GEOLOGICAL SURVEY OF CANADA

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Canada-Brazil cooperation project for sustainable development in the minerals sector Serra da Onça Complex, Pará State, Brazil: assessment of platinum-group element potential

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Canada-Brazil cooperation project for sustainable development in the minerals sector (CIDA Project 204/13886)

Serra da Onça Complex, Pará State, Brazil: assessment of platinum-group element potential

October 23-24, 1996

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INTRODUCTION

In June 1996, before departing for the Muskox Complex in the Northwest Territories, to undergo training in the field, Mr. Edésio Macambira of CPRM (Belém) gave an informal presentation on the geology of Serra da Onça to Geological Survey of Canada (GSC) scientists in Ottawa . The audience, and in particular the PGE specialists who have been working on the evaluation of CPRM's PGE program, were most impressed and surprised by Macambira's presentation and description of what could only be described as potentially one of the best targets for stratiform PGE mineralization in Brazil. What caused our amazement was that this complex and the entire area had never been mentioned to us at any time during our first mission to Brazil in October 1995. Therefore, a visit to Serra da Onça by GSC's specialists was a matter of prime importance in order for the Canadians to be in a better position to assist Brazil in its quest for PGEs. After conducting laboratory examinations in Belém and subsequent field investigations on the intrusive complex in October 1996, it became clear that a new area had been discovered in Brazil that contained classic Bushveld-Stillwater type layered intrusions and could potentially host similar styles of mineralization. This report summarizes the findings of a brief expedition to the Serra da Onça Complex which took place on October 23 and 24, 1996.

ACKNOWLEDGMENTS

The author would first like to acknowledge his colleague Roger Eckstrand who participated in the field trip, for his important observations and numerous discussions pertaining to the Serra da Onça Complex, before, during and after visiting the body. The following Brazilian colleagues are thanked for their warm hospitality and their efforts in arranging this mission: Edésio Macambira, Xafi S. João, and Samir Nahass. The presence and comments of Dr. J. Findlay, Canamera Geological Ltd. (Vancouver), during the mission is also appreciated. Special thanks are directed to Dr. Yvon Maurice for his assistance in arranging the mission and patience in awaiting this report.

SERRA DA ONÇA COMPLEX

Location and access

The Serra da Onça mafic-ultramafic complex is located in the southern portion of Pará State near Tucumã, approximately 650 km southwest of Belém (Fig. 1). Access to Tucumã is available via commercial airline services and by road from Belém. The mafic-ultramafic complex is located approximately 75 km north of Tucumã and is accessible by dirt roads.

Geological Setting

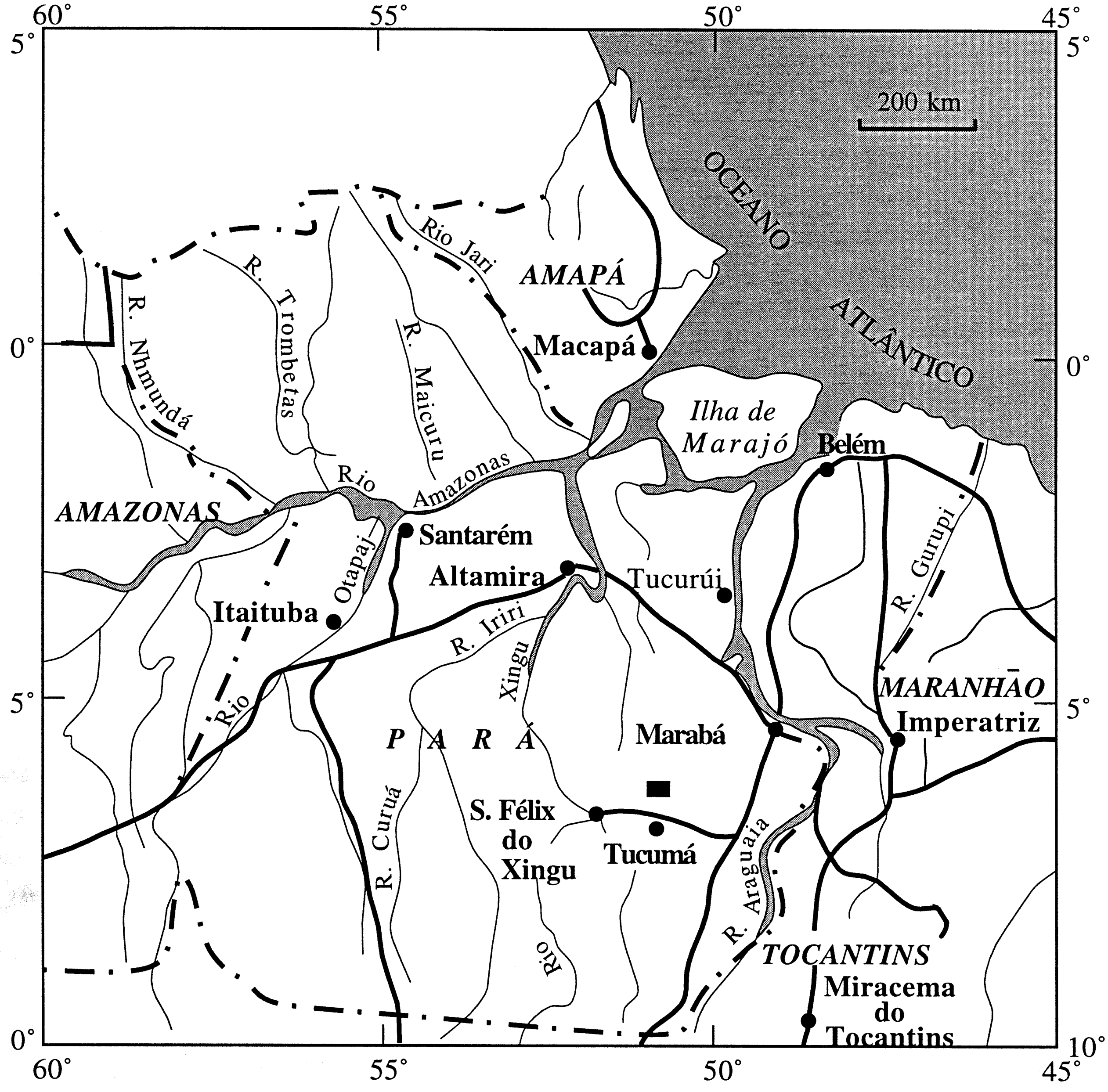
Geologically, the Serra da Onça mafic-ultramafic complex is located in the Amazon Craton (Almeida, 1976), central sector of the Araguacema Block (Hasui and Haraly, 1984), within the Itacaiunas Shear Zone (Araújo and Maia, 1991). To date, the best account of the geology of the complex is by Macambira et al., 1993.

The complex is part of the Proterozoic Catete Intrusive Suite. It has an east-west strike and can be traced for at least is 25 km; it attains widths of between 2.5 and 4.0 km. The strike of the intrusive complex is concordant with the regional east-west trending Itacaiunas Shear Zone; however, it dips 40°–50° south in contrast to the 70°–80° northerly dip of the enclosing mylonites.

Country rocks consist of proto- to ultramylonites derived from monzogranites of the Plaque Granite Suite (Araújo & Maia, 1991) that pass eastward into mylonitized tonalite and granodiorite belonging to the Xingu Complex (Silva et al., 1974). The granitic country rock suites are believed to be Archean (Figs. 2 & 3).

From the base to the top the ultramafic and mafic cumulates of the complex consist of macro-layered units of serpentinites, pyroxenites and gabbros respectively

MAPA DE LOCALIZAÇÃO



SERRA DA ONÇA

Fig. 1

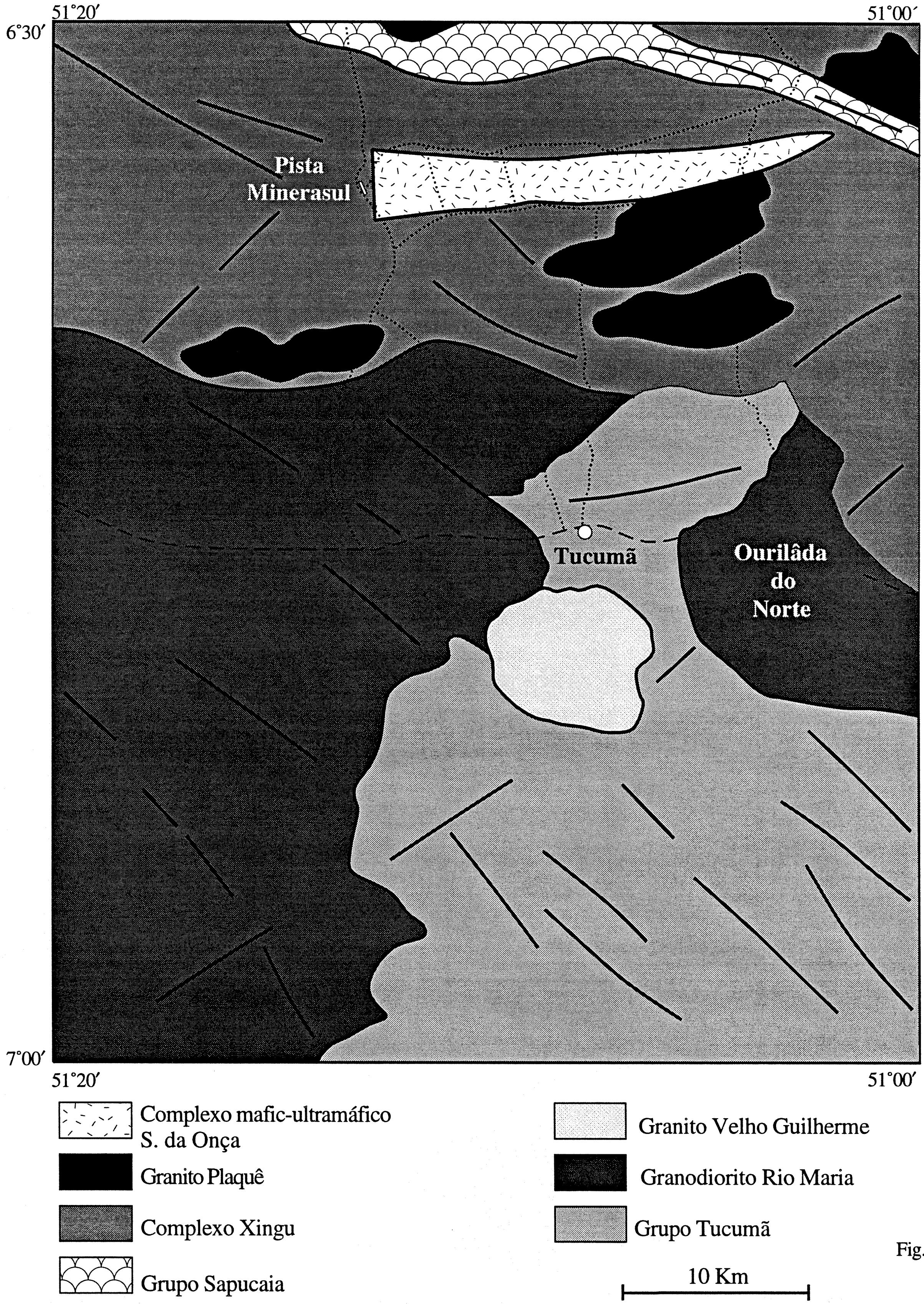

51°20′
51°00′
6°30′
6°30′
Pista
Minerasul
Tucumã
Ourilâda
do
Norte
7°00′
7°30′
51°20′
51°00′
Complexo mafic-ultramáfico
S. da Onça
Granito Plaquê
Complexo Xingu
Grupo Sapucaia
Granito Velho Guilherme
Granodiorito Rio Maria
Grupo Tucumã
10 Km

Fig. 2

COMPLEX0 MAFICO - ULTRAMAFICO DA SERRA DA ONÇA

ESBOÇO GEOLÓGICO SIMPLIFICADO

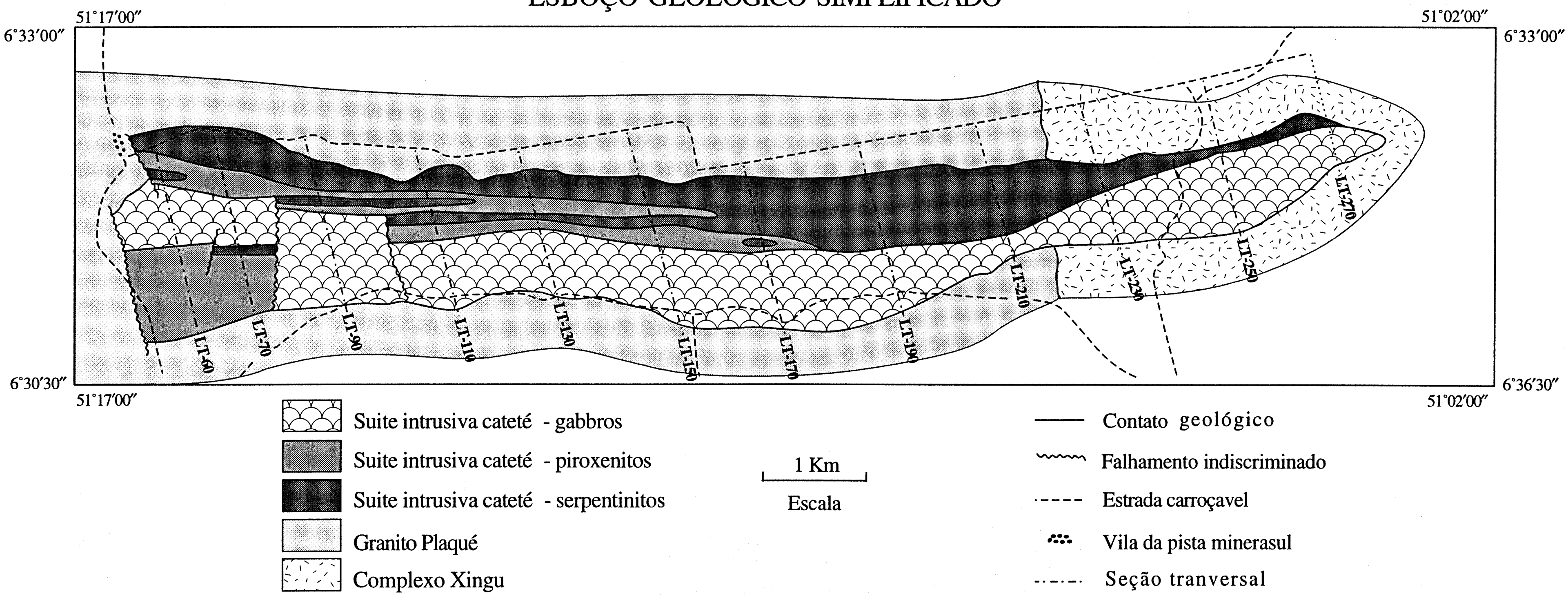


Fig. 3

with the late differentiates (gabbros) occupying the northern portion of the complex (Fig. 3). The well developed macro-layering, associated differential weathering, and extensive strike length are revealing characteristics of these bodies on LANDSAT images and provided the first indications of their existence. Although the age of the Serra da Onça complex is unknown, it is inferred to be early Proterozoic. For further details see Macambira et al., 1993.

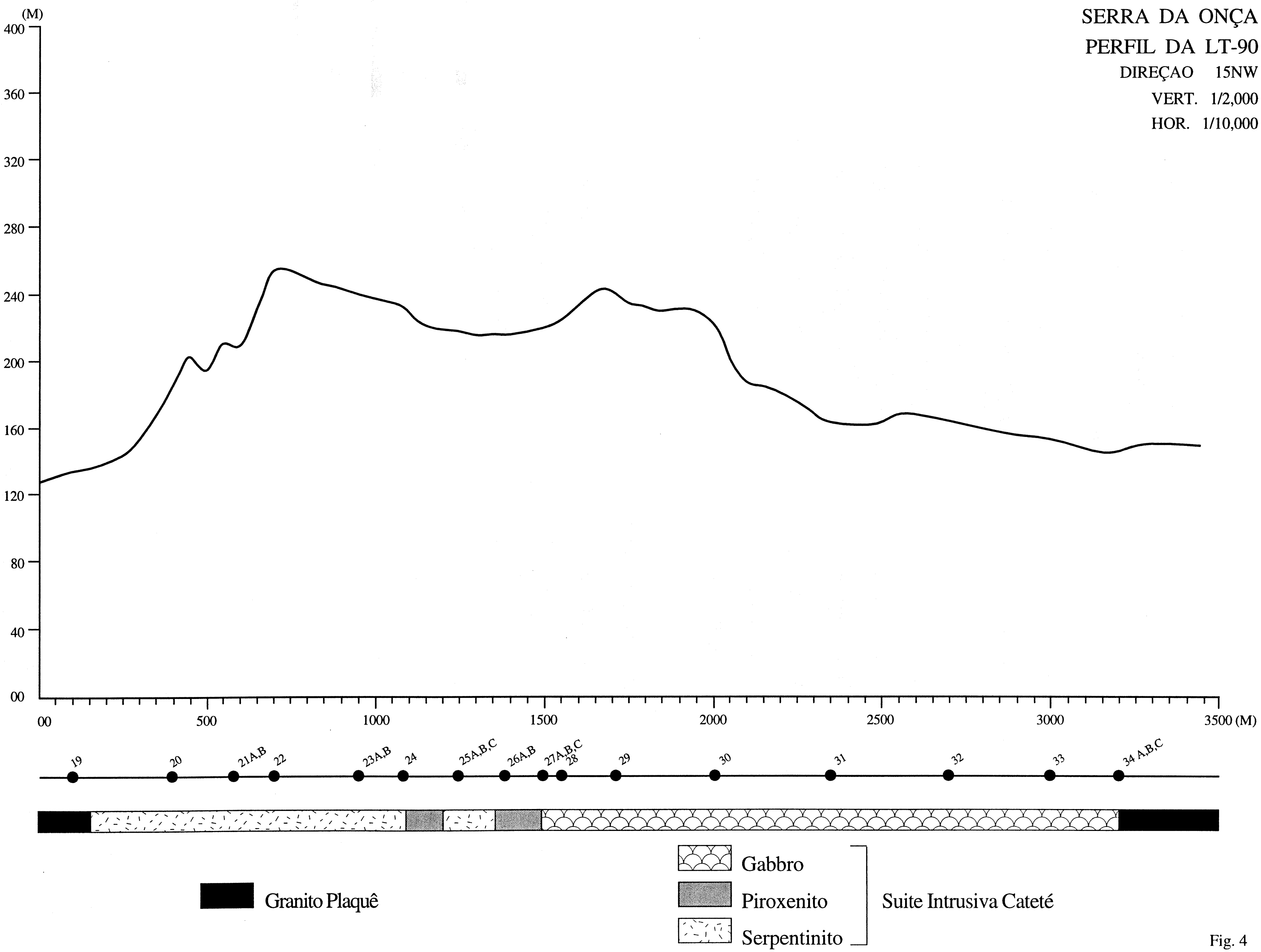
From regional mapping it would appear that at least ten other mafic-ultramafic bodies similar to the Serra da Onça with respect to cumulate stratigraphy and lithologies exist in an 8000 km^2 area north and west of Tucumã (Fig. 6). The diversity of attitudes of these complexes suggests that their present distribution and trends are possibly an eroded reflection of a huge mafic-ultramafic complex and its various compartments, similar to that of the Bushveld Complex (Sharpe and Bahat, 1981).

FIELD AND LABORATORY EXAMINATIONS

On Oct. 21 &22 maps, hand specimens, thin sections and petrographic reports and geochemical data were examined in Belém in preparation for the field work. Examination of the cumulate stratigraphic profiles and accompanying thin sections confirmed that this was indeed a classic cumulate succession very similar to that present in the Stillwater and Bushveld igneous complexes.

On the morning of October 23 we flew from Belém to Tucumã and were met by CPRM technical field staff. The remaining half of the day was taken up by a reconnoitering field trip around Serra da Onça examining the different country rock lithologies and structure as well as limited exposures of laterized serpentinite and fresh gabbro.

A 2 km north-south traverse along line LT-90 was conducted on October 24. This traverse in conjunction with the CPRM map (Fig. 3) and section (Fig. 4) were intended to provide an opportunity for the GSC and Canamera Geological Ltd. representatives to



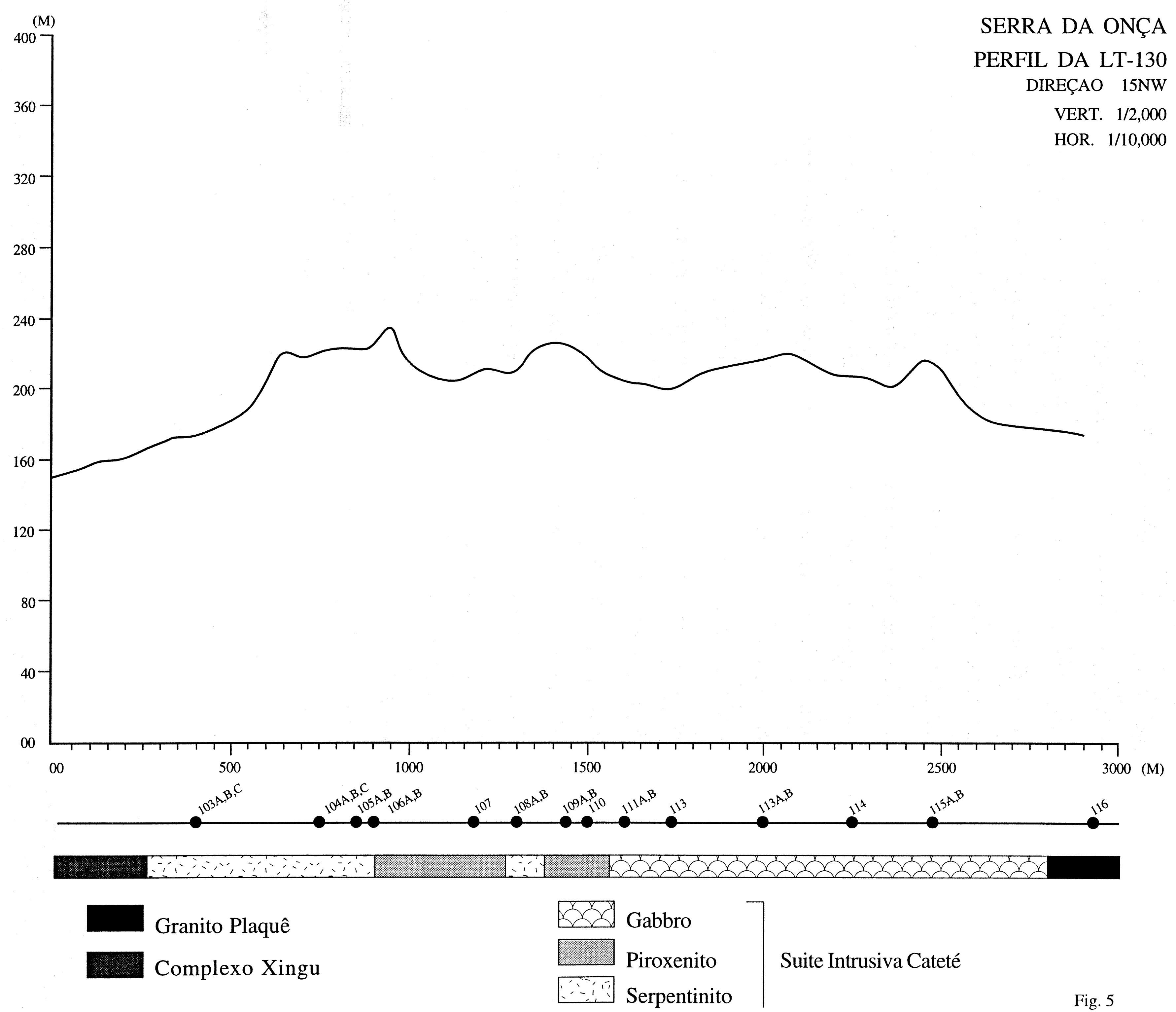
SERRA DA ONÇA
PERFIL DA LT-90
DIREÇAO 15NW
VERT. 1/2,000
HOR. 1/10,000
(M)
400
360
320
280
240
200
160
120
80
40
00
00
500
1000
1500
2000
2500
3000
3500 (M)
19
20
21A,B
22
23A,B
24
25A,B,C
26A,B
27A,B,C
28
29
30
31
32
33
34 A,B,C
Granito Plaquê
Gabbro
Piroxenito
Serpentinito
Suite Intrusiva Cateté

Fig. 4

examine the northern intrusive contact with the Plaque Granites, the Ultramafic Zone and the thick overlying succession of gabbros and gabbronorites of the Gabbro Zone.

Serpentinized peridotite, dunite and their laterized equivalents define the earliest members of the ultramafic zone. Although these lithologies are generally totally serpentinized and/or laterized the remaining cumulates within the overlying stratigraphy is surprisingly fresh and clearly undeformed and unmetamorphosed. The lack of apparent intercumulus orthopyroxene or clinopyroxene and poikilitic texture through this zone, relict textures, color and mineralogy suggests that these serpentinites were originally very olivine-rich and thus more dunitic than peridotitic in composition. The first appearance of intercumulus pyroxene, as 1 to 2 cm oikocrysts, occurs near the top of the first serpentinite member (Figs. 3 & 4). The general absence of noticeable pyroxene in the underlying serpentinized ultramafics suggests that olivine adcumulate dominated this portion of the cumulate record at Serra da Onça.

The introduction of intercumulus pyroxene (orthopyroxene) near the top of the serpentinite unit is a precursor to the onset of cumulus orthopyroxene crystallization that follows with the development of thick orthopyroxenite units. These monomineralic rocks are generally coarse grained orthopyroxene adcumulates. The coarse grained adcumulate texture is very distinctive. The light green color of the orthopyroxene would suggest that it is very rich in the enstatite component (approx. En_{88-90}). Olivine reappears as a cumulus phase marking the introduction of the second serpentinite (Fig. 4) unit which once again passes into an orthopyroxenite unit in a fashion similar to that previously observed in the lower stratigraphic levels. However, the second orthopyroxenite unit is distinctly finer grained than the previous orthopyroxenite horizon and is becoming darker (dark brown) due to Fe-enrichment in the orthopyroxene phase accompanying differentiation. Orthopyroxene from this darker unit will probably fall in the compositional range En_{83-85}. Although this unit is generally massive 0.5 to 1.0 m scale partings dipping 40° S are apparent and represent relict cumulate layering. Sparse



SERRA DA ONÇA
PERFIL DA LT-130
DIREÇAO 15NW
VERT. 1/2,000
HOR. 1/10,000
(M)
400
360
320
280
240
200
160
120
80
40
00
00
500
1000
1500
2000
2500
3000 (M)
103A,B,C
104A,B,C
105A,B
106A,B
107
108A,B
109A,B
110
111A,B
113
113A,B
114
115A,B
116
Granito Plaquê
Complexo Xingu
Gabbro
Piroxenito
Serpentinito
Suite Intrusiva Catetê

Fig. 5

chromite grains were observed in some samples, however, intercumulus chrome-diopside which is commonly observed in these rocks in the Bushveld and Stillwater Complexes was not apparent here.

The overlying Gabbro Zone traverse along this section appeared to consist of a thick sequence of mafic gabbronorites. This lithology is generally fine to medium-grained, massive and uniform in appearance. Localized leuco-gabbronorite lithological breaks and partings were observed near the basal contact of the Gabbroic Zone the importance of which would not be appreciated until next days traverse along LT-130. The remaining portion of the stratigraphic section along line LT-90 is more mafic than its underlying gabbroic counterparts and has a grayish-black to brownish-black color. These rocks look similar to the Main Zone gabbronorites of the Bushveld.

On October 25, a 1.5 km traverse was conducted in a N–S direction along cut line LT-130 once again examining the northern contact with the Plaque Granite, the Ultramafic Zone (serpentinites and pyroxenites) and the thick overlying succession of gabbros and gabbronorites as well as lithological and structural variations not observed on line LT-90.

The Ultramafic Zone (serpentinites and pyroxenites) along this traverse is not unlike that observed along LT- 90; however, the first pyroxenite unit is finer grained (m.g.) than its LT-90 equivalent.

The most striking difference between the two lines is recorded in the nature of the transition from the Ultramafic to Gabbro Zone. It was observed that the top of the second orthopyroxenite unit contained fairly well developed cumulate layering but the attitude of the layering changed to an easterly dip. The overlying Gabbro Zone is marked by the introduction of anorthositic and noritic cumulates that display evidence of rather turbulent magmatic conditions: thin anorthositic layers and lenses a few centimeters thick and up to several meters long were observed to be truncated, some anorthositic lenses are vertically dipping and consist of tapering lens shaped laminae with flat tops and concave down basal plagioclase accumulations possessing reverse grading orthopyroxene concentrations. The anorthosite, anorthositic norite, noritic anorthosite and norite lithologies within this 100 to 200 m interval overlying the Ultramafic Zone distinctly demarcates this ***critical horizon*** from the overlying Gabbro Zone and is similar to their counterparts from the Critical Zone of the Bushveld Complex.

The introduction of cumulus clinopyroxene introduces the more fractionated overlying gabbronorite cumulates of the Gabbro Zone. The lithological character from this point towards the top of the Gabbro Zone is the same as that observed on line LT-90. Nevertheless, it is clear that approximately 40–50% of the remaining differentiation sequence is missing when one reaches the top or southern contact of the gabbro which defines the edge of the intrusion.

CONCLUSIONS

Although the Canadian geologists only spent two days on the Serra da Onça Complex it could be concluded that, if lines LT-90 & 130 are truly representative of the cumulate stratigraphic and lithological succession of the complex, then their field observations coupled with earlier laboratory investigations in Belém leave little doubt that the Serra da Onça Complex is a classic example of a Bushveld-Stillwater-type layered mafic-ultramafic complex. Although no known economic concentrations of PGE have yet been found in this complex or others in the area, the above mentioned similarities, the size of this and other complexes in the area, as well as the regional distribution of these bodies is a clear indication of the potential of this complex and of the others in the region to host stratiform PGE mineralization similar to that found in the Bushveld and Stillwater complexes. To date, this complex and region is the most promising in Brazil with respect to potential candidates to host stratiform PGE mineralization. From both a petrological and economic aspect this body and area could represent one of the most significant global discoveries of layered mafic-ultramafic complexes in the past 30 years.

The regional distribution of the remaining mafic-ultramafic complexes (Fig. 6) suggests that one is not just dealing with a "one-shot" intrusion like the Stillwater Complex but instead a huge complex potentially the size of the Bushveld Complex or a large number of intrusive complexes . Although the nature of regional faulting appears to be complex, one does not get the impression that the faults are controlling the distribution of these bodies. The regional distribution of these bodies is reminiscent of an eroded equivalent of the Bushveld Complex and its various compartments and the role of large scale "Hertzian Fractures" in the formation of the complex. It is highly recommended that the readers consult the work of Sharpe, Bahat and von Gruenewaldt (1980) and Sharpe and Bahat (1981, A & B)

Although it is very clear that CPRM has done an excellent job of identifying these bodies regionally and mapping them on a local scale a new mapping and sampling approach is now needed in order to evaluate their economic potential. Unfortunately, this expertise has not yet been attained by CPRM; however, a successful program could be implemented with the guidance and supervision of specialists with experience in this field. The success of such a program will clearly be governed by three factors, none of which CPRM has yet adequate expertise in:

(1) recognition and detailed ("hands and knees") mapping of the critical horizon(s) to investigate;

(2) experience at sampling for PGE mineralization; and

(3) obtaining reliable PGE analytical data with low detection limits (<0.1 ppb) and quality control standardization.

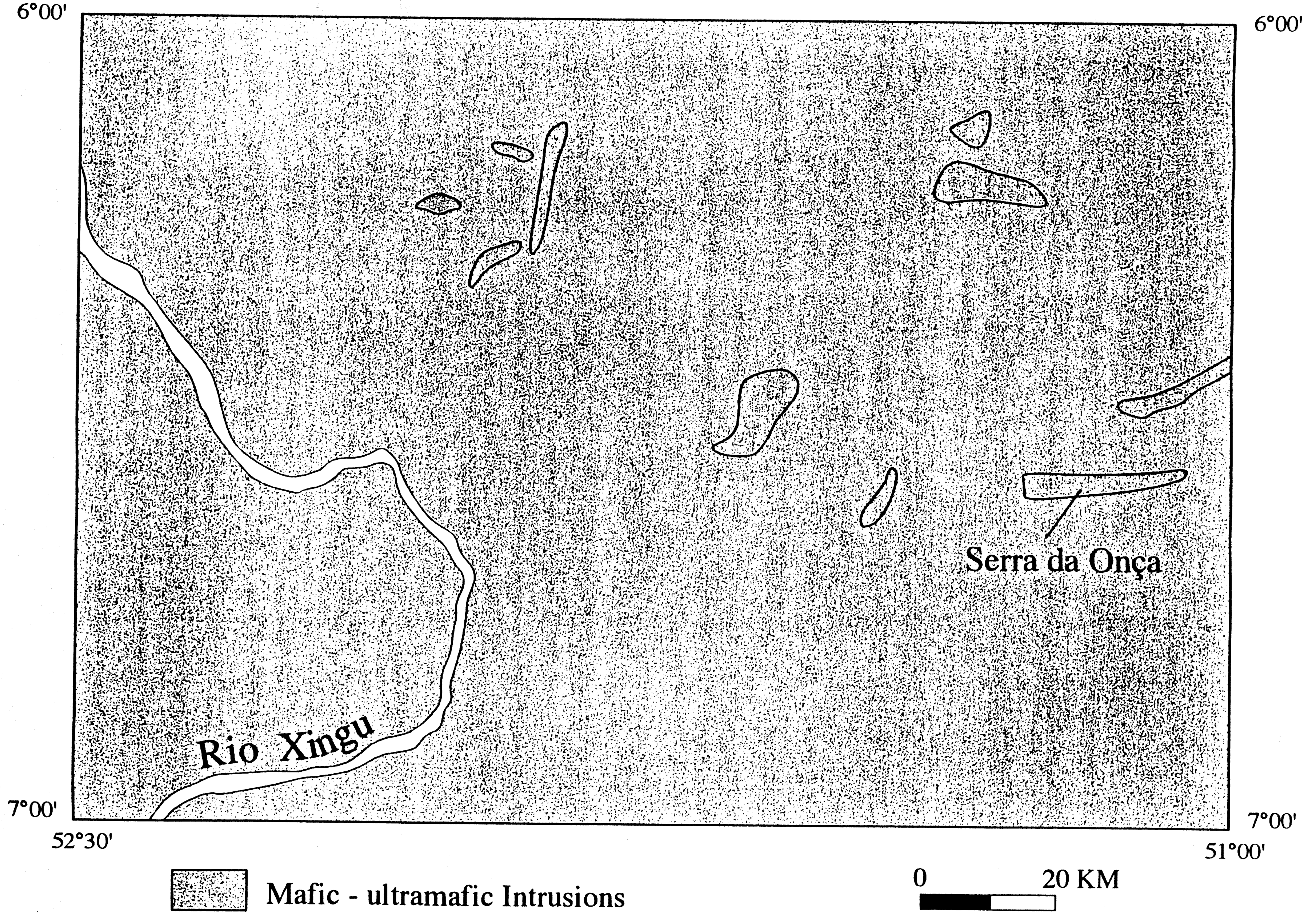

6°00'
6°00'
Serra da Onça
Rio Xingu
7°00'
7°00'
52°30'
51°00'
Mafic - ultramafic Intrusions
0
20 KM

Fig. 6

RECOMMENDATIONS

The following is a brief list of suggestions that should be implemented:

(1) analyze all soil samples for Pt, Pd, Ni, Cu, Cr, S, Se. Within the past few years a soil sampling program was conducted over the complex but the samples have yet to be analyzed for the above elements;

(2) process the geophysical data obtained in the recent magnetometer profiles conducted over the entire complex. This and the above are extremely important due to the sparse outcropping over the complex. With the results from 1 & 2 completed, try to better define the contact between the Ultramafic and Gabbro Zones particularly in areas of poor exposure.

(3) conduct detailed ('hands and knees") mapping in the stratigraphic interval between upper levels of the main serpentinite unit and the basal gabbroic unit (Hulbert et al., 1988). The interval should start at about 250 m below the top of the main serpentinite unit and extend for at least 250 m into the basal portion of the gabbroic zone (i.e., LT-90, 950–1750 m interval in Fig. 4, and a comparable interval on LT-130, Fig. 5).

(4) detailed geochemical sampling should also be taken along these intervals

(5) special attention should be directed towards recognition of the reappearance of olivine grains no matter how small or sparse they may be. Such is also the case for chromite and sulphide.

(6) signs of structural disturbances in the cumulate stratigraphy indicative of turbulent magmatic activity should be sought since such horizons can indicate critical levels within the intrusion at which the products of major magma mixing events were taking place.

(7) from mapping, try to demarcate were plagioclase first appears as a cumulus phase in the cumulate stratigraphic record and use this as a further constraining exploration parameter to that of the intervals mentioned above (recommendation #3).

(8) once the critical horizon is better defined hand and/or bulldozer trenches should be constructed in order to better expose, map and sample this zone.

(9) a number of complete geochemical profiles should be conducted across the entire complex as well as the ***critical horizon***. In addition to analyzing for the above mentioned elements, a number of elemental ratios Cu/Pd, S/Se, Pd/S, Pt/Pd, etc. should be determined since these ratios can not only help define were the PGE-rich level could be but whether a given level is in the hanging or footwall of the mineralized horizon (Maier et al., 1996).

(10) CPRM must become more current as to who owns the mineral rights on a particular property at a given time. This will facilitate local and foreign exploration companies in acquiring the mineral rights and then get on with the task of exploring the ground. Since Canamera's site visit to Serra da Onça last October, they have hired the services of a Brazilian lawyer in Vancouver (specializing in mining and exploration and business law of Brazil) who gave them his version of the mining and exploration rules. A Brazilian consulting geologist in Brazil was also employed and he gave them another version of the rules and provided an endless trail of who may or may not own the mineral rights. In the final analyses it would appear that CVRD probably owns most of the mineral rights in the area and it would take years to negotiate a deal with this massive organization. After considerable time, effort and money spent pursuing this problem, Canamera has given up in frustration. Without the resources of foreign companies or large Brazilian companies the true potential of these bodies cannot be evaluated.

(11) any future work on the complex as well as the area must employ GIS. The amount of data collected in the past and yet to be processed as well as future data sets can only be treated with GIS systems like ArcView or MapInfo.

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