is facilitated by the railway and good roads in the area.

VALE DO JACURICI PROJECT

As already mentioned, the main goal of the Jacurici Project was the definition of the chromite potential reserves of the region withim the homonymous river valley (Fig. 1).

The Project activities started at the end of 1983. It was then observed that, although the region already possessed a considerable amount of information, the existing data were fragmented and represented by a great number of detailed localized maps.

As a result of this situation, it was not possible to have a clear understanding of the geological conditioning factors for rationalization and choice of the most favourable sites for finding mineralization. To improve this situation, a systematic work program was conceived, which included compilation and integration of all available data and execution of systematic field campaigns for semi-detailed geological mapping, which made it possible to homogenize all previously extant information. In addition, regional geological reconaissance work was also planned in order to correlate the geologic features of the area with those of the regional context. Finally, drilling campaigns were also planned in order to localize orebodies in selected targets.

In order to achieve these objectives, the following successive activities were developed:

- Compilation of the data accumulated during the various mapping and mineral exploration activities carried out in the region;
- Geological reconaissance, on the scale 1:25,000, of an area of approximately 500 km², with emphasis on deciphering the structural behaviour and establishing the regional lithostratigraphy;
- Aerophotogrametric recognition, in the scale 1:10,000, of an area of 140 km² encompassing the main strips of the mafic-ultramafic sill;
- Plani-altimetric restitution, in the scale 1:2,000, of a surface of 14 km², embodying areas with development of mining activities;
- Geological mapping, in the scale 1:10,000, of 140 km², corresponding to the area of aerophotogrametric coverage. During these activities approximately 220 km of trails, 500 m apart, were mapped.

- Re-evaluation of the existing geophysical surveys (magnetometry and gravimetry);
- Petrographic studies for characterization of the various lithotypes and aquisition of field data for the understanding of the structural evolution;
- Execution of 4,300 m of drilling in selected areas.

GEOLOGY OF THE VALE DO JACURICI

Figura 2 shows the main lithologic assemblies that compose the geology of the central-northern region of the State of Bahia, where the chromitiferous district of the Vale do Jacurici is located. With the exceptions of the Canudos Group, the Tucano-Jatobã Basin, and the Salitre limestone, (Calcário Salitre), the other elements belong to the geotectonic unity of the São Francisco Craton, stabilized at the end of the Transamazonic cycle. In the specific area of the chromitiferous district, all the assemblies compose the infra-structure of the Craton.

Stratigraphic Sequence of the Vale do Jacurici

The following data result from the geological reconnaisance work in the scale 1:25,000, as well as from the mapping in the scale 1:10,000. The limit of the examined area on a scale of 1:25,000 is shown in Figura 2 and that relative to the area mapped on the scale of 1:10,000 is shown in Figs. 3, 4 and 5. Some interpretation of concerning the stratigraphy and the structural geology of the area are due to the geologist Emanuel Jardim de Sã who was brought to the region as a consultant.

The temporal sequence shown in the following table and in figures 3, 4 and 5 is based on the intrusive relations exhibited by different generations of plutonic rocks both among themselves and with the supracrustal sequence.

LITHOLOGIC UNITS	THERMOTECTONIC EVENTS
Itiúba syenite and correlated biotite-granite (G_3)	F_3
Granodiorite and tonalite dikes (G_2)	F_2
Mafic dikes	F_1
Tonalitic and granodioritic orthogneisses (G_1)	
Chromite-bearing mafic-ultramafic sill	
Banded gneisses, principally quartz-feldspathic, of supercrustal origin, with variable intercalations	

Jardim de Sã (1984) - modified

The principal basis for this sequence up include the facts that: a) each of the three plutonic felsic suites truncates the oldest fabric of the previous one; b) the mafic dikes cut G_1 but not G_2; and c) the banded gneisses occur as xenoliths in G_1.

a. Supracrustal Sequence

This sequence shows great lithological variability compatible with its supracrustal origin. In addition to lithologic contacts (So preservation), the unity also shows a milli- to centimetric gneissic banding which is parallel to So probably due to deformation F_1

The dominating lithologic type is a leucocratic gneiss composed of quartz (always dominant) and feldspar (mesoperthite or k-feldspar + plagioclase), with accessory biotite and hyperthene. The leucocratic gneiss is followed by lithotypes where amphibole occurs along with hypersthene ± biotite.

The most frequent intercalations are of pyroxene-amphibolites (anphibole + plagioclase ± diopside ± hypersthene) which may represent mafic lava on subvulcanic rocks, Their thickness ranges from a few centimetres to a metre.

Other intercalations of metassedimentary origin include oxide facies iron formations, olivine-marbles, calcosilicate rock rich in diopside, quartzites, garnet-bearing gneisses and metacherts.

b. Differentiated Mafic-Ultramafic Sill

This unit exhibits a maximum thickness of 300 metres and it is situated along a synclinorial discontinuous strip, of N-S direction, inserted in the supracrustal sequence. It will be more detailedly described on the item related to the Geology of the Deposits.

c. Orthogneisses G_1

They are a homogeneous rock on the outcrop scale, and show clear metamorphic banding (S_1). They possess numerous xenoliths of pyroxene-amphibolites, banded amphibolite-gneisses, diopsidites and iron formation from the supracrustal sequence. Petrographically they are characterized by the feldspar dominancy (plagioclase or mesoperthite with subordinate k-feldspar over the quartz, including also biotite ± hyperstene. At the presently exposed level, it seems that all of these orthogneisses reached granulite facies conditions. Coarse hypersthene-bearing felsic mobilizates are commonly found.

d. Mafic Dikes

The unit of mafic dikes represents ancient subvulcanic and intrusive rocks, transformed into amphibolites with or without diopside ± hypersthene ± biotite. They are present in the form of milimetric to centimetric strips which cutt off the S_1 metamorphic banding and are truncated by sin-Fe_2 mobilizates.

e. Granodioritic and tonalitic dikes and chronocorrelated felsic mobilizates

The granodioritic and tonalitic dikes are orthogneisses G_2 which also truncate the S_1 banding of the orthogneisses G_1. Their thicknesses vary from under to about a metre and they present fine metamorphic banding or a schisrosity (S_2). Their parageneses are of granulite facies, except where the orthogneisses G_1 also remained in the amphibolite facies.

The chronocorrelated felsic mobilizates cut the gneisses S_1 banding and also the mafic dikes. Their parageneses are of granulite facies.

f. Itiúba sienite and chronocorrelated granitic bodies

Itiúba sienite is the generic term, largely used in the literature, to designate the lithologies that compose the Itiúba mountain range (Serra de Itiúba). In reality, their compositions vary from granites to quartz-sienite. Volumetrically, the porphyritic components (perthitic orthoclase or microcline), transformed into augen gneisses, dominate over the other textural types. In their mineral associations, amphibole + biotite with diopside are still present. The gneissic fabric of the pluton, designated S_3, post-dates the F_2 event and the associated granulitization.

Deformational and Metamorphic History

By using interference patterns and relations among different intrusive suites, with petrographic support, it was possible to establish the thermotectonic evolution of the Vale do Jacurici.

The most ancient S_1 fabric represents a metamorphic banding printed on the gneisses of supracrustal origin and on orthognaisses G_1. Mobilized intrafoliate folds are also attributed to this phase. The principal meso and macroscopic effects of this deformation are repetition, rupture and stretching of the layers due parallelism between S_0 and S_1. The emplacement of the orthogneisses took place early or syntectonically this deformation phase.

The intrusion of the mafic dikes occurred after F_1, probably under shallower crustal conditions, filling ancient fractures and shear zones.

The S_2 fabric is also a metamorphic banding. In the suite of mafic dikes, S_2 is represented by a schistosity of amphibole ± biotite. F_2 folds are typically closed to isoclinal and they fold S_1 in the banded gneisses and the G_1 orthogneisses. The interference relations, later described, indicate an original trend near E-W.

Althoug parageneses with hyperstene are encountered in the felsic dikes G_2 and other more ancient unities, they have not been found in the Itiúba sienite and chronocorrelated granites G_3. This suggests that if there was only one granulatization event, the same took place during the F_2 phase. The quartz-feldspathic mobilizates with hypersthene cut off S_1, being, therefore, correlated to the F_2 event. Conclusive elements are not available to characterize metamorphic facies of the F_1 phase. However, the presence of green hornblende or biotite inclusions in the hypersthene of the orthogneisses G_1 may suggest an amphibolite metamorphic facies for that phase.

The regional trend from NNE to NNW is determined by the F_3 phase elements. These generate numerous inteference structures, typically including boomerangs (type 2 of Ramsay) printed on the S_1 foliation and observed especially on the G_1 orthogneisses. Such a fact suggests an orthogonal trend (near E-W) for the F_2 folds.

Metamorphism during the F_3 phase, as already mentioned, was probably of the amphibolite facies, as indicated by the amphibole facies, as indicated by the amphibole + biotite $\pm$ diopside parageneses of the Itiúba syenite.

Two final phases of deformation have also been defined but their relative chronology has not been established. One of them has a relatively constant north-south trend, generating open folds. The other is also open and has trends in both NW an ENE directions. The principal effects of the NW and ENE phase appear as ondulations of the verticalized F_3 structures generating open folds and, sometimes, interference patterns 1/2 (dome/mushroom), The folds of the north south phase result in an additional shortening of the F_2 structures generating co-axial refolding where the latter had gentle axial planes.

GEOLOGY OF THE DEPOSITS

The chromitiferous deposits of the Vale do Jacurici are hosted by a differentiated mafic-ultramafic sill, contained within the above described supracrustal sequence. This sill has been studied in the area of the Medrado deposit by Barbosa de Deus and Vianna (1982), and, more recently, by SGM/SME through the Jacurici Project that considerably improved the geological knowledge over the whole valley.

According to mapping systematics, the area was divided into 3 blocks (I, II and III) and mapped at the scale of 1:10,000 (Figs. 3, 4 and 5).

The mafic-ultramafic rocks of the stratified sill are relatively narrow, discontinuous and strongly elangated. Their true thicknesses reach up to 300m. The elongation and the discontinuity result mainly from a strong east-west compression which caused folding, transposition and boudinage in a north-south direction.

In the Block I subarea (Fig. 3) there are deposits, namely, the Cemitério, Monte Alegre and Riachão mines. In Monte Alegre, the sill constitutes a folded structure, indicating a complex structure with considerable increase in thickness of the mafic-ultramafic rocks. The Cemitério and Riachão mines are to the north ant to the south of Monte Alegre, respectively. The Lajedo and Algodões mines are situated in Block II. In Algodões, the sill appears as small and discontinuous bodies, and in Lajedo there exists a relatively continuous and undulated body, situaded to west of the Algodões bodies. In the Block III (Fug. 5) the sill exhibits a remarkable degree of continuity for approximately 12 km and hosts the main deposits of the Vale do Jacurici: the mines of Medrado and of Ipueira.

LITHOLOGICAL UNITS OF THE STRATIFIED SILL

The mafic-ultramafic sill of the Jacurici Valley described previously by Barbosa de Deus and Vianna (1982) constitutes a differentiates stratified sequence, relatively uniform through out valley. From the base to the top, following lithological units were indentified: olivine-orthopyroxene-spinel cumulate, orthopyroxene-olivine-spinel cumulate, chromite-cumulate, and plagioclase-orthopyroxene cumulate. In addition, clinopyroxene-spinel cumulate has been identified in the block III.

Olivine-orthopyroxene-spinel cumulate

This unit possesses variable thickness, locally reaching up to 60 m, and occuring cyclically with the orthopyroxene-olivine-spinel cumulate. They are light green on the surface and dark green when unweathered. They are generally fine grained but orthopyroxene plates are common. They are considerable serpentinized, preserving however, relics of the primary phases.

They are formed essentially by serpentine, orthopyroxene and olivine, and accessorily, by clinopyroxene, amphibole, chromitiferous spinel, magnetite and phlogopite.

Serpentine, derived mainly from the olivines, represents approximately 55% in volume of the rock. Olivine and orthopyroxene can account for 31% in volumetric proportion. The spinel occurs dispersed in the rock, reaching up to 10% in volume.

Orthopyroxene-Olivine-Spinel Cumulate

This unit presents variable thickness, reaching up to 33 m. It alternates cyclically with the last unit and hosts chromite seams in its basal cycles.

It is greenish, fine - to medium - grained, and shows orthopyroxene plates mesoscopically visible in a serpentine mass. It is composed of orthopyroxene, serpentine, olivine, chromiferous spinel, amphibole, clinopyroxene, phlogopite and magnetite.

Orthopyroxene is granular and normally constitutes the most abundant mineral phase. Its volumetric proportion varies from 15 to 64%.

Olivine amounts to less than half the orthopyroxene in abundance. However, due to the high degree of serpentinization, these are certainly not the original proportions. The olivine has irregular forms and occurs as islands in the serpentinic mass. In modal terms it represents from 4 to 27%.

Chromite Cumulate

This unit is located close to the base of the last described unit, possessing an average thickness of 7 m. Chromite represents approximately 80% of the unit but in the massive level olivine or orthopyroxene are not observed. Some sulphides were observed in polished sections. The chromite grains exhibit different forms, prevailing pentagonal forms prevails but also including lozenge and square forms, indicating the possible presence of octahedrons. Chromite grain size ranges between 0.2 and 0.8 mm, with major frequency around 0,4 mm.

The chromite has a Cr_2O_3 medium content of 48,80%. Electron microprobe chemical analyses carried out by Barbosa de Deus and Vianna (1982) indicate the following average composition:

Cr_2O_3%	FeO%	MgO%	Al_2O_3%
48.80	16.66	14.13	19.72

Orthopyroxene-Spinel Cumulate

It is represented by a small level (2 m) of a dark-green inequigranular rock where the orthopyroxene grains occur in an amphibole mass. Clinopyroxene can occur, sometimes expressively in this rock. Chromiferous spinel is observed as accessory, although it was observed, in thin section, forming rare concentrated levels.

The orthopyroxene varies from 42 to 75%, in modal proportions and textural evidence indicating formation from clinopyroxene.

Plagioclase-Orthopyroxene Cumulate

This constitutes the uppermost unit of the stratified complex, exhibiting a thickness of approximately 30 m and an alternation of light and dark levels, the former rich in plagioclase and the latter in orthopyroxene and amphibole.

Plagioclase is the most abundant mineral in this rock, although the orthopyroxene, which varies from 24 to 68% in modal proportions, may locally dominate.

The amphibole, that represents generally from 1 to 6% in volume of the rock, occurs interstitially to the orthopyroxene plagioclase grains.

Clinopyroxene-Spinel Cumulate

This unit appears only in block III (Fig. 5). It possesses variable thickness and occurs discontinuously to the west of the Medrado-Ipueira mafic-ultramafic strip associated with serpentinites in the south portion of block III.

It was not possible to determine the stratigraphic position of this in relation to the previously described units. It is possible that it represents a magmatic differentiate post-depositional in relation to the plagioclase-orthopyroxene cumulates.

The rock is fine to medium grained, greenish-grey in colour, normally banded and essentially composed of clinopyroxene (diopside) and spinel.

The clinopyroxene forms granular cumulate aggregates, isolated or tangential with straight or curved contacts. Volumetrically, it forms from 40 to 90% of the rock.

STRUCTURAL FEATURES

The mafic-ultramafic sill occurs in a synformal structure in the Monte Alegre and Medrado areas. In Medrado, the axial plane is nearly vertical, with vergence to the west, and the axis undulates, plunging approximately 20-30º to the south. The interlimbo angle was estimated as 20º (Fig. 5).

In the Monte Alegre area the sill possesses a more complex structural morphology (Fig. 3) with re-folding and later faulting. Geological section 1 (Fig. 6) shows the faulting geometry in the central portion of the syncline. The sill units dip 40º to the southern direction.

In other areas the sill is structured, probably as discontinuous synformal limbs dipping variably from 50^{o} to 80^{o} in an eastern direction (Figs. 7, 8, 9 and 10).

Barbosa de Deus and Vianna (1982) recognized three main fault sets in the Medrado area: a) N50°-70°E, N50°-70°W, ENE-WNW and NNE-NNW; b) NNE, NNW and c) ENE and WNW. The first set corresponds to conjugate transcurrent faults with ENE-WNW extension fractures and NNE-NNW alleviation (relief) fractures. The set (b) corresponds to inverse faults with variable dips from 20 to 70° to E and W. Field observations indicate that this set displaces the previous one and, is thus later. The third suite (c) are also inverse faults with dips to N and S; relative age is not known. It should be stressed that it was not possible to define the relationship of the fracturing with the folding phases mentioned above.

POTENTIAL RESERVES

The geological information obtained by the Jacurici Project, together with the previously available data, made it possible to estimate the chromitiferous potential of the region.

For this, information from detailed maps, in the scales 1:10,000, 1:1,000 and 1:500, geological sections and shallow and deep drillings was utilized. In order to obtain the estimate potential the method of vertical sections and influence areas was used. Spacing between sections was not uniform: in areas with mineralization the interval was considerably tight but in newly discovered sill strips the spacing was between 500 and 800 m.

The maps presented in the Figs. 3, 4 and 5, as well as the geological sections (Figs. 6,7,8,9 and 10) show the obtained elements.

The sum of all the explored and evaluated blocks amounts to 28 million tons of estimated potential reserves for the Vale do Jacurici District.

CONCLUSIONS

We are convinced that a correct decision was made in launching the program we described here. Its results can be measured not only by the expressive increase in chromite reserves of the State's mineral assets but also by the better chances of localizing new deposits due to the greater and better control over the District's geology. Stimulated by these results, the program has already been extended to the Manganiferous District of Licinio de Almeida.

The adopted systematics was considerably efficient and shall be applied in new projects. The comprehension of the regional aspects has improved the interpretation accuracy, thus diminishing the costs of mineral prospection.

The obtained results in terms of potential reserves are expressive and offer a considerable guarantee to specific programs of reserves evaluation which will certainly be carried out by the company that operates in the region. They will, furthermore, ensure medium to long term mining projects in the area.

Finally, on the basis of the available geological elements, we feel that the two districts of Vale do Jacurici and Campo Formoso have enormous potential for increasing still further the chromite reserves in the State of Bahia.

REFERENCES

BARBOSA DE DEUS, P. and VIANNA, J. 1982. Distrito cromitífero do Vale do Jacurici. In: CONGRESSO BRASILEIRO DE GEOLOGIA (32 - 1982: Salvador). Roteiro das excursões. Salvador, Sociedade Brasileira de Geologia (Boletim, 3). p. 44-60.

D'EL REY, J.L.H., 1985. Geologia e controle estrutural do depósito cuprífero de Caraíba Vale do Curaçá - Bahia. In: SÁ, P.V. da S. & DUARTE, F.B., ed. Geologia e Recursos Minerais do Estado da Bahia; textos básicos. Salvador, Coordenação da Produção Mineral, 1985 - v. 6, p. 51-136.

JARDIM DE SÁ, E.F., 1984 - Geologia da região do Vale do Jacurici; Tecnical report for Coordenação da Produção Mineral. Natal, s. ed. 17p.

FIGURE-I: LOCATION MAP OF THE AREA STUDIED IN THE JACURICI VALLEY PROJECT

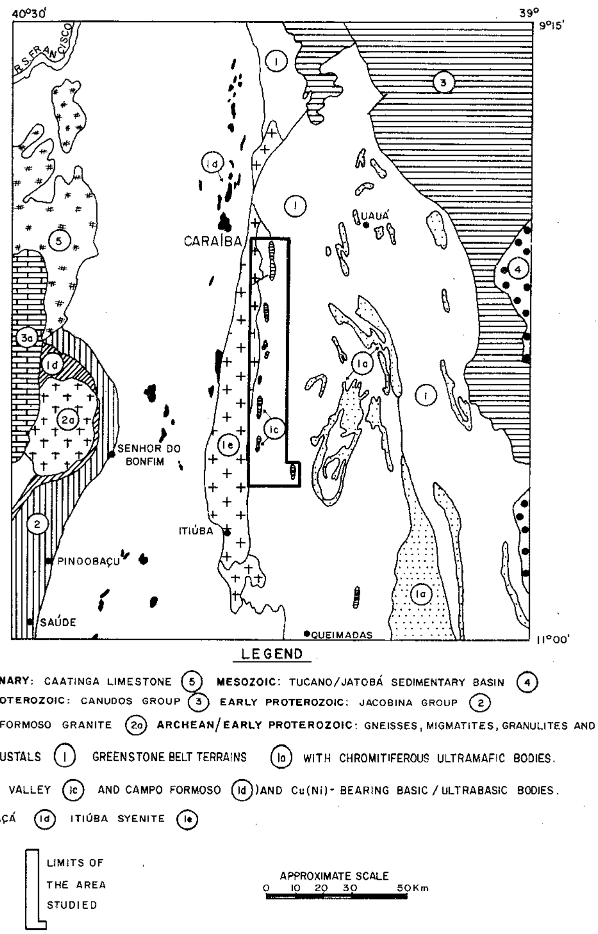

FIGURE - 2: REGIONAL GEOLOGIC SETTING COMPILED AND MODIFIED FROM DEL REY SILVA, L.J.H. (1985)

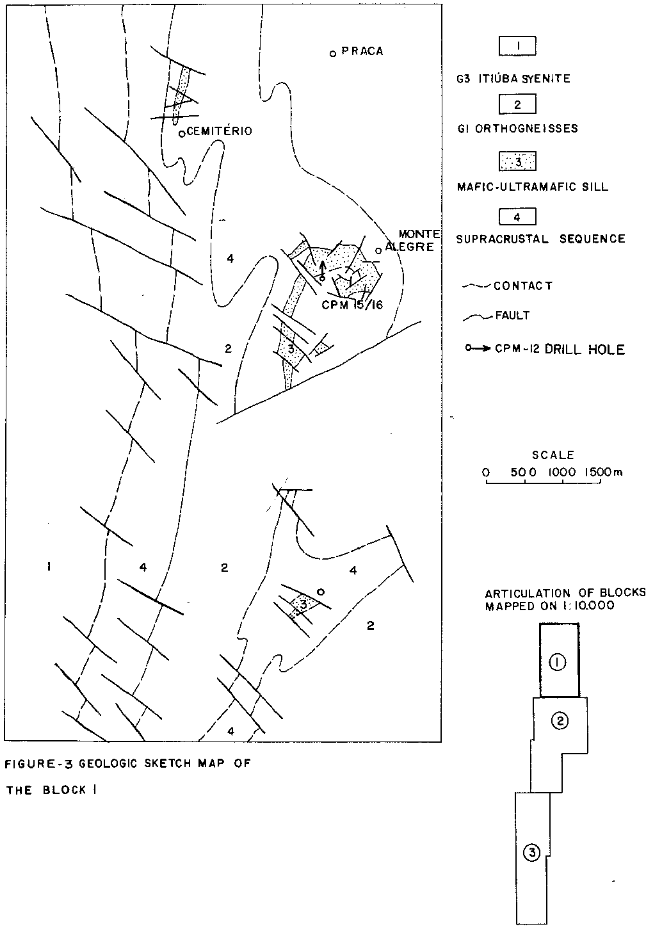

FIGURE-3 GEOLOGIC SKETCH MAP OF THE BLOCK 1

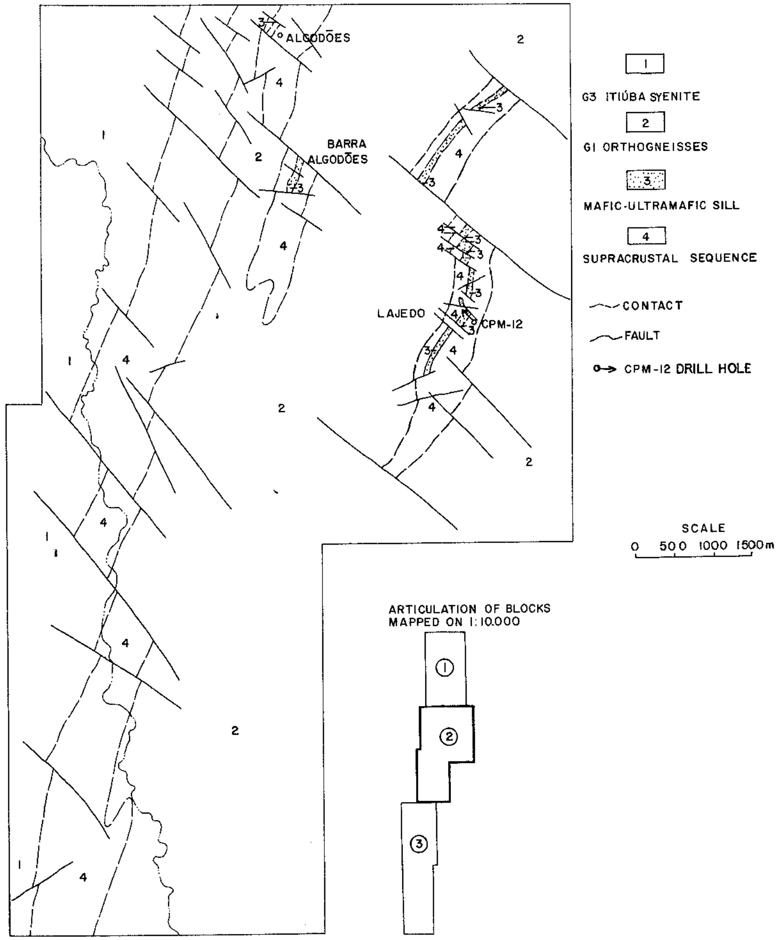

FIGURE-4 GEOLOGIC SKETCH MAP OF THE BLOCK-2

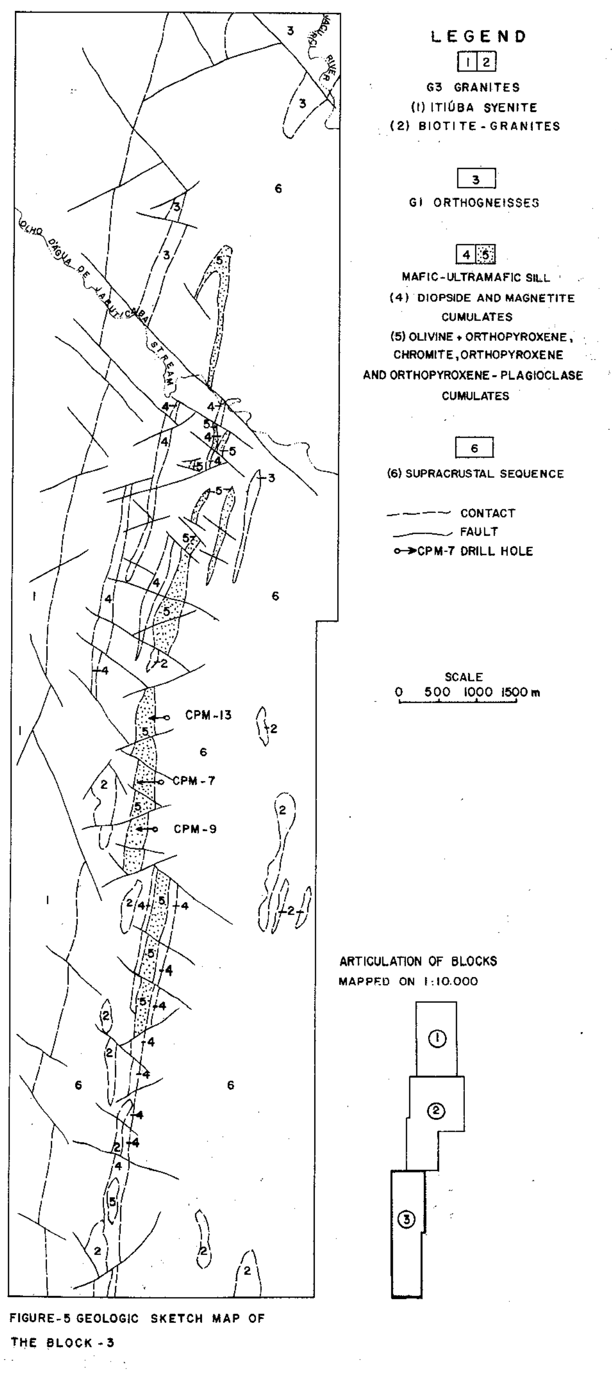

FIGURE-5 GEOLOGIC SKETCH MAP OF THE BLOCK-3

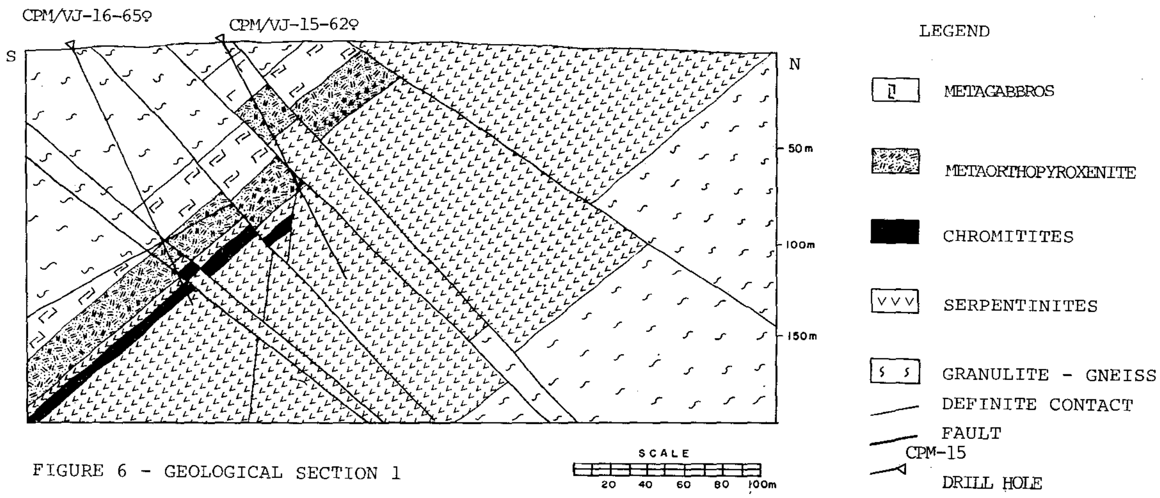

FIGURE 6 - GEOLOGICAL SECTION 1

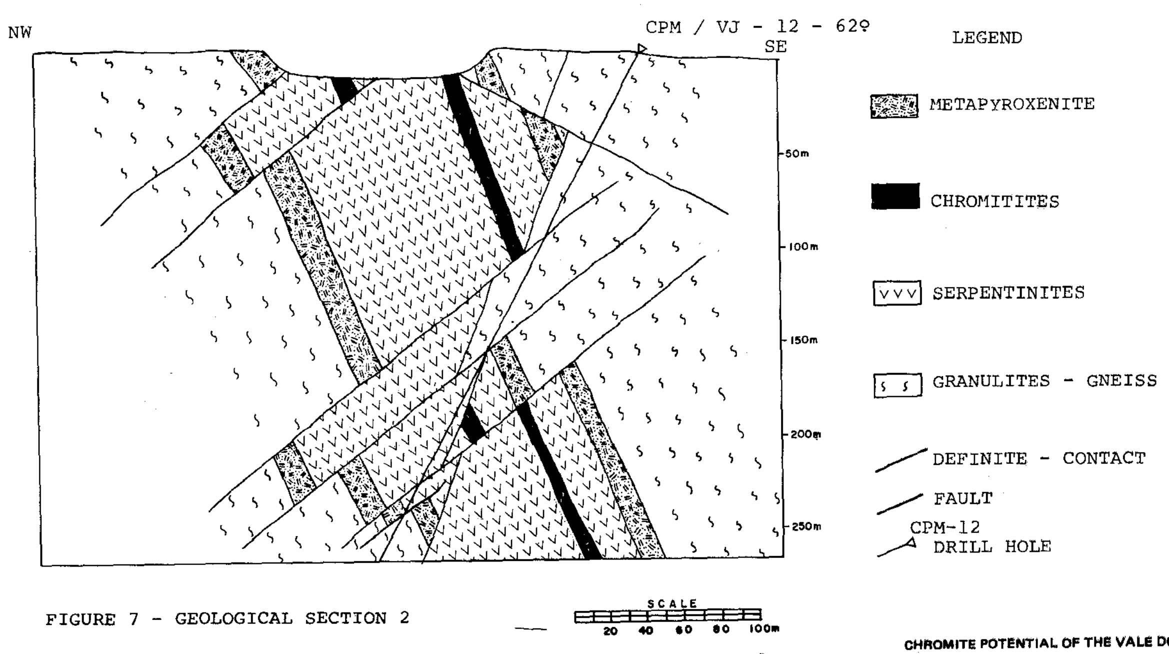

FIGURE 7 - GEOLOGICAL SECTION 2

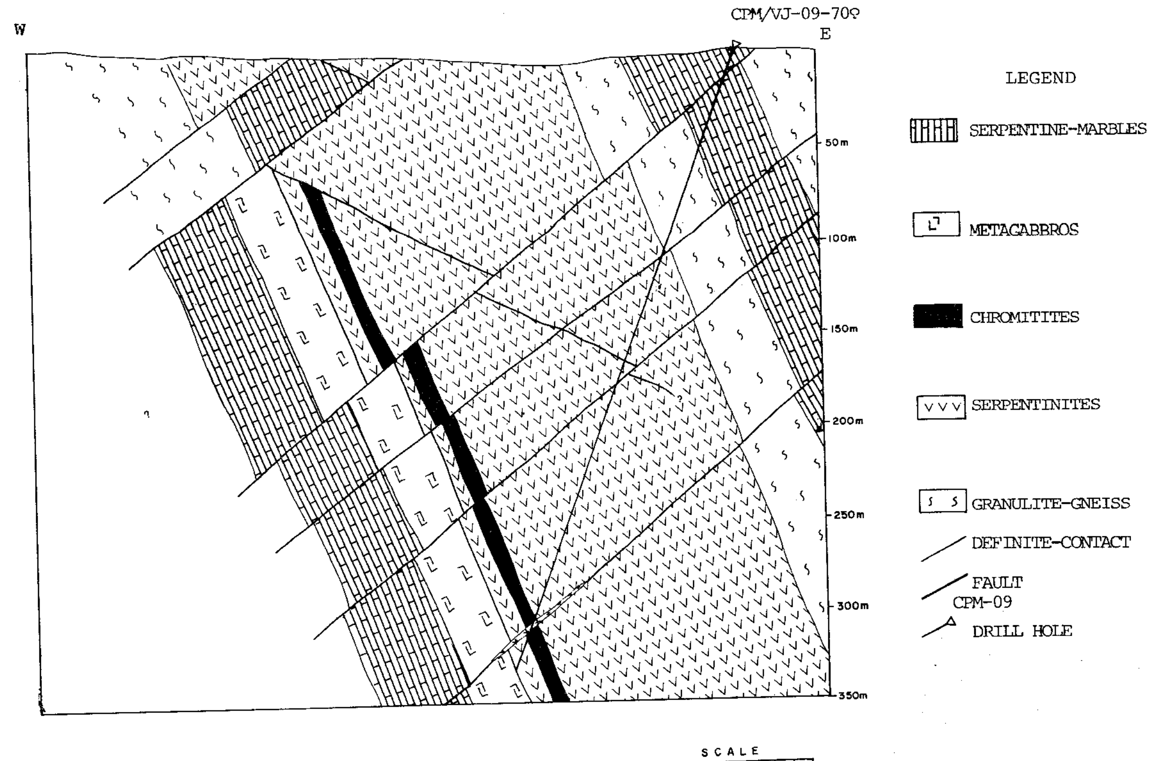

FIGURE 9 - GEOLOGICAL SECTION 4

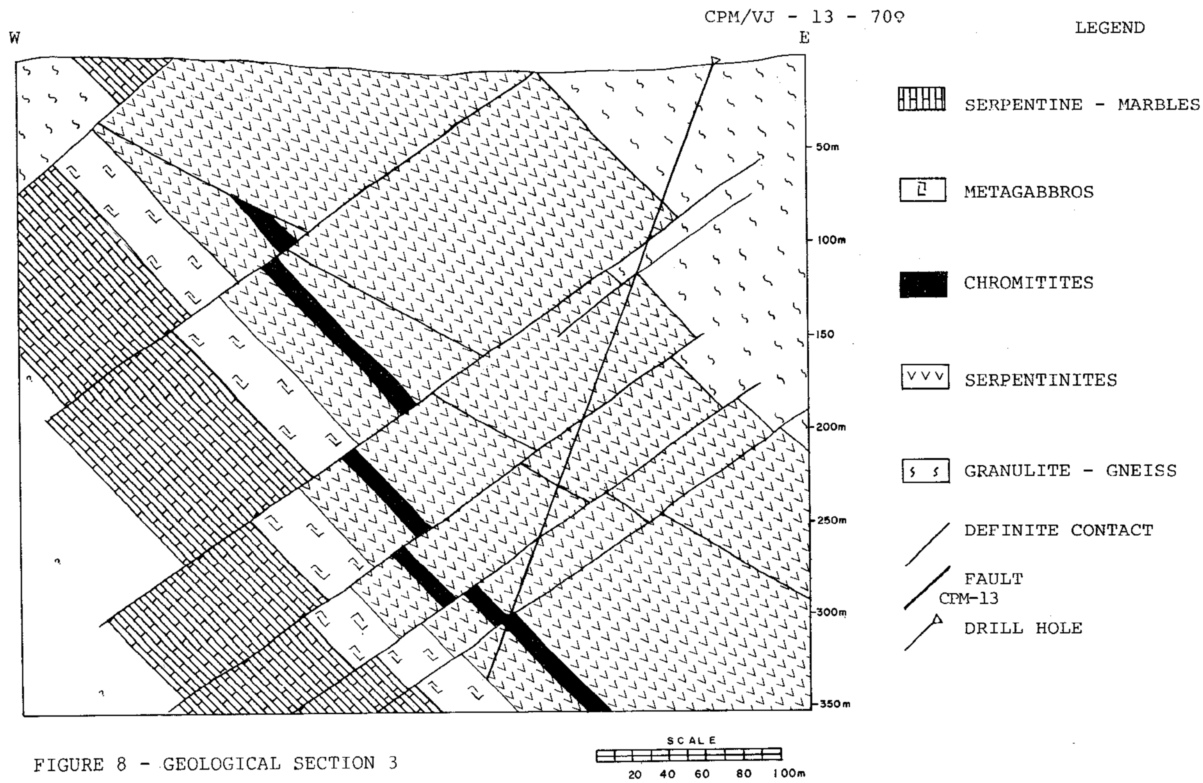

FIGURE 8 - GEOLOGICAL SECTION 3

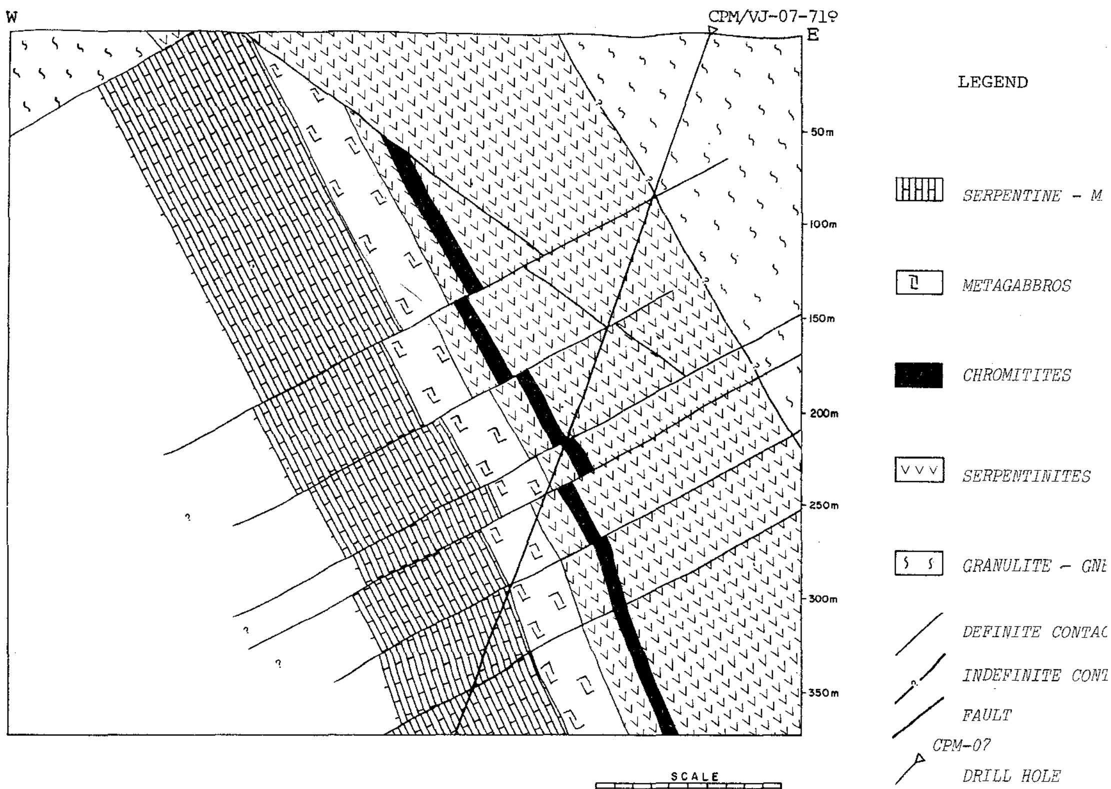

FIGURE 10 - GEOLOGICAL SECTION 5