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THE RAPAKIVI GRANITES OF THE RONDÔNIA TIN PROVINCE, NORTHERN BRAZIL [1]

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ABSTRACT

Seven distinct successive episodes of rapakivi magmatism in part associated with mafic and ultramafic rocks have been identified in the Rondônia Tin Province (RTP), as follow: 1 - Serra da Providência Intrusive Suite (SPIS: 1606±24 to 1532±4.5 Ma); 2 - Santo Antônio Intrusive Suite (SAIS: 1406±32 Ma); 3 - Teotônio Intrusive Suite (TIS: 1387±16 Ma); 4 - Alto Candeias Intrusive Suite (ACIS: 1347±4.7 to 1346±4.6 Ma); 5 - São Lourenço-Caripunas Intrusive Suite (SLCIS: 1314±13 to 1309±24 Ma); 6 - Santa Clara Intrusive Suite (SCIS: 1082±4.9 Ma); and 7 - Younger Granites of Rondônia (998±5 to 991±14 Ma).

The suites are confined almost to the Rio Negro-Juruena Province (RNJP: 1.80-1.55 Ga) and part of the Rondonian-San Ignácio Province (RSIP: 1.50-1.30 Ga) and their intrusion was contemporaneous with orogen activity in the immediate surroundings. The exception is the SPIS, the oldest suite, which was emplaced during extention at the end on the Rio Negro Juruena orogeny. The next four younger suites (SAIS, TIS, ACIS and SLCIS) represent inboard anorogenic magmatism in the same province and in part of the (RSIP). The SAIS, TIS and ACIS were emplaced probably during back-arc rifting related to the Rondonian-San Ignácio orogeny, developed along or close to the continental margin of the Greenvillian ocean. The SLCIS was emplaced during late extention preceeding the Sunsás/Aguapei orogeny (1.25-1.00 Ga). The two youngest rapakivi suites (SCIS and YGR) are thought to represent distal effects of the Sunsás/Aguapei orogen, overprinted on the RNJP and RSIP accompanied or was synchronous with convergent tectonics at the orogen scale between the time interval 1.1 to 1.0 Ga.

The rapakivi suites of the RTP are mainly subalkaline and metaluminous to slightly peraluminous in character, show geochemical features of A-type and within-plate granites and had different magmatic sources and evolutionary histories through time.

$\varepsilon_{Nd}(T)$ values of the older suites 1300 Ma (+1.93 to +0.35) at 1.86 to 1.52 Ga indicate minimal contribution from older crust and characterize a significant amount of juvenile paleo to middle Proterozoic crust as main magmatic source of rapakivis. $\varepsilon_{Nd}(T)$ values of the younger suites Ma (-1.59 to -3.28) at 1.66 to 1.9 Ga correspond to assimilation of upper RNJP or RSIP crust materials. Some intersuite late-stage granite facies have TDM ages in the range of 1.47 to 1.58 Ga and ε_{Nd} values of +2.74 to +1.93 higher than those of the main phases which probably indicate young crustal residences (juvenile late-middle proterozoic crust). Present day whole rock Pb/Pb data of the granitoids clearly demonstrate a dominance of crustal Pb. The suggested origin is consistent with available $^{87}Sr/^{86}Sr$ values (0.705).

The rapakivi granites seem to derive from successive partial melting events not only from the RNJ arc complex but also from younger crustal sources (1.45-1.6 Ga) probably induced by intrusion of basaltic magma into the lower crust and crustal underplating.

Tin-granites and associated Sn, W, Nb, Ta, F, REE, topaz and beryl mineralizations are bound to the latest granitic phases mainly of the SLCIS and the YGR.

Styles of mineralization are: cassiterite dissemination in the Li-mica leucogranite as well as in greisen bodies, stockworks of veinlets associated with greisen and quartz-veins, quartz-veins, quartz-vein swarms and breccias, whereas W occurs most of the time as wolframite in quartz veins. Pegmatite-bearing topaz and beryl are also common.

FIELD TRIP LOG

08.18.97 - Monday (first day)

Santo Antônio batholith and Ouro Preto charnockite

Stop 1.1: Coarse- and medium granites (Santo Antônio Intrusive Suite)
Stop 1.2: Alkali-feldspar granites and syenites (Teotônio Intrusive Suite)
Stop 1.3: Charnockite gneiss (Serra da Providência Intrusive Suite)

08.19.97 - Tuesday (second day)

Serra da Providência batholith (Serra da Providência Intrusive Suite)

Stop 2.1: Wiborgite
Stop 2.2: Gabbro
Stop 2.3: Granite porphyry
Stop 2.4: Even-grained granite
Stop 2.5: Porphyritic granite
Stop 2.6: Porphyritic granite/Pyterlite
Stop 2.7: Pyterlite.

08.20.1 - Wednesday (third day)

Massangana massif (Younger Granites of Rondônia)

Stop 3.1: Pyterlite
Stop 3.2: Internal contact breccia
Stop 3.3: Pyterlite
Stop 3.4: Contact breccia
Stop 3.5: Even-grained granite

08.21.97 - Thursday (fourth day)

Bom Futuro mining district (Younger Granites of Rondônia).

Stop 4.1: Topaz lithium-mica albite granite and greisen bodies
Stop 4.2: Gneiss and amphibolite
Stop 4.3: Subvolcanic breccia
Stop 4.4: Topaz-quartz-feldspar porphyry
Stop 4.5: Quartz veins

08.22.97 - Friday (fifth day)

São Carlos, Caritianas, and Santa Bárbara massifs (Younger Granites of Rondônia).

Stop 5.1: Alkaline and subalkaline rocks
Stop 5.2: Nove Mina Quarry
Stop 5.3: Contact breccia
Stop 5.4: Even-grained biotite granite
Stop 5.5: Porphyritic biotite granite
Stop 5.6: Even-grained biotite granite
Stop 5.7: Even-grained biotite granite, greisens, quartz veins
Stop 5.8: Exogreisen and elluvial tin placer

INTRODUCTION

The State of Rondônia is situated in the southwestern part of the western Brazilian region, which corresponds roughly to the Brazilian Amazônia (Figure 1). The State of Rondônia was almost covered by tropical forest; today the forest is partially destroyed or exploited by colonization, ranches, and lumbering. Porto Velho is the capital of the State of Rondônia and is situated on the south side of the Madeira river, the larger tributary of the Amazon river.

Cassiterite was discovered in Rondônia Territory in 1952. During the 1960's intense exploitation by small workers was recorded, and exploration programs and mining operations were launched in some regions. From 1959 to 1984 the Rondônia Tin Province (RTP) has contributed 78,5% of the total Brazilian tin production. After the tin marked collapse in 1985, the majority of the tin mines in the province were closed, but tin production increased because of the discovery of the Bom Futuro district in 1987. The historical tin production of the RTP until 1995 is ca. 222,000 tons, and at present the province is the second largest tin producer in Brazil with an annual output of ca. 7,250 tons. Figure 2 show all the mining district areas of the RTP, althougth at the moment only the Bom Futuro and Santa Bárbara mining districts are in operation.

Figure 1 - Situation of the Rondônia Tin Province in the northern region of Brazil.

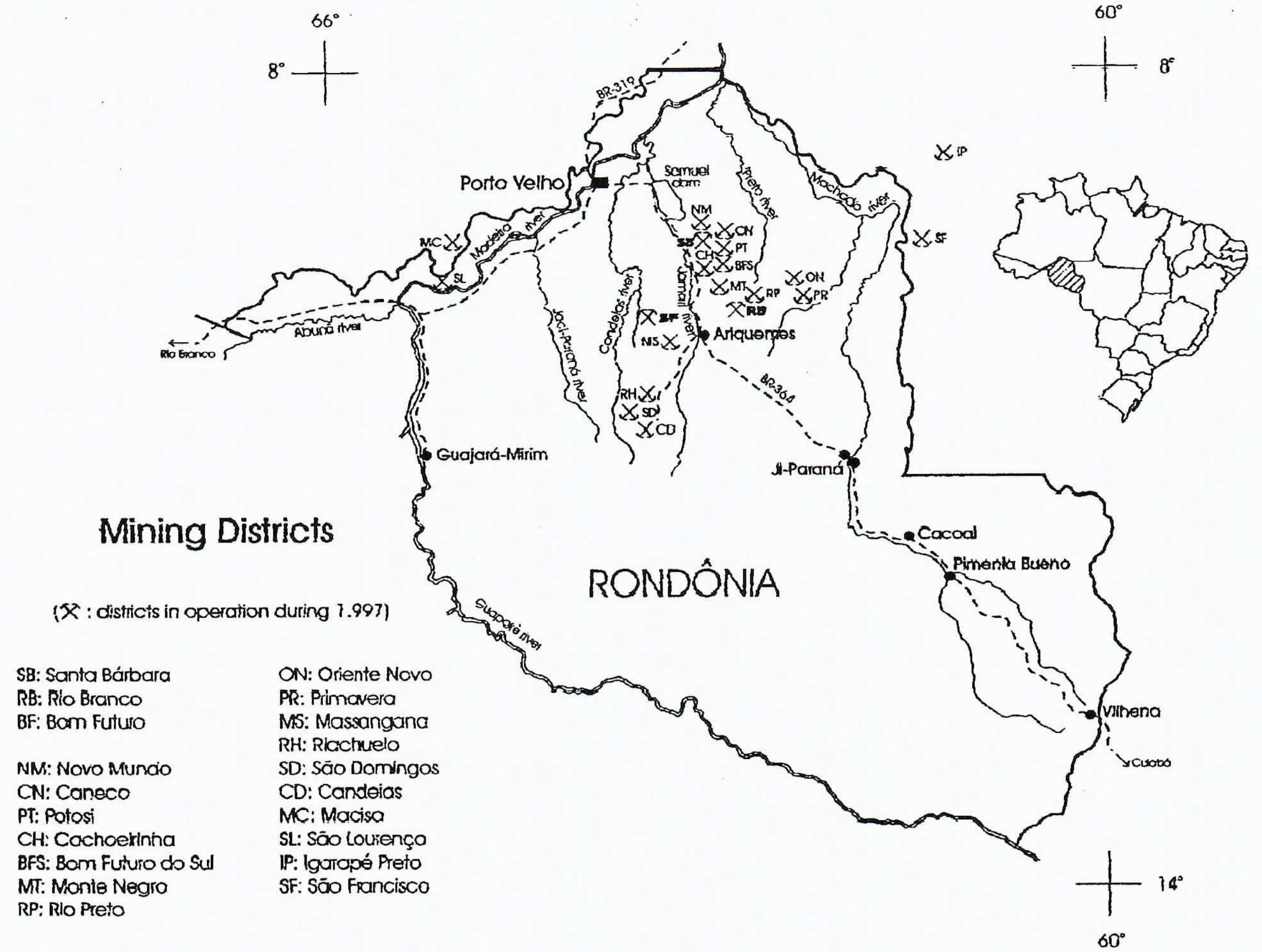


Figure 2 - Location of the mining districts in the Rondônia Tin Province.

The anorogenic granites and related tin mineralization in the RTP were first described by Kloosterman (1968), who called them Younger Granites of Rondônia, with conventional Rb-Sr ages of 940 Ma. Leal et al. (1976) recognized rapakivi features in the granites of the Serra da Providência batholith, and Isotta et al. (1978) considered this rapakivi character typical for all the anorogenic granites of the RTP. Isotta et al. (op. cit.) included these granites under the denomination of Rondônia Intrusive Suite, and correlated them with the Parguazense event (ca. 1550 Ma).

In a extended review, Bettencourt et al. (1987) recognized at least four main distinct suites based on petrographic and geochemical aspects, as well as on some whole-rock Rb-Sr isochron ages, and called them as: Serra da Providência Intrusive Suite (1400 to 1200 Ma), Younger Rapakivi Granites (1270 to 1180 Ma), Costa Marques Group (ca. 1018 Ma), and Younger Granites of Rondônia (ca. 980 Ma). More recently, Bettencourt et al. (1995) redefined four anorogenic rapakivi suites based mainly on additional petrography, geochemistry, Rb-Sr isochron ages, and preliminary U-Pb zircon ages, viz: Serra da Providência Intrusive Suite (ca. 1570 Ma), Teotônio Intrusive Suite (1406 to 1387 Ma), Younger Rapakivi Granites (ca. 1310 Ma) and Younger Granites of Rondônia (1081 to 991 Ma). The primary tin mineralization is thought to be related to the last two suites.

REGIONAL SETTING

Over the last thirty years much progress has been made in understanding the Precambrian geology of the southwestern part of the Amazonian craton. The systematic geologic studies were initiated in Rondônia region in the sixties by private mining companies and the national government, owing to tin potential. Afterwards, regional geological mapping was carried out by the Brazilian government in Brazil and by the British Geological Survey in Bolivia (e.g., Leal et al., 1978; Litherland et al., 1986). Additionaly, a number of complementary regional and local studies have been published in the last several years based on geology, geochronology (mostly Rb-Sr and K-Ar), and geophysical data (e.g., Hasui et al., 1984; Litherland et al., 1989; Priem et al., 1989; Teixeira et al., 1989; Carneiro et al., 1992; Sadowski & Bettencourt 1996).

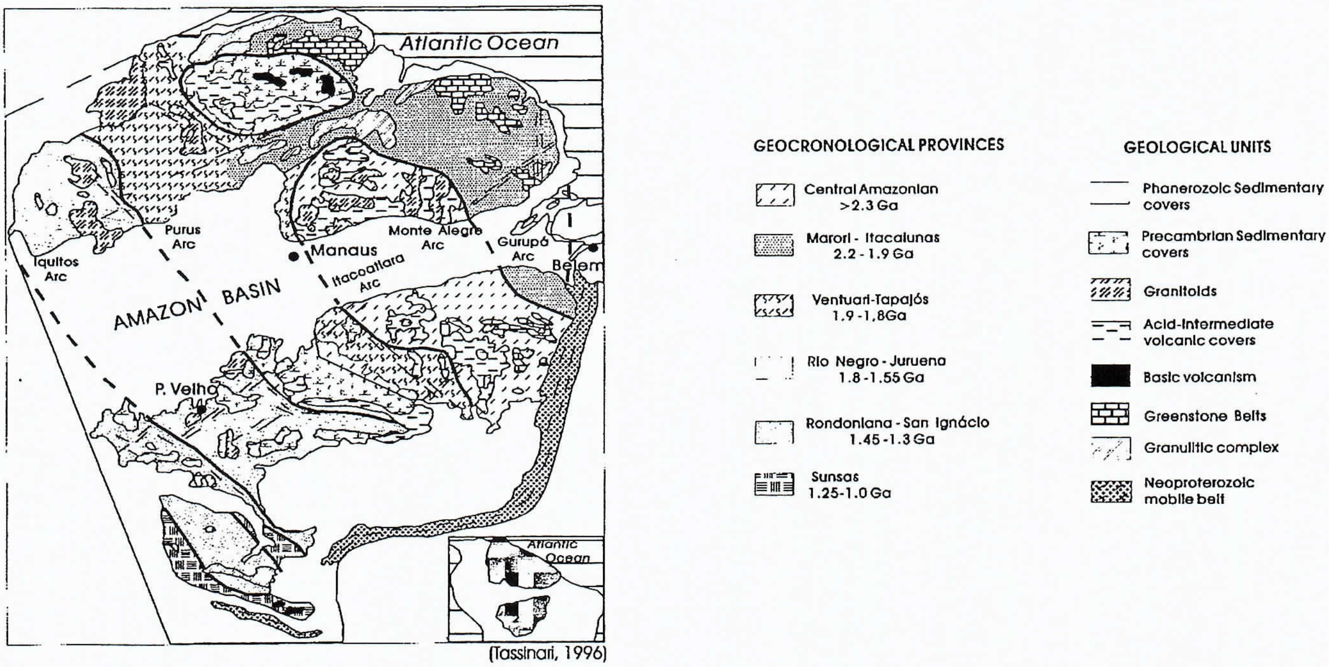


Figure 3 - Sketch map of the Amazonian craton showing the geochronological provinces and the location of the Rondônia Tin Province.
Modified after Tassinari et al. (1996). Inset: + Amazonian craton; 1 -

As proposed by Litherland et al. (1986) for eastern Bolivia and by Teixeira et al. (1989) for Brazilian area, and revised by Tassinari (1996), the southwestern margin of the Amazonian craton is made up by sucessive, subparallel, NNW-SSE trending late Paleoproterozoic to Mesoproterozoic geochronological provinces, viz: Rio Negro-Juruena Province (RNJP: 1.80-1.55 Ga), Rondonian-San Ignácio Province (RSIP: 1.50-1.30 Ga), and Sunsás-Aguapeí Province (SAP: 1.25-1.00 Ga) (Figure 3). These provinces show a distinctive geological record preserved in their basement complexes, supracrustal metamorphic sequences, platform volcanic-sedimentary covers, and granitic and basic to alkaline intrusions (Teixeira et al., 1989).

The RNJP is considered to represent either a partially preserved subduction-related magmatic arc, based on isotopic data (low initial $^{87}Sr/^{86}Sr$ ratios of ca. 0.703 and Pb-Pb μ_1 values around 8.1) and a lack of evidence for the existence of old basement (Tassinari, 1981; Tassinari 1984), or a continental collision belt, based on the occurrences of S-type granitoids (Dall'Agnol et al., 1987). The Rondonian-San Ignácio and Sunsás-Aguapeí provinces show an ensialic character, with both exhibiting older (1.50 Ga) basement nuclei (Teixeira & Tassinari, 1984; Litherland et al., 1989; Tassinari, 1996). Mesoproterozoic undeformed sedimentary cover correlative with the RSIP and SAP are recognized mainly in the RNJP and RSIP, respectively (Brito Neves et al. 1990; Sadowski and Bettencourt, 1996). Anorogenic granites are also identified in both provinces and show Rb-Sr ages ranging from 1.65 to 0.95 Ga in the RNJP, and 1.40 to 0.95 Ga in the RSIP (Tassinari, 1984; Teixeira & Tassinari, 1984; Priem et al., 1989).

Recently, a possible link between the Amazonian and Laurentian cratons has been suggested by several authors based on geologic and geotectonic similarities and geometric fit. For the southwestern border of the Amazonian craton and eastern Laurentia, Sadowski and Bettencourt (1996) stressed the presence of felsic volcanism at 1.60 Ga, a significant AMCG magmatism ca. 1.50 to 1.40 Ga in Elsonian/Rondonian-San Ignácio time, and the occurrence of several pulses of high potassium plutonism (1.10 to 0.95 Ga) in Grenvillian/Sunsás-Aguapeí time. Furthermore, Bettencourt et al. (submitted), using U/Pb zircon ages, make direct chronological comparisons between the anorogenic magmatism in both cratons within the time span of 1.60 to 0.99 Ga.

In the RTP the basement rocks of the so called Xingu Complex (Leal et al., 1978) or Jamari Complex (Isotta et al., 1978) comprise mainly migmatites, granitic and tonalitic gneisses, and basic rocks metamorphosed to amphibolite or to granulite facies. Recently, Scandolara et al. (1996) redefined and subdivided the Jamari Complex into two distinct domains, viz: i) the Samuel Orthogneisses is composed mainly of granitic gneisses, with subordinate granodioritic gneisses; and ii) the Ariquemes wedge is composed of high grade ortho- and paragneisses, migmatites, and basic granulites (Figure 4). Tassinari et al. (1996) reported a SHRIMP U-Pb zircon age of 1750±24 Ma on a sample of metadiorite belonging to the Samuel Orthogneisses domain. Low- to medium-grade metamorphic volcano-sedimentary sequences are hosted by the Jamari Complex in the RTP (Isotta et al., 1978; Adamy and Romanini, 1990; Scandolara et al., 1992).

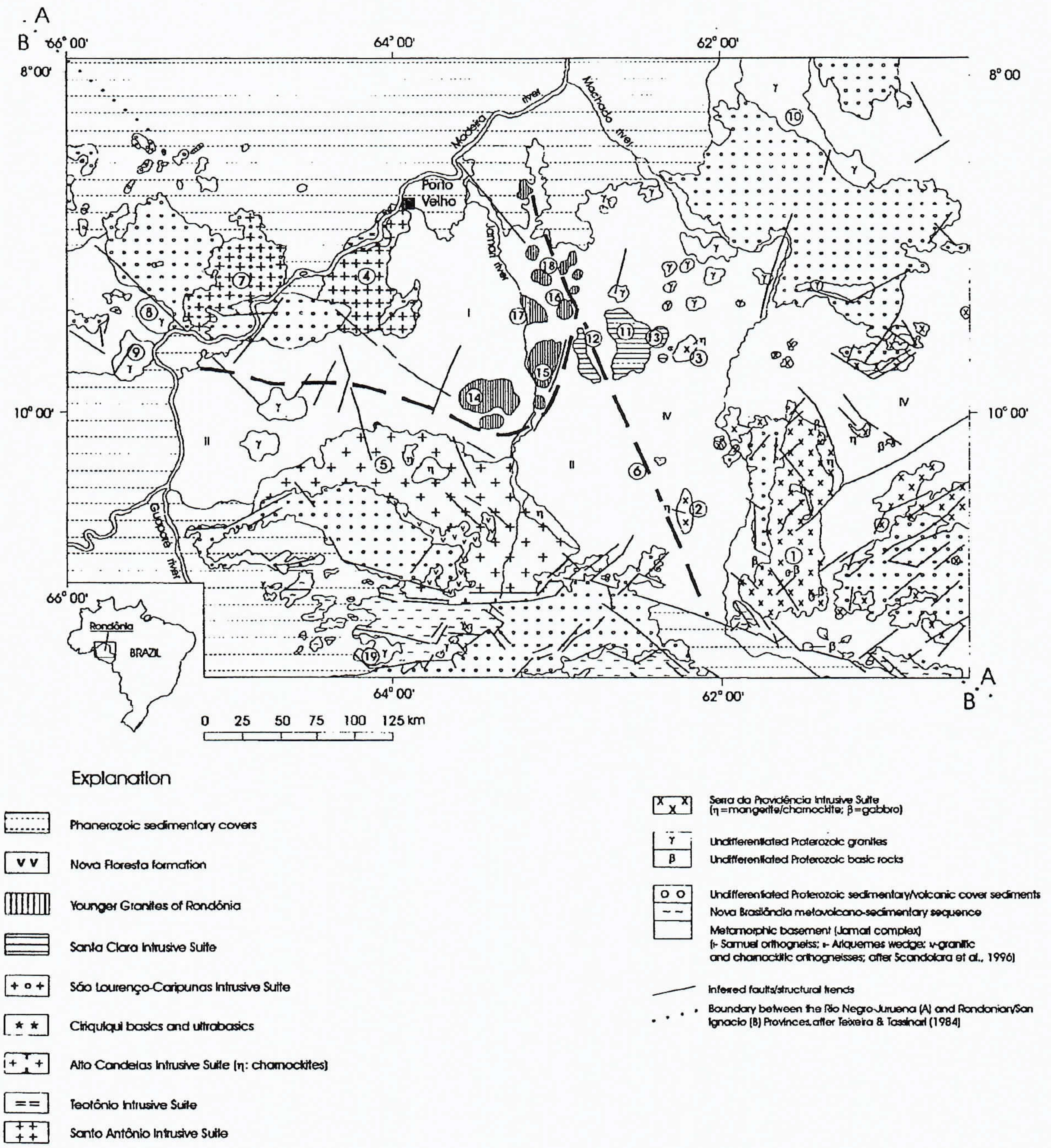


Figure 4. Geological map of the Rondônia Tin Province, simplified after Leal et al. (1978), Isotta et al. (1978), Schobbenhaus et al. (1981), Bettencourt & Dall'Agnol (1987), Bettencourt et al. (1995), and Rizzotto et al. (1996). (1) Serra da Providência batholith; (2) Ouro Preto charnockite, (3) União massif, (4) Santo Antônio batholith, (5) Alto Candeias batholith, (6) Jaru charnockite, (7) São Lourenço-Caripunas batholith, (8) São Simão massif, (9) Abunã massif, (10) Igarapé Preto massif, (11) Santa Clara massif, (12) Manteiga massif, (13) Oriente Novo massif, (14) Massangana massif, (15) São Carlos massif, (16) Pedra Branca massif, (17) Caritianas massif, (18) Santa Bárbara massif, and (19) Costa Marques Group.

THE RAPAKIVI GRANITE SUITES OF THE RONDÔNIA TIN PROVINCE

The anorogenic granite suites in the RTP were reviewed by Bettencourt et al. (1987, 1995). Bettencourt et al.(submitted) recommend a new designation for these suites based on geologic, petrographic and geochemical aspects, as well as on U-Pb zircon ages (Figure 4, Table 1 and 2), viz: Serra da Providência Intrusive Suite (1606 to 1532 Ma), Santo Antônio Intrusive Suite (ca. 1406 Ma), Teotônio Intrusive Suite (ca. 1387 Ma), Alto Candeias Intrusive Suite (ca. 1347 Ma), São Lourenço-Caripunas Intrusive Suite (1314 to 1309 Ma), Santa Clara Intrusive Suite (ca. 1082 Ma) and Younger Granites of Rondônia (998 to 991 Ma). Tin and associated metal (e.g., W, Nb, Ta, Cu, Zn, Pb) deposits are spatially related to the latest granitic phases of the São Lourenço-Caripunas Intrusive Suite and the Younger Granites of Rondônia.

PETROGRAPHY	GEOCHEMISTRY	MINERALIZATION
Serra da Providência Intrusive Suite Amphibole-biotite monzogranite (wiborgite, pyterlite and porphyritic); biotite monzogranite and syenogranite (porphyry and equigranular); charnockite and mangerite; basic rocks	Subalkaline; SiO_2 (67-77 wt%), Na_2O+K_2O (7.07-8.36 wt%); FeO*/FeO*+MgO (0.72-0.97); A/CNK (1.00-1.22); K/Rb (141-251)	
Santo Antônio Intrusive Suite Biotite monzogranite and syenogranite; amphibole-biotite quartz monzonite; hybrid rocks; diabase dikes	Subalkaline; SiO_2 (68-74 wt%); Na_2O+K_2O (7.43-8.46 wt%); FeO*/FeO*+MgO (0.86-0.94); A/CNK (0.96-1.08); K/Rb (109-225); La_N/Yb_N (5.58-10.34); Eu/Eu* (0.23-0.41)	
Teotônio Intrusive Suite Fayalite-pyroxene-amphibole alkali-feldspar syenite, alkali-feldspar quartz syenite, and alkali-feldspar granite; amphibole-biotite syenite, quartz syenite, and syenogranite; monzonite, monzodiorite, and diorite	Alkaline silica oversaturated series; SiO_2 (60-76 wt%); Na_2O+K_2O (8.16-10.64); FeO*/FeO*+MgO (0.82+0.99); A/CNK (0.83-1.04); K/Rb (221-782); La_N/Yb_N (5.39-38.38); Eu/Eu* (0.16-0.91)	
Alto Candeias Suite Intrusive Amphibole-biotite syenogranite and biotite syenogranite; syenitoid and charnockitoid rocks	Subalkaline; SiO_2 (68.4-74.6 wt%); Na_2O+K_2O (8.5-9.2 wt%); FeO*/FeO*+MgO (0.86-0.95); A/CNK (0.86-0.93)	Sn, W, sulphide (undated mineralization, might be related to the YGR)
São Lourenço-Caripunas Suite Intrusive Fayalite-amphibole alkali-feldspar granite; amphibole-biotite syenogranite, alkali-feldspar granite, and quartz syenite; biotite syenogranite; rhyolite porphyry	Subalkaline; SiO_2 (67-76 wt%); Na_2O+K_2O (7.90-9.80 wt%); FeO*/FeO*+MgO (0.88-0.99); A/CNK (0.88-1.05); K/Rb (39-213); La_N/Yb_N (2.18-15.61); Eu/Eu* (0.11-0.60)	Sn, Nb, Ta, W, Cu, Pb, Zn, F
Santa Clara Intrusive Suite Amphibole-biotite quartz monzonite, monzogranite, and syenogranite; biotite syenogranite	Subalkaline; SiO_2 (63-74 wt%); Na_2O+K_2O (7.32-8.99 wt%); FeO*/FeO*+MgO (0.80-0.99); A/CNK (0.92-1.08); K/Rb (83-185); La_N/Yb_N (4.54-34-67); Eu/Eu* (0.13-0.74)	Au(?)
Younger Granites of Rondônia Amphibole-biotite alkali-feldspar granite; biotite syenogranite and alkali-feldspar granite; rhyolite porphyry; lithium-mica albite granite; topaz rhyolite	Subalkaline; SiO_2 (71-76 wt%); Na_2O+K_2O (8.05-9.80 wt%); FeO*/FeO*+MgO (0.92+0.99); A/CNK (0.83-1.06); K/Rb (26-181); La_N/Yb_N (3.49-24.09); Eu/Eu* (0.09-0.38)	Sn, W, Nb, Ta, Cu, Pb, Zn, F, Be, topaz
Pyroxene-amphibole alkali-feldspar syenite and trachyte; amphibole alkali-feldspar syenite and trachyte; sodic amphibole alkali-feldspar granite; biotite alkali-feldspar granite; hybrid rocks	Alkaline; SiO_2 (55-72wt%); Na_2O+K_2O (9.40-10.40); FeO*/FeO*+MgO (0.95-0.99); A/NK (0.92-1.15); K/Rb (52-407); La_N/Yb_N (3.56-8.07); Eu/Eu* (0.22-0.59)	

Table 1 – Petrography, geochemistry and associated mineralization of rapakivi suites in the Rondônia Tin Province (from Bettencourt et al., submitted).

EPISODES	RAPAKIVI SUITES	U-Pb ages (Ma)	Rb-Sr ages (Ma)	TECTONIC SETTING
1	**Serra da Providência Intrusive Suite**			
	Serra da Providência batholith	1606±24	1400±57	
		1573±15		Extentional regime at
		1566±05		the end of the Rio
		1566±03		Negro-Juruena orogenic
		1554±14		cycle
	União massif	1532±4.5		
	Ouro Preto charnockite	1560		
2	**Santo Antônio Intrusive Suite**	1406±32	1305	
3	**Teotônio Intrusive Suite**	1387±16	1250	
4	**Alto Candeias Intrusive Suite**			Extentional regime
	Alto Candeias batholith	1347±4.7	1358±74	related to Rondonian-
		1346±4.6		San Ignacio orogenic
		1338±3.5		cycle or to the opening
	Jaru charnockite	1351±8.0		of the Grenville ocean
5	**São Lourenço-Caripunas Intrusive Suite**	1314±13	1268±15	
		1312±03		
		1309±24		
6	**Santa Clara Intrusive Suite**			
	Manteiga massif	1082±4.9	1052±21	
	Santa Clara massif	1081±50		Extentional regime
	Oriente Novo massif	1080±27		related to collisional
				stage of Sunsas
7	**Younger Granites of Rondônia**			orogenic cycle
	Pedra Branca massif	998±05	954±20	
	São Carlos massif	995±73		
	Massangana massif	991±14	960±05	

Table 2 – Chronologic and tectonic framework of rapakivi suites in the Rondônia Tin Province (from Bettencourt et al., submitted)

The anorogenic rapakivi granites are dominantly syenogranites and monzogranites in modal composition, although alkali-feldspar granites predominate in the Younger Granites of Rondônia at the present level of erosion. Porphyritic and equigranular varieties are abundant, pyterlites are common in some massifs, and wiborgites are rare. Biotite and amphibole are the main mafic minerals; clinopyroxene is sometimes present in some facies. The granites are mostly subalkaline, metaluminous to slightly peraluminous in character, and show geochemical features of A-type and within-plate granites. Contemporaneous plutonic rocks are poorly understood, but in general include gabbros, syenites, mangerites, charnockites, and rare anorthosite. Subvolcanic rocks are recognized in some massifs and are represented mainly by granite porphyry, quartz-feldspar porphyries, microgranites, aplites, and microsyenites, in addition to minor diabase

The rapakivi suites in the RTP are confined to the RNJP and RSIP in accordance with the limits as proposed by Teixeira et al. (1989) (Figure 4), although the tectonic boundary between both provinces might be confirmed by further field work, geophysics, and refined geochronology. Bettencourt et al. (submitted) propose the following tectonic relationships for these suites: 1- the Serra da Providência Intrusive Suite is related to an extentional regime at the end of the Rio Negro-Juruena orogeny; 2- the Santo Antônio Intrusive Suite and Teotônio Intrusive Suite are inboard silicic anorogenic magmatism in the RNJP, in a back-arc ritfing environmenta related to the Rondonian-San Ignacio orogeny; 3- the Alto Candeias Intrusive Suite and São Lourenço-Caripunas Intrusive Suite are related to an extentional regime at the end of Rondonian-San Ignacio orogeny and/or to the oppening of the Grenvillian ocean; and 4- the Santa Clara Intrusive Suite and Younger Granites of Rondônia might represent distal effects of Sunsás-Aguapeí orogenesis within the RNJP.

Preliminary Sm-Nd data from the majority of these rapakivi granite suites provide TDM ages of 2.0 to 1.47 Ga and ε_{Nd} (t) values of + 2.2 to - 3.3 based on U-Pb zircon ages, indicating the involvement of Paleo- to Mesoproterozoic crust with mixing of depleted mantle magma and high level crustal material in the granite genesis. Whole-rock Pb-Pb data from the granites of the Santo Antônio, Teotônio, São Lourenço-Caripunas, Santa Clara, and Younger Granites of Rondônia suites indicate a dominant crustal Pb contribution in the formation of these rocks (Tosdal et al., 1995). The Pb-Pb values are consistent with high initial $^{87}Sr/^{86}Sr$ ratios (0.707) for the last three suites (cf., Tassinari et al., 1984; Priem et al., 1989).

Serra da Providência Intrusive Suite

The name Serra da Providência Intrusive Suite was proposed by Tassinari et al. (1984) based on a whole-rock Rb-Sr isochron age of 1400±57 Ma. The suite comprises the Serra da Providência batholith and several satellite stocks as described by Leal et al. (1976, 1978) (Figure 4). Basic, charnockitic, and mangeritic rocks were recently included in this suite by Bettencourt et al. (1987, 1995) and Rizzotto et al. (1996). The granites and associated rock: are massive or folliated (Rizzoto et al., 1996. Scandolara e al., 1996), and the massive granites in the Serra d: Providência batholith show U-Pb zircon ages ranging fron 1606 to 1554 Ma (Bettencourt et al., submitted). Va Schmus & Tassinari (verbal comm.), Bettencourt et al (submitted) and Tassinari et al. (1996) reported U-Pb zirco ages of 1560 Ma, 1532 Ma, and 1570 Ma from the Our Preto charnockite, União quartz-syenite, and blastomyloniti granite-gneiss, respectively. The high initial 87Sr/86S ratios (0.713±0.005) obtained from granites indicat involvement of older crustal material in the magm: genesis (Tassinari et al., 1984).

Rizzoto et al. (1995) recognized four granitic units i the Serra da Providência batholith, viz: coarse pyterliti monzogranites with subordinated wiborgites, pink-gra coarse porphyritic monzogranites, pink equigranular bioti syenogranites, and granite porphyries. Biotite an hornblende are the main mafic silicate minerals in th pyterlites, wiborgites, and porphyritic granites; only bioti is identified in the equigranular granites and granit porphyries. Additionally, gabbros, gabbronorites charnockites, mangerites, and quartz-latite occur in lesse amounts (Rizzoto et al., 1996). At this time no detaile petrographic and geochemical data are available for thes rocks.

Santo Antônio Intrusive Suite

The Santo Antônio Intrusive Suite constitutes th major part of the Santo Antônio batholith. This batholit covers an area of ca. 2000 km^2 in the NW sector of RTF Its true dimensions are unknown since the norther domain is overlain by Cenozoic continental sediments o the Amazon basin (Figure 4). The rocks of this suite hav been investigated principally by Souza & Marque (1974), Isotta et al. (1978), and more recently by Adam and Romanini (1990) and Payolla (1994). Th coarse-grained granite from REMA quarry near Port Velho city yields an U-Pb zircon age of 1406 M (Bettencourt et al., submitted).

At the NE part of the batholith (Porto Velho area) Payolla (1994) recognized two main granitic units, viz (a) coarse-grained, seriate to locally porphyritic, bioti monzogranite and syenogranite with sparse rapakivi an anti-rapakivi textures; and, (b) medium graine equigranular biotite monzogranite. In addition, som distinctive lithologies of smaller areal extent are als identified such as: fine-grained hornblende-bioti quartz-monzonite, dyke-like bodies of hybrid rocks, an synplutonic diabase dikes. These two latter rocks provid evidence for bimodal magmatism. Adamy & Romanin (1990) described the presence of wiborgite and pyterlit together with porphyritic, equigranular, and porphyr varieties at Jaciparaná area (W portion of the batholith Petrographic and geochemical data from selected rocks o this suite at Porto Velho region are plotted in Figure 5: a modal composition, b. Na_2O+K_2O vs. Si_2O, c Na_2O+K_2O vs. 10000 Ga/Al, and d. chondrite-normalize REE abundances.

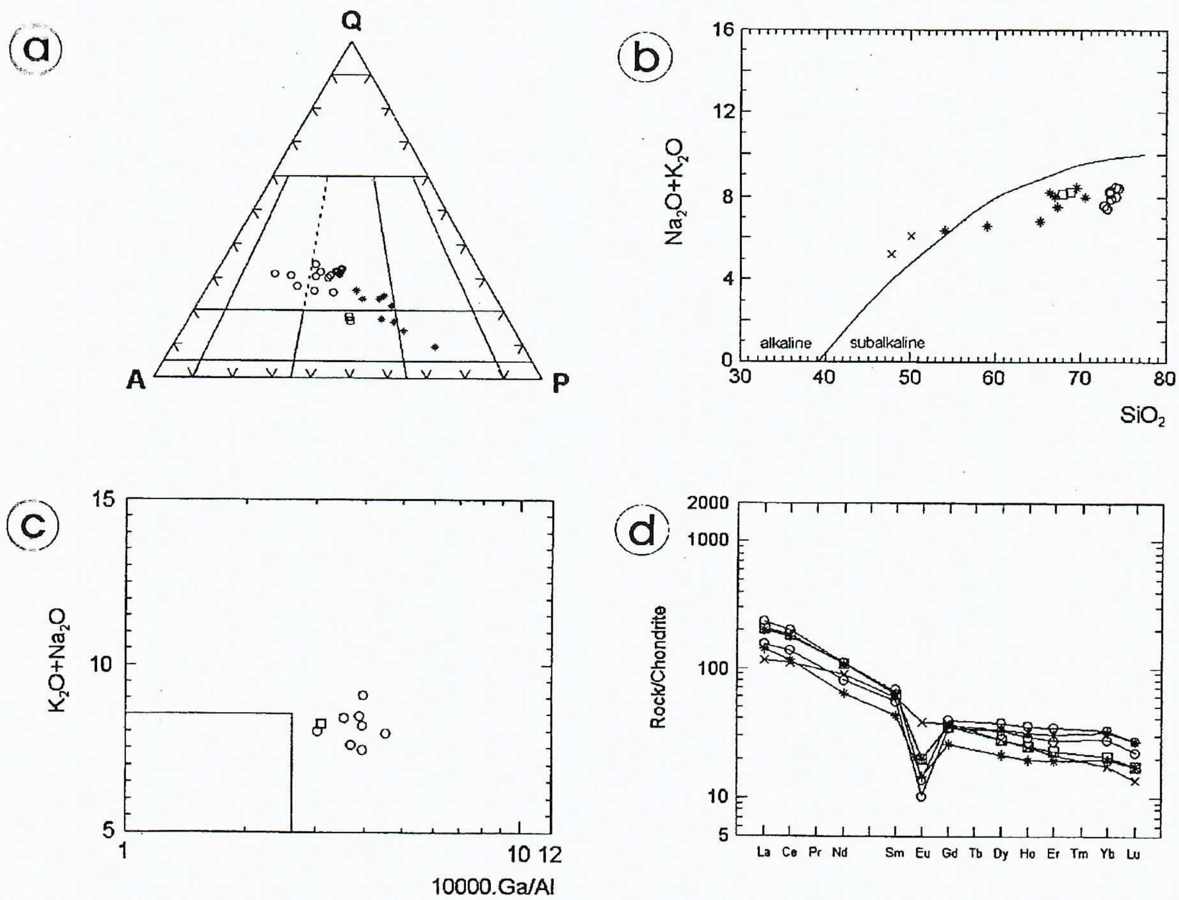


Figure 5 - Modal and geochemical characterization of the rocks from the Santo Antônio Intrusive Suite at the Porto Velho region. (A) - QAP diagram (Streckeisen, 1976); (B) - SiO_2 x Na_2O+K_2O diagram, alkaline and subalkaline fields from Irvine & Baragar (1971); (C) - 10000Ga/Al x K_2O+Na_2O diagram from Whalen et al. (1987); (D) – Chondrite-normalized (Boynton, 1984) REE-patterns. Open circle: biotite granite; open square: hornblende-biotite quartz monzonite; asterisk: hybrid rocks; X: diabase.

Teotônio Intrusive Suite

The Teotônio Intrusive Suite comprises apparently a minor portion of the Santo Antonio batholith at the present level of erosion. The typical rocks of this suite were described by Leal et al. (1978) at Teotônio cataract area (Teotônio Alkalines), and by Adamy & Romanini (1990) in the region between Morrinhos cataract and Jiparaná town (Morrinhos Complex). The actual designation was proposed by Payolla (1994) to include syenitoid and granitoid rocks that crop out in the Madeira river area between Jaciparaná town and Teotônio cataract (Figure 4). A coarse-grained alkali-feldspar granite sample from Teotônio cataract yelds an U-Pb zircon age of 1387 Ma (Bettencourt et al., submitted).

At Teotônio cataract area, Payolla (1994) recognized three main hypersolvus rock types, viz: massive coarse-grained ferrohedenbergite alkali-feldspar granite, banded medium-grained ferrohedenbergite alkali-feldspar granite, and pink coarse- to medium-grained alkali-feldspar quartz syenite and syenogranite. The coarse-grained and banded granites are cut by NE dipping, up to 2 meters wide, tabular bodies of fine- to medium-grained fayalite-ferrohedenbergite alkali-feldspar syenites, as well as synplutonic dykes of intermediate rocks (diorite, monzodiorite, and monzonite). The parallel arrangement of the tabular bodies and dykes defines a large scale banding in outcrops at Teotônio cataract. Late pink, fine-grained, subsolvus monzogranites occur as SW dipping dykes cutting through the above rock types.

The original anhydrous, high temperature mineralogy of syenitic and granitic hypersolvus rocks has been partially altered to hydrous phases. Alkali feldspar shows coarse exsolution textures (ribbon, braid, and patch perthites). Fayalite is partially to completely altered to grunerite, iron oxide, and iddingsite. Clinopyroxene (ferrosalite, hedenbergite, and ferrohedenbergite) is altered to green hornblende showing crude symplectitic intergrowths with quartz. The alterations are more intense in pink coarse- to medium-grained syenites and granites. Petrographic and geochemical data from selected rocks of this suite at Teotônio cataract region are plotted in Figure 6: a. modal composition, b. Na_2O+K_2O vs. Si_2O, c. Na_2O+K_2O vs. 10000 Ga/Al, and d. chondrite-normalized REE abundances. These rocks define an alkaline silica-oversaturated series with high Fe/Fe+Mg (0.81 to 0.99).

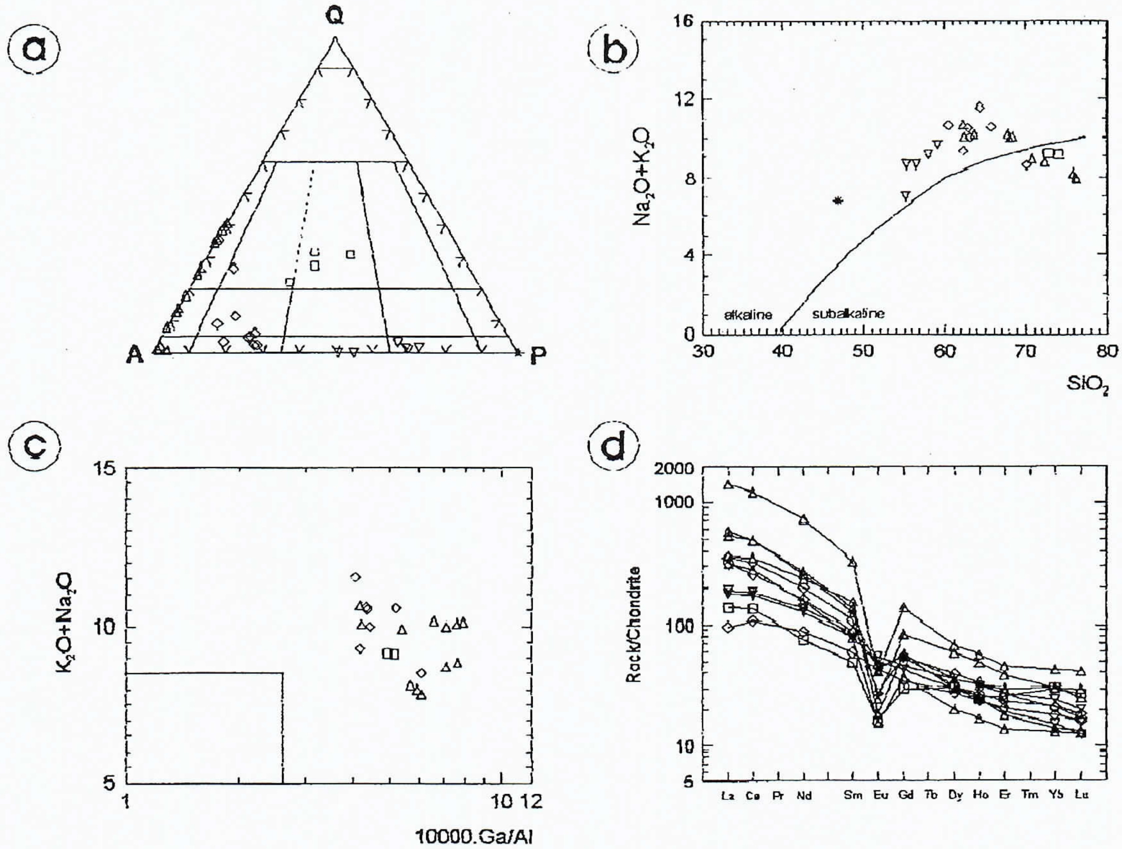


Figure 6 - Modal and geochemical characterization of the rocks from the Teotônio Intrusive Suite at the Teotônio cataract region. (A) - QAP diagram (Streckeisen, 1976); (B) - SiO_2 versus Na_2O+K_2O diagram, alkaline and subalkaline fields from Irvine & Baragar (1971); (C) - 10000Ga/Al versus K_2O+Na_2O diagram from Whalen et al. (1987); (D) – Chondrite-normalized REE plots (Boynton, 1984). Open triangle: hypersolvus granite and syenite; open losenge: pink syenite and granite; inverted triangle: intermediate rocks; asterisk: diorite; open square: subsolvus granite.

Alto Candeias Intrusive Suite

The granitoids of the Alto Candeias region were recognized first by Lobato et al. (1966) and Kloosterman (1968), and later on by Waghorn (1974), Souza et al. (1975), and Isotta et al. (1978) in reconnaissance studies (Figure 4). Leal et al. (1978) delimited an extensive batholith and two satellite plutons by radar imagery and included all the granitic and charnockitic rocks into the Xingu Complex. Rb-Sr data from porphyritic and pyterlitic granites reveal a isochron age of 1358 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.703±0.009 (Bettencourt et al., 1995). This age is equivalent to the U-Pb zircon age of ca. 1347 Ma on the same samples (Bettencourt et al., submitted), and is also comparable to the U-Pb zircon age of 1351 Ma from the Jaru charnockite that is situated beyond the eastern limit of the batholith (Olszewski et al., 1989).

The Alto Candeias Intrusive Suite is largely composed of coarse to medium-grained porphyritic and pyterlitic granites, with lesser amounts of medium- to fine-grained equigranular granites, aplites, syenites, and charnockites. Biotite and minor hornblende are the main mafic silicate minerals in the porphyritic and pyterlitic granites, whereas only biotite is recognized in the equigranular granites. Syenite is associated with biotite equigranular granites a various places (Waghorn, 1974), and coarse porphyriti charnockites occur in the porphyritic and pyterlitic granit domains (Souza et al., 1975; Leal at al., 1978). The ti mineralization is spatially related to biotite equigranula granites, mainly as quartz veins with cassiterite, wolframit and minor sulphides. The ages of the biotite granites and th mineralization are unknown. Although they are spatiall related to Alto Candeias granitoids, we believe that the might be genetically related to the Younger Granites o Rondônia. At this time no detailed petrographic an geochemical data for these are available for these rocks.

São Lourenço-Caripunas Intrusive Suite

Plutonic and volcanic rocks of this suite were previousl decribed in the São Lourenço region by Kloosterma (1966), Lobato et al. (1966), Isotta et al. (1978), and Leal e al. (1978), and later on in the Caripunas region b Bettencourt & Kaedei (1984) (Figure 4). Tassinari et a (1984) proposed São Lourenço-Macisa Intrusive Suite fo the granites with a whole-rock Rb-Sr isochron age o 1186±28 Ma in the homonym region. However, Priem et a

(1989) indicate an Rb-Sr whole rock isochronic age of 1268±15 Ma. This age is 40 Ma younger than U-Pb zircon ages ranging from 1314 to 1309 Ma presented by Bettencourt et al.(submitted), and indicates that the Rb-Sr system did not behave as a closed isotopic system since the emplacement of the granites. The hydrothermal system related to primary tin mineralization might be the cause of the opening of the Rb-Sr system.

The rocks of this suite are mostly syenogranites and alkali-feldspar granites, showing pyterlitic, porphyritic, even-grained, and minor wiborgitic textures. Biotite, minor hornblende, and locally augite and fayalite are the main mafic silicate minerals identified in these granites, in addition to accessory minerals as zircon, apatite, ilmenite, fluorite, and more rarely magnetite, sphene, and allanite in some facies. Quartz-feldspar porphyries and gabbros occur clearly in subordinate proportions at the present level of erosion. The mineralization is spatially related to medium- to fine-grained equigranular biotite syenogranites and alkali feldspar granites mostly as: greisen bodies with cassiterite, and quartz veins with cassiterite, minor wolframite, and Cu-Zn-Pb-Fe sulphides. Petrographic and geochemical data from selected granites of this suite are plotted in Figure 7: a. modal composition, b. Na_2O+K_2O vs. Si_2O, c. Na_2O+K_2O vs. 10000 Ga/Al, and d. chondrite-normalized REE abundances.

Santa Clara Intrusive Suite

The granites of this suite were first described by Kloosterman (1967, 1968) and included in the Younger Granites of Rondônia. This new designation proposed by Bettencourt et al. (submitted) encompass the granites with U-Pb zircon ages of ca. 1082 Ma from the following main massifs: Santa Clara, Oriente Velho, Oriente Novo (in part), and Manteiga (Figure 4). Rb-Sr data on these rocks define an isochron age of 1052±21 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.710±0.008 (Bettencourt et al., 1995).

The Santa Clara Intrusive Suite is mainly composed of coarse-grained porphyritic monzogranite and syenogranite, with subordinate amounts of quartz-monzonite and, more rarely, pyterlite. Microcline, drop quartz, plagioclase, biotite and minor hornblende are essential minerals, and zircon, apatite, ilmenite, magnetite, allanite, fluorite, and sphene (hornblende facies) are typical accessory minerals. Petrographic and geochemical data from selected granites of this suite are plotted in Figure 8: a. modal composition, b. Na_2O+K_2O vs. Si_2O, c. Na_2O+K_2O vs. 10000 Ga/Al, and d. chondrite-normalized REE abundances.

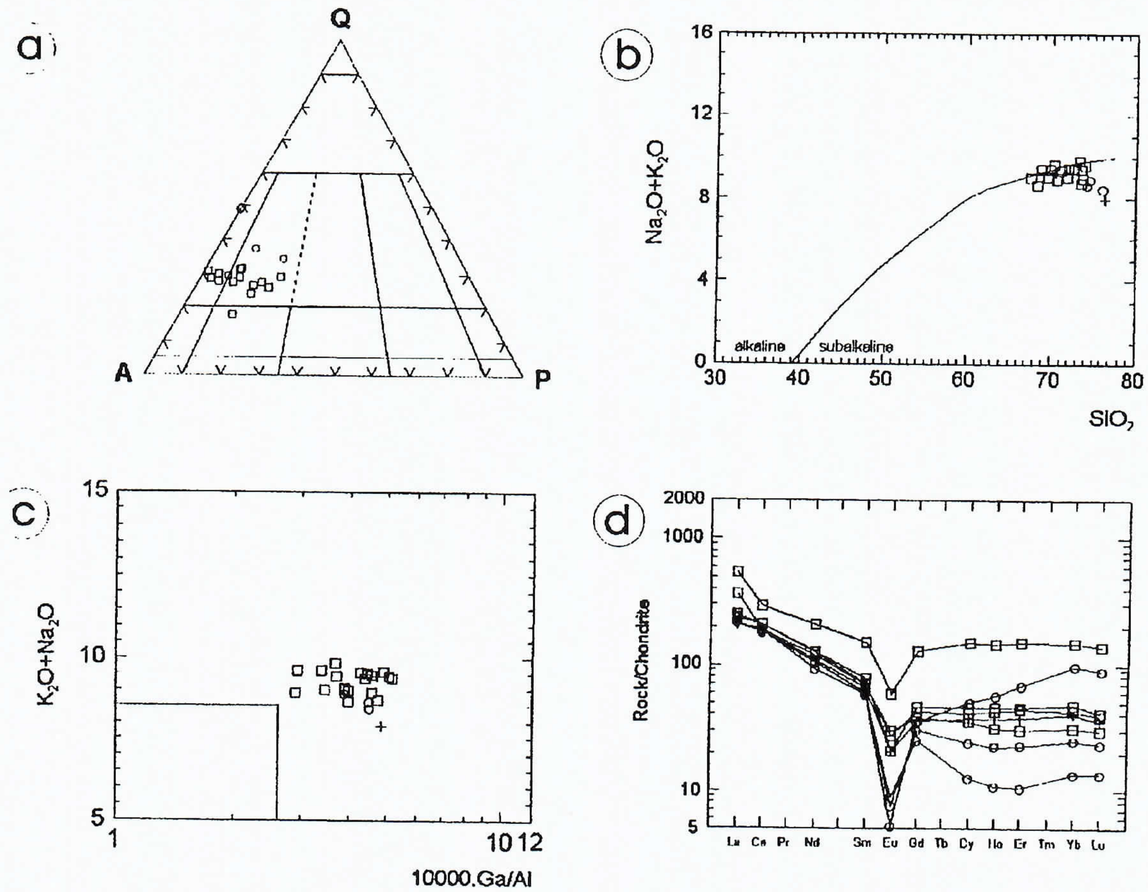


Figure 7 - Modal and geochemical characterization of the rocks from the São Lourenço-Caripunas Intrusive Suite. (A) - QAP diagram (Streckeisen, 1976); (B) - SiO_2 versus Na_2O+K_2O diagram, alkaline and subalkaline fields from Irvine & Baragar (1971); (C) - 10000Ga/Al versus K_2O+Na_2O diagram (Whalen et al., 1987); (D) – Chondrite-normalized REE-diagrams (Boynton, 1984). Open square: hornblende-biotite granite; open circle: biotite granite.

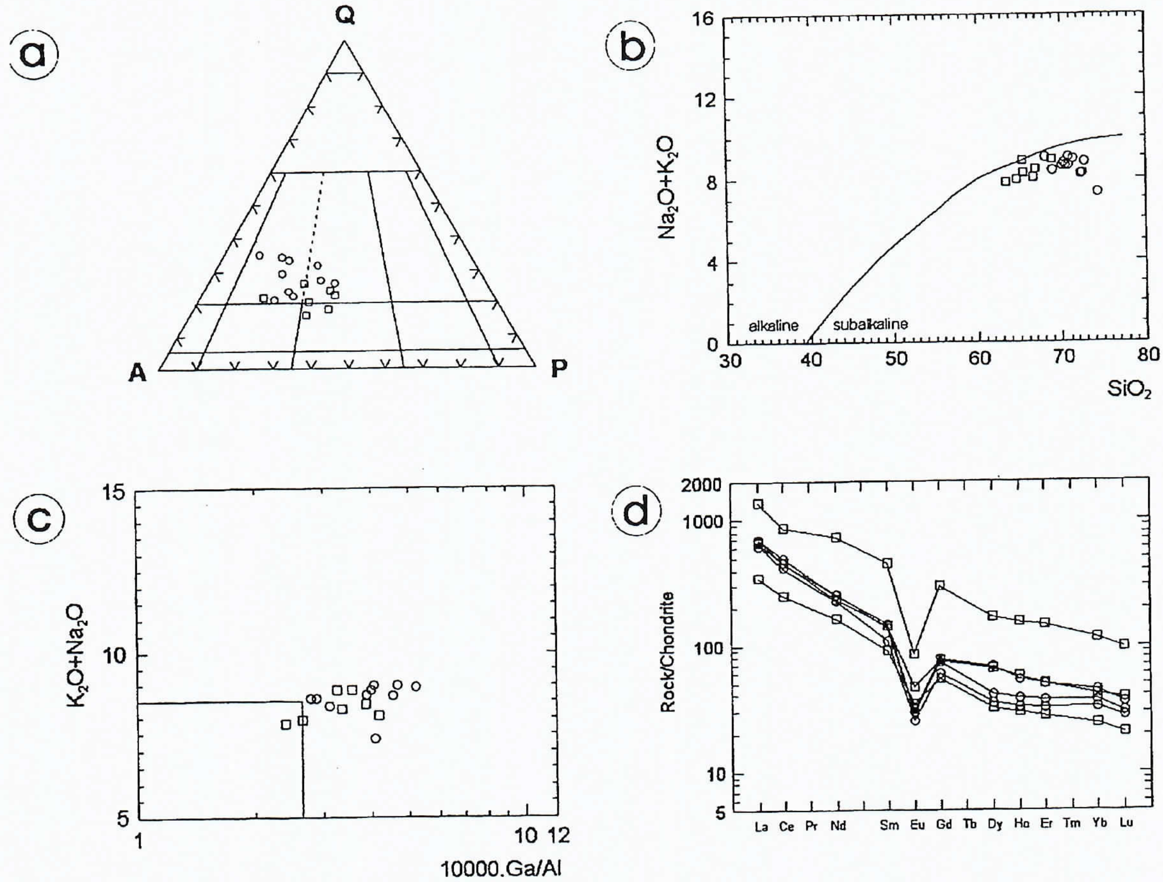


Figure 8 - Modal and geochemical characterization of the rocks from the Santa Clara Intrusive Suite. (A) - QAP diagram (Streckeisen, 1976); (B) - SiO_2 versus Na_2O+K_2O diagram, alkaline and subalkaline fields from Irvine & Baragar (1971); (C) - 10000Ga/Al versus K_2O+Na_2O diagram from Whalen et al. (1987); (D) - Rare earth elements normalized against chondrite composition from Boynton (1984). Open square: hornblende-biotite granite; open circle: biotite granite.

Younger Granites of Rondônia

The Younger Granites of Rondônia were first described by Kloosterman (1968), who included in this designation several granitic complexes situated mostly at the central part of the RTP. Priem et al. (1971) dated part of these granites at around 980 Ma (Rb-Sr isochron age), and later on Tassinari et al. (1984) included all these granites in a whole-rock Rb-Sr isochron age of 997 Ma under the designation of Rondonian Suite. Bettencourt et al. (submitted) maintained Kloosterman's definition, but embracing only the granites with U-Pb zircon ages ranging from 998 to 991 Ma, which occur principally in the following massifs: Massangana, Ariquemes, São Carlos, Caritianas, Pedra Branca, Santa Bárbara, and Jacundá (Figure 4).

Among the Younger Granites of Rondônia two distinct suites are recognized, a dominant one with subsolvus and subalkaline features, and another one of shorter areal extent shows an hypersolvus character and an alkaline affinity (i.e., relatively high K_2O+Na_2O contents). They occur in close association in some massifs (e.g., São Carlos, Massangana), and the field relationships suggest that the alkaline rocks are younger than surrounding subalkaline ones.

The subalkaline suite consists at least of three distin intrusive granitic phases. Early intrusive bodies are recognize only in Massangana massif and are composed mainly of coars pyterlitic to porphyritic biotite (minor hornblend syenogranites, with zircon, apatite, ilmenite, magnetite, an fluorite as accessory minerals. Late intrusive syenogranites an alkali-feldspar granites are dominant in the area and sho medium- to fine-grained, porphyritic to equigranular texture with biotite and, locally, hornblende as the main mafic silicat minerals; zircon, monazite, ilmenite, and fluorite are commo accessory minerals. Latest intrusive rocks are rare, poorl exposed, and comprise mainly (topaz) lithium-mica albi granites, and (topaz) quartz-feldspar porphyries. Primary ti and associated metals deposits are spatially related to granit of the two latter phases, mostly as: lithium-mica albite grani with disseminated cassiterite, and minor columbite-tantalit pegmatite with topaz, beryl, cassiterite, and min columbite-tantalite(?); greisen bodies with cassiterite; quar vein with cassiterite and wolframite; and quartz vein wi Cu-Pb-Zn-Fe sulphides. Petrographic and geochemical da from selected subalkaline granites of this suite are plotted Figure 9: a. modal composition, b. Na_2O+K_2O vs. Si_2O, Na_2O+K_2O vs. 10000 Ga/Al, and d. chondrite-normaliz REE abundances.

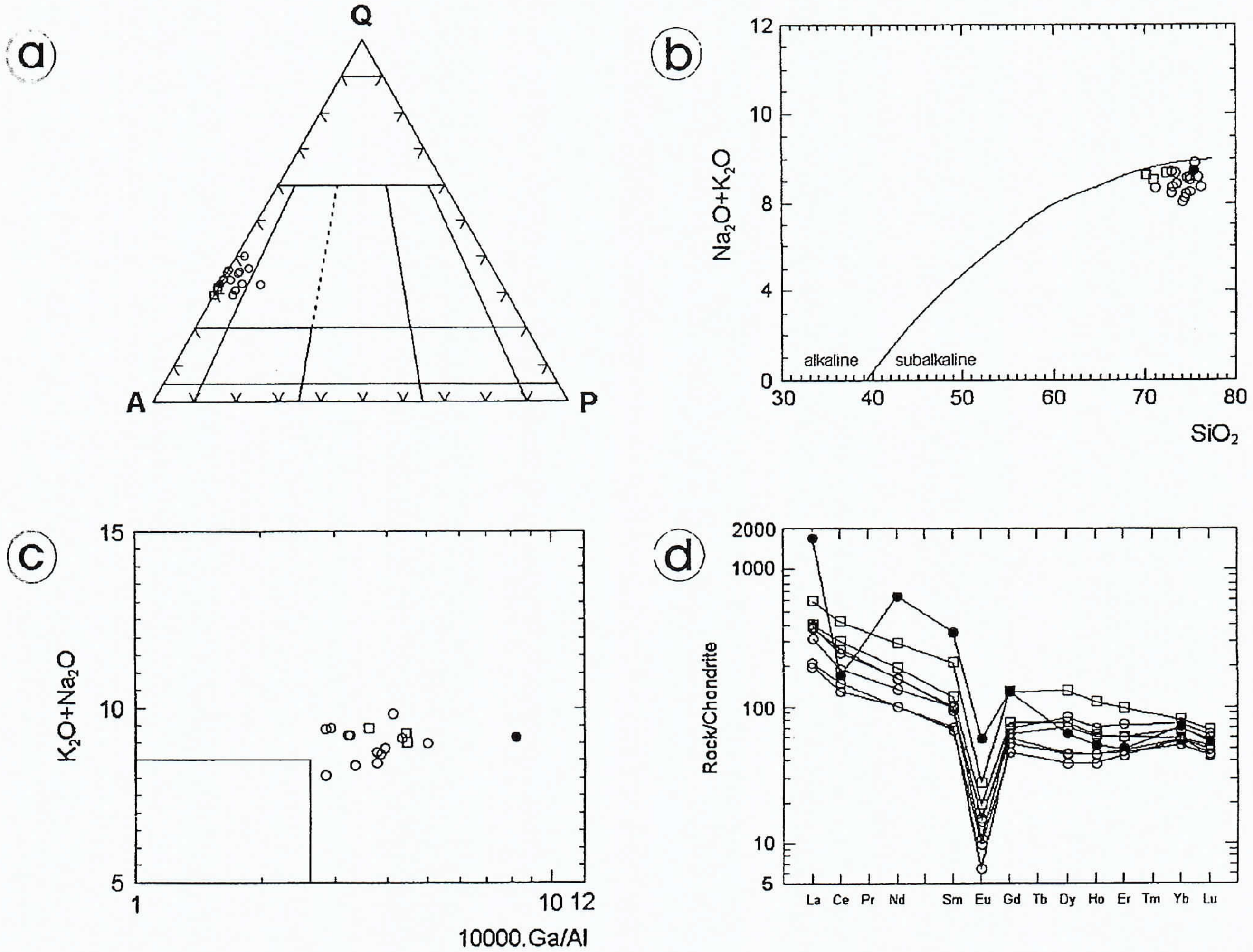


Figure 9 - Modal and geochemical characterization of the rocks for the subalkaline suite of the Younger Granites of Rondônia. (A) - QAP diagram (Streckeisen, 1976); (B) - SiO_2 versus Na_2O+K_2O diagram, alkaline and subalkaline fields from Irvine & Baragar (1971); (C) - 10000Ga/Al versus K_2O+Na_2O diagram from Whalen et al. (1987); (D) – Chondrite-normalized REE abundances (Boynton, 1984). Open square: horblende-biotite granite; open circle: biotite granite.

The alkaline suite involves alkali-feldspar granites and peralkaline granites, alkali-feldspar syenites and microsyenites, and subalkaline quartz-feldspar porphyries and hybrid rocks. Biotite and more rarely sodic amphibole are the main mafic silicate minerals in the granites, whereas augite and/or hornblende are common in the syenites and microsyenites. Hybrid rocks are quartz microsyenites or quartz syenite, both showing typical quartz ocelli mantled by pyroxene and/or amphibole. Mafic microgranular enclaves are also observed in the quartz syenites. Petrographic and geochemical data from selected alkaline granites of this suite are plotted in Figure 10: a. modal composition, b. Na_2O+K_2O vs Si_2O, c. Na_2O+K_2O vs. 10000 Ga/Al, and d. chondrite-normalized REE abundances.

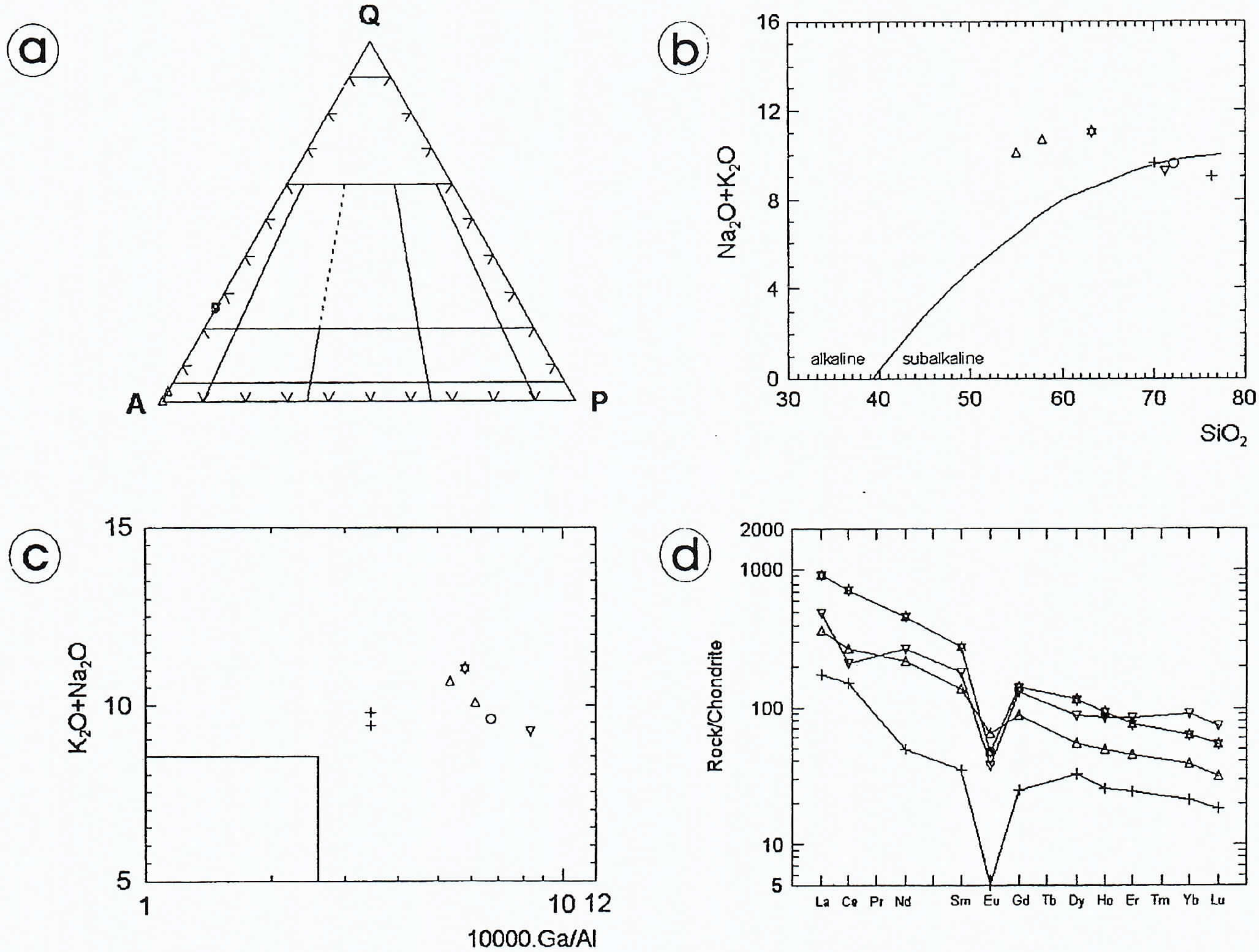


Figure 10 - Modal and geochemical characterization of the rocks from the alkaline suite of the Younger Granites of Rondônia. (A) - QAP diagram (Streckeisen, 1976); (B) - SiO_2 versus Na_2O+K_2O diagram, alkaline and subalkaline fields from Irvine & Baragar (1971); (C) - 10000Ga/Al versus K_2O+Na_2O diagram from Whalen et al. (1987); (D) – Chondrite-normalized REE plots (Boynton, 1984). Open triangle: microsyenite; star: syenite; open circle: biotite granite; inverted triangle: alkali granite; cross: quartz-feldspar porphyry.

FIELD TRIP AND STOP DESCRIPTION

A general outline and locations of the outcrops that will be visited are shown in Figure 11.

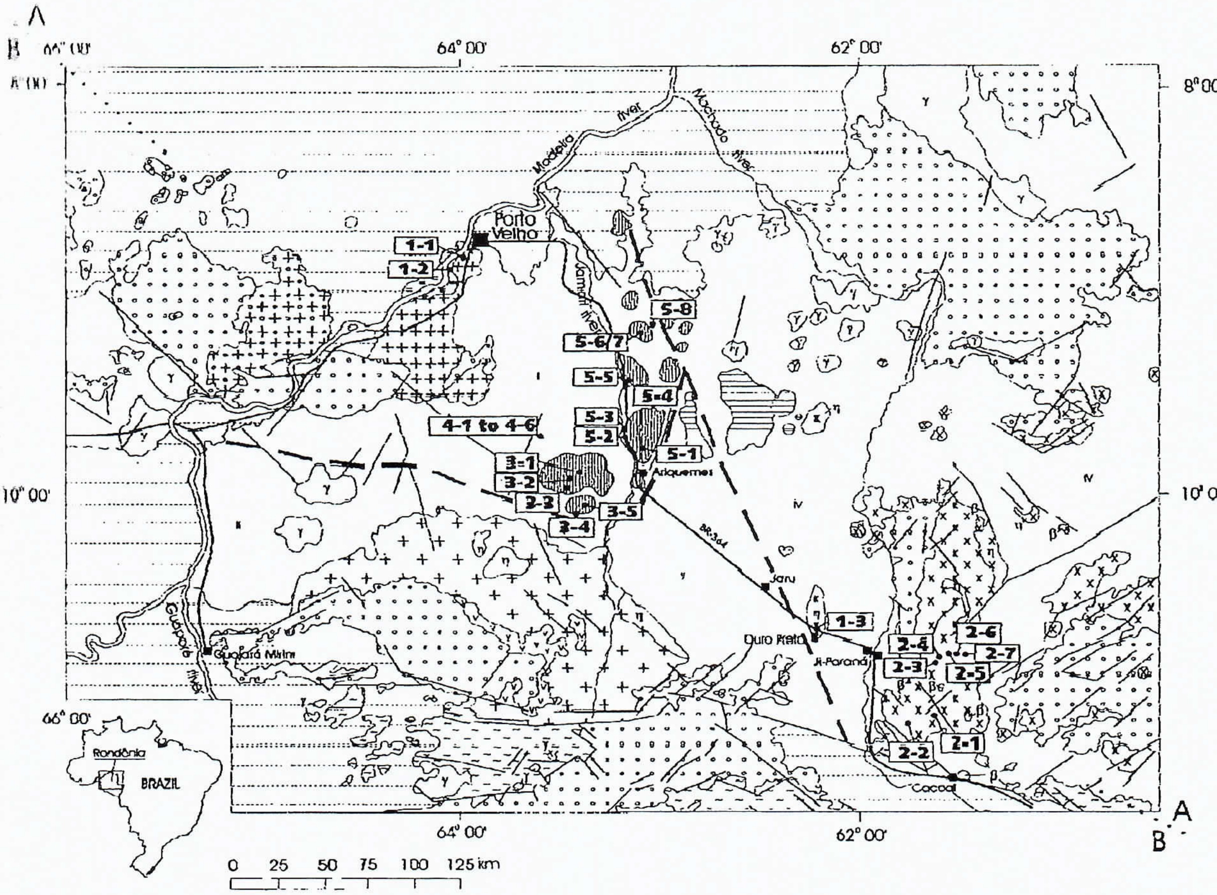


Figure 11 - Route map. Numbers in squares indicate the day and the stop on that day. See also Field Trip Log and Figure 4 for legend.

MONDAY 08.18.97 (first day)

Departure: 7:00 a.m. Hotel Vila Rica (Phone: -69-224.3433), Porto Velho city.
Route: Porto Velho-Teotônio cataract-Cacoal - 550 km.
Overnight: Cacoal town. Cacoal Palace Hotel (Phone: 069-441.5011).

Bruno Leonello Payolla - *Centrais Elétricas do Norte do Brasil S.A*
Jorge Silva Bettencourt - *Universidade de São Paulo São Paulo, Brazil*

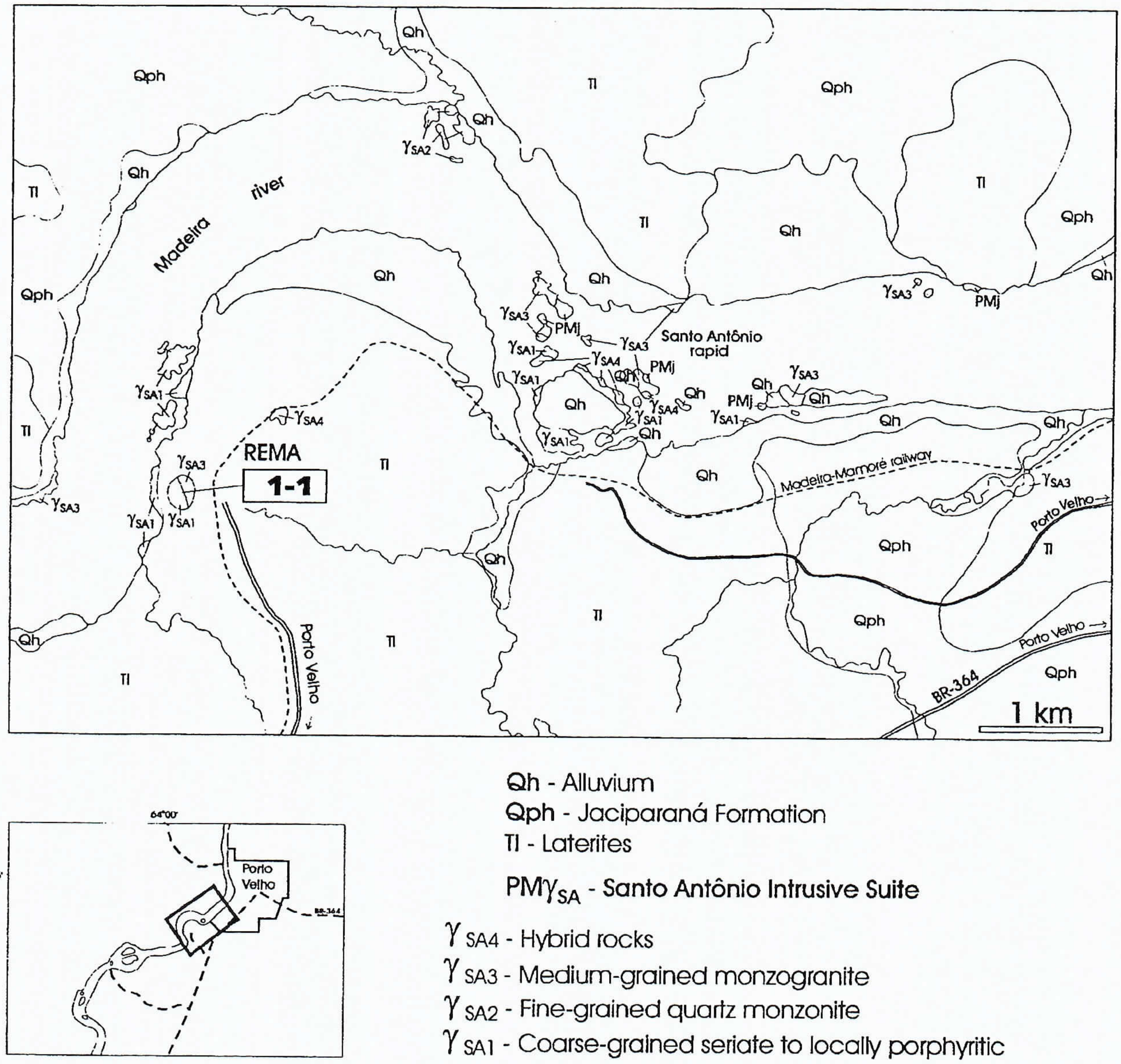
The first excursion day will be spent during the morning in inspecting outcrops of rocks belonging to the Santo Antônio Intrusive Suite and Teotônio Intrusive Suite (NE part of the Santo Antônio massif). The BR-364 route (Porto Velho city-Teotônio cataract) goes through Quaternary formations (sand, clay, and alterites) which have been used as building materials in the Porto Velho city and region. During the afternoon, we will stop on a road-cut outcrop of Ouro Preto charnockite (Serra da Providência Intrusive Suite).

Stop 1.1 - Coarse- and medium-grained granites

Location: REMA quarry, ca. 17.0 km from Porto Velho city (Figure 12).

Description: The quarry was opened at the contact between the two major rock types of the Santo Antônio Intrusive Suite in the Porto Velho region. A coarse-grained, seriate to locally porphyritic, monzogranite and syenogranite contain sparse mantled feldspars (anti-rapakivi and rapakivi types), and interstitial drop quartz. A medium-grained equigranular monzogranite exhibits diffuse porphyritic portions, and flow structure, defined by elongated biotitic schlieren, mafic (biotite and plagioclase) enclaves, and pegmatitic pods. The contacts between them are shown in the lateral walls of the quarry, where it is possible to see enclaves of coarse-grained granite in the medium-grained granite.

Problem to be discussed: coexistence and significance of rapakivi and anti-rapakivi textures



Qh - Alluvium
Qph - Jaciparaná Formation
Tl - Laterites

PMγ_{SA} - Santo Antônio Intrusive Suite

γ_{SA4} - Hybrid rocks
γ_{SA3} - Medium-grained monzogranite
γ_{SA2} - Fine-grained quartz monzonite
γ_{SA1} - Coarse-grained seriate to locally porphyritic monzogranite and syenogranite

PMj - Jamari Complex

Figure 12 - Geological map of the Porto Velho region and location of the Rema quarry.

Stop 1.2 - Alkali-feldspar granites and syenites.

Location: East side of the Madeira river at Teotônio cataract, ca. 34.0 km from Porto Velho city (Fig. 13).

Description: The outcrops expose typical coarse-grained alkali-feldspar granite of the Teotônio Intrusive Suite. This rock hosts a series of NE dipping, up to 2 meters wide, tabular bodies of gray to greenish fine- and medium-grained fayalite-ferrohedenbergite (quartz) alkali-feldspar syenite. A discontinuous border of coarse-grained quartz alkali-feldspar syenite occurs in the contact between the granite and medium-grained syenite. The medium-grained syenite shows igneous banding revealed by planar arrangement of tabular crystals of alkali-feldspar and elongated enclaves of fine-grained alkali-feldspar granite. Late pink fine-grained monzogranite occurs as SW dipping dikes cutting through the contacts between the granite and syenite.

Problems to be discussed: hypersolvus and subsolvus rock type associations, nature of syenite border.

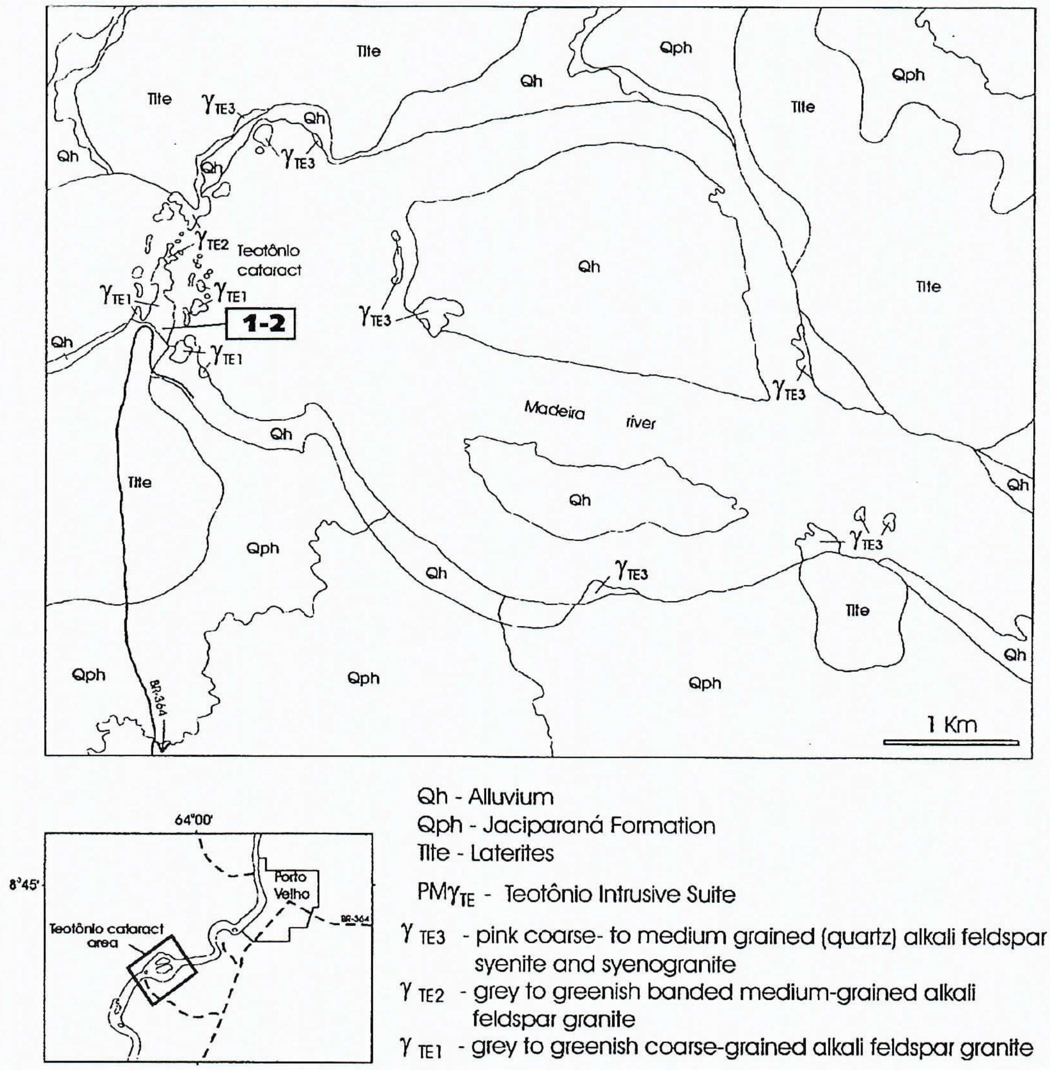


Figure 13 - Geological map of the Teotônio cataract region, showing the excursion site.

Stop 1.3-- Charnockite gneiss

Location: BR-364, km 412, within Ouro Preto town (Figure 4).

Description: Marginal area of a massive body. The rock shows greenish gray colour, slightly foliated structure, and coarse-grained porphyritic texture. Deformation and recrystallization at amphibolite facies is shown by occurrence of mortar texture in the perthitic K-feldspar, polycrystalline quartz aggregates, amphibole coronas around hyperstene and clinopyroxene, and by the presence of garnet. An U-Pb zircon age of 1.56 Ga provided by Van Schmus & Tassinari (1995, verbal comm.) is comparable to the ages of the massive granitoids from Serra da Providência batholith.

Problems to be discussed: charnockites in rapakivi suites, metamorphic imprint, primary and secondary mineral assemblages.

TUESDAY 08.19.97 (second day)

Departure: 7:00 a.m. Cacoal Palace Hotel. Cacoal town.
Route: Cacoal-Minister Andreazza-Ji-Paraná - 300 km
Overnight: Ji-Paraná town. Vitória Régia Hotel
(Phone: 069-422.1432).

Jayme Estevão Scandolara - Cia. de Pesquisa de Recursos Minerais, Porto Velho, Brazil
Jorge Silva Bettencourt - Universidade de São Paulo, São Paulo, Brazil

The whole day will be devoted to the rapakivi granites and associated gabbros of the Serra da Providência Intrusive Suite at the southern part of the Serra da Providência batholith (Figura 14). This portion of the batholith was recently mapped in a reconnaissance scale by CPRM (Companhia de Pesquisa de Recursos Minerais), and at this time no detailed petrographic and geochemical information are available. In general problems to discussed are tectonic setting, basic and granitoid rock relationships, enclaves, K-feldspar megacrysts texture and inclusions features.

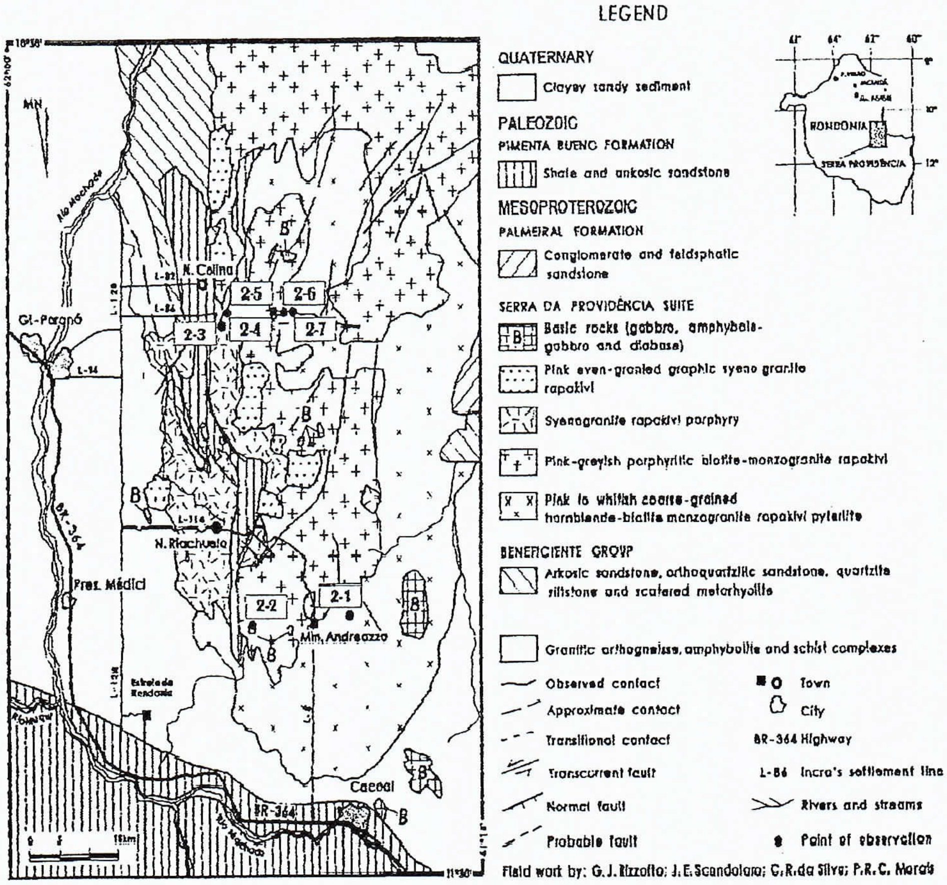


Figure 14 - Geological map of the southern part of the Serra da Providência batholith and adjacent area, showing the excursion sites.

Stop 2.1 - Wiborgite

Location: 10.6 km east from Minister Andreazza town.

Description: Pink, coarse-grained, porphyritic hornblende-biotite monzogranite with ovoid-shaped megacrysts of perthitic orthoclase, 2-6 cm or more in diameter, mostly mantled by plagioclase (andesine-oligoclase) shells (1-5 mm in thickness), and with inclusions of biotite, quartz and plagioclase. The groundmass is formed by K-feldspar (orthoclase and microcline), drop quartz, plagioclase, biotite and minor hornblende, as well as zircon, apatite, allanite, and opaque minerals. The wiborgite contain portions of dark hybrid rocks composed of plagioclase mantled K-feldspar megacrysts, gray-blueyish quartz ocelli, together with oval shaped mafic microgranular enclaves in a fine groundmass of biotite, hornblende, pyroxene, and subordinate quartz, plagioclase and K-feldspar.

Problem to be discussed: rapakivi texture, magma mixing and mingling evidences.

Stop 2.2 - Gabbro

Location: 11.5 km west from Minister Andreazza town.

Description: Small boulders of a gabbro (cross the road over about 30 meters) within a coarse-grained porphyritic biotite monzogranite domain. The gabbro is greenish gray in colour and shows mostly coarse-grained to porphyritic (idiomorphic whitish plagioclase phenocrysts) and subophitic or ophitic textures. Sometimes very coarse-grained subophitic or cumulate plagioclase laths in a fine groundmass zones are observed. At a microscopic scale the rock shows strong evidence of hydrothermal alteration, such as: pyroxene and subordinate amphibole transformed into aggregates of actinolite and chlorite, plagioclase altered to epidote and sericite, opaque minerals with mica rims, and quartz, epidote and chlorite filling microfractures, and intergranular spaces within the groundmass.

Problems to be discussed: relationship between basic and granitoid rocks, hydrothermal alteration

Stop 2.3. Granite porphyry

Location: L-86 secondary road, ca. 33.5 km from Ji-Paraná town.

Description: Small hill made up of subrounded boulders. The rock is a red-gray medium- to fine-grained porphyritic syenogranite. Subhedral and ovoid-shaped phenocrysts of K-feldspar (0.5 to 1.5 cm) are involved in a fine-grained granophiric groundmass consisting of quartz, K-feldspar, plagioclase, and green biotite. The granite porphyry includes numerous subrounded and elongated microgranular enclaves (5 to 10 cm), containing ovoid-shaped K-feldspar megacrysts.

Problems to be discussed: tectonic setting, controlling structures and contact relatinship.

Stop 2.4. Even-grained granite

Location: L-86 secondary road, ca. 36.7 km from Ji-Paraná town.

Description: Subrounded blocks and continuous large flat outcrops on top of a hill. The rock is pink medium-grained equigranular syenogranite, with typical micrographic texture and sparse K-feldspar phenocrysts, sometimes mantled by plagioclase. Perthitic orthoclase, quartz, plagioclase and minor biotite are the major constituents, with zircon and apatite as accessory minerals. The rock contain miarolitic cavities (2 to 5 cm) filled with quartz, K-feldspar, biotite, and more rarely fluorite, and is cut by millimetric pink aplitic dykes.

Problems to be discussed: fluid saturation evidences and hydrotermal alteration.

Stop 2.5. Porphyritic granite

Location: L-86 secondary road, 45.6 km from Ji-Paraná town.

Description: This is the most predominant granite type in the batholith. This is a pink-gray coarse-grained porphyritic hornblende-biotite monzogranite, with tabular and ovoid shaped K-feldspar phenocrysts (3 to 5 cm), occasionally mantled by plagioclase. A medium- to coarse-grained matrix is composed mainly of K-feldspar (orthoclase and microcline), quartz, plagioclase, biotite, minor hornblende, with zircon, apatite, opaque minerals, and allanite as accessory minerals. A feature common in this granite is the presence of rounded enclaves (10 to 15 cm in diameter) of quartz-dioritic to granodioritic composition. Agglomerates of green biotite and epidote, besides minor pegmatitic pods containing K-feldspar, quartz, and biotite are also observed.

Problems to be discussed: nature of the enclaves.

Stop 2.6. Porphyritic granite and pyterlite (optional)

Location: L-86 secondary road, ca. 47.0 km from Ji-Paraná town.

Description: The outcrop consists of a "boulder field" where it is possible to observe a greater amount of ovoid-shaped K-feldspar phenocrysts in granitic rock than the last outcrop. All other features are very similar those recognized in the last outcrop.

Problems to be discussed: transitional contact.

Stop 2.7. Pyterlite

Location: L-86 secondary road, ca. 49.0 km from Ji-Paraná town.

Description: A pink, coarse-grained, pyterlitic hornblende-biotite monzogranite containing mostly unmantled ovoids (3 to 5 cm in diameter) of K-feldspar phenocrysts. Biotite and minor hornblende (with rare clinopyroxene relicts) are the predominant mafic silicate minerals, whereas zircon, apatite, opaque minerals, and allanite are common acessory minerals. The granite shows centimetric oval-shaped microgranular enclaves of granitic to quartz-dioritic composition, and more rarely angular xenoliths of foliated metassedimentary rock.

Problems to be discussed: pyterlite texture

WEDNESDAY 08.20.97 (third day)

Departure: 7:00 a.m. Vitória Régia Hotel. Ji-Paraná town.
Route: Ji-Paraná-Massangana-Ariquemes - 320 km.
Overnight: Ariquemes town. Ariquemes Hotel
(Phone: 069-535.2200).
Jorge Silva Bettencourt - Universidade de São Paulo, São Paulo, Brazil.

We shall reach Massangana mining district at approximately 12:00 a.m. for lunch. No excursion stops will be made on the way, though gneissic rocks (Jamari Complex ?) can be seen in dozens of road cuts. The main problems to be discussed here are not much different from what has been discussed in the Serra da Providência batholith, although important tin mineralization is associated to the Massangana rocks.

THE MASSANGANA MASSIF

The Massangana pluton intrudes rocks of the Jamari Complex, and was briefly described by Kloosterman (1967, 1968), Waghorn (1974), and Isotta et al. (1978). More recently Romanini (1982) distinguished four intrusive phases, viz: Massangana, Bom Jardim, São Domingos, and Taboca (Figure 15). The Massangana phase is represented by coarse porphyritic biotite granites, with tabular and ovoid shaped megacrysts of K-feldspar (porphyritic and pyterlitic granites). These granites are dominant in the massif, and were the first to be emplaced. Bom Jardim and São Domingos granites are latter than Massangana granites, and are normally coarse-, medium- to fine-grained, equigranular in texture, and sometimes they exhibit scarce phenocrysts of K-feldspar. Biotite is the main mafic silicate mineral identified in these rocks. The Taboca is the latest phase, and is primarily represented by hornblende syenites and quartz-syenites cutting the Bom Jardim granites. Bom Jardim and São Domingos granites define a reliable Rb-Sr whole rock isochron age of 960±27 Ma, with Ri=0.714±0.014 (Bettencourt et al., 1995), which is about 31 Ma younger than the U-Pb zircon age of 991±14 Ma from the Massangana pyterlite (Bettencourt et al., submitted). Primary tin mineralization is spacially associated with Bom Jardim and São Domingos granites, mostly as quartz veins with cassiterite and minor wolframite, greisen bodies with cassiterite, and pegmatites with beryl, topaz, cassiterite, and minor columbite-tantalite. Tin placers were exploited during the last thirty years, and big topaz crystals were only mined from alluvium deposits for the last ten years. At the moment the mine is closed.

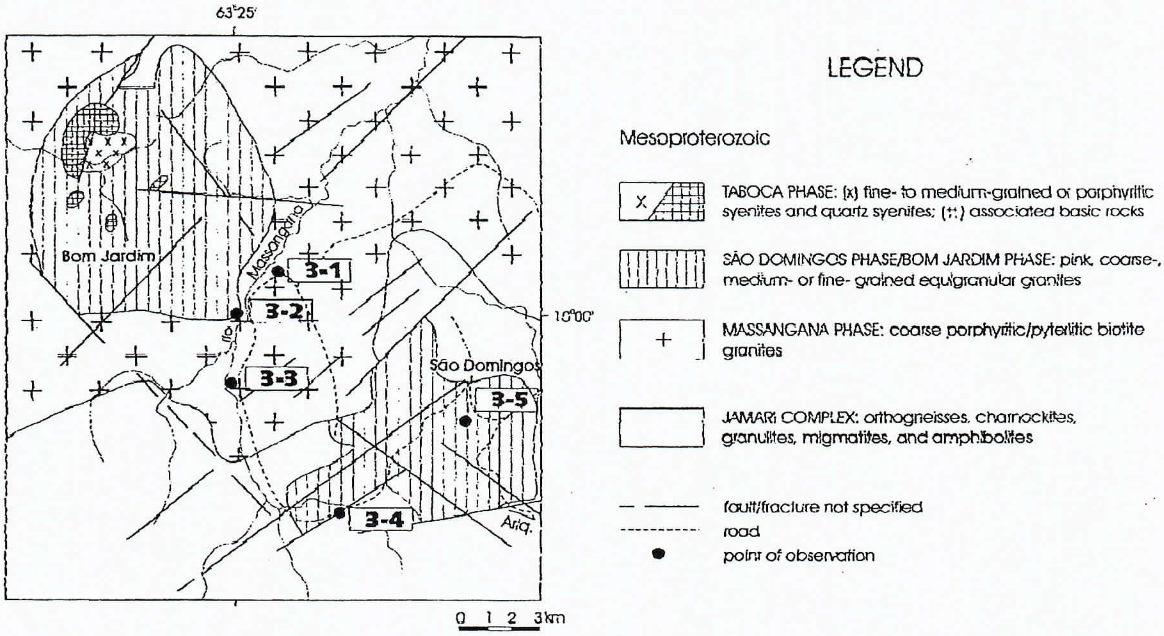


Figure 15 - Geological map of part of the Massangana massif and adjacent area (after the exploration staff of the Taboca Mining C. and Romanini, 1982), showing the excursion sites.

Stop 3.1 - Pyterlite (Massangana phase)

Description: This is a massive porphyritic syenogranite with dominant ovoid-shaped K-feldspar phenocrysts (2-5 cm in diameter) dispersed in medium-grained groundmass composed mainly of K-feldspar, plagioclase, drop quartz, and brown biotite. The K-feldspar phenocrysts are perthitic microcline, usually with plagioclase, biotite and quartz inclusions. The accessory minerals are zircon, apatite, allanite, and opaque minerals. A sample of this rock provides an U-Pb zircon age of 991±14 Ma.

Stop 3.2 - Internal contact breccia (agmatite)

Location: Small hill at left margin of the Massangana river, near a bridge.

Description: The Bom Jardim, fine to even-grained biotite granite intrudes the Massangana coarse-grained porphyritic biotite granite. The contact is sharp and blocky, with many fragments of the Massangana granite in the Bom Jardim granite, as far as 50 m from the contact.

Problems to be discussed: magmatic stoping.

Stop 3.3 - Pyterlite (Massangana phase)

Description: Typical coarse-grained pyterlitic granite of the Massangana phase. The megacrysts are mostly oval-shaped, comprising around 50% of the rock and attaining dimensions of 10 cm. They are dominantly perthitic microcline without plagioclase rims, but some megacrysts of plagioclase are also observed. The matrix exhibits a medium- to coarse-grained texture and is composed mainly of microcline, drop quartz, plagioclase and biotite.

Stop 3.4 - Contact breccia (xenolithic granite)

Description: The São Domingos granite contains angular, decimetric to metric xenoliths of different types of rocks among which predominate a biotite augen gneiss (Jamari Complex); some of them showing bands of mylonitic gneiss or small fragments of amphibolite. The xenoliths are dislocated from their original positions and show sharp contact with the host granite.

Problems to be discussed: magmatic stoping and basement country rocks.

Stop 3.5 - Even-grained granite (São Domingos phase)

Description: A pink, medium grained equigranular biotite syenogranite showing some centimetric, oval shaped microgranular enclaves, rare foliated enclaves, and biotite aggregates. This granite is affected by pervasive post-magmatic alteration, with sericite, fluorite, topaz, and chlorite as the main secondary minerals.

THURSDAY 08.21.97 (fourth day)

Departure: 7:00 a.m. Ariquemes Hotel. Ariquemes town.
Route: Ariquemes-Bom Futuro-Ariquemes - 150 km
Overnight: Ariquemes town. Ariquemes Hotel
(Phone: 069-535.2200).
Renato Muzzolon - Empresa Brasileira de Estanho S.A.
Jorge Silva Bettencourt - Universidade de São Paulo, São Paulo, Brazil.

Augen gneiss (Jamari Complex) and granite (Younger Granites of Rondônia) outcrops can be seen on both sides of the road during the trip to the Bom Futuro mining district. The excursion will examine in detail several geologic and petrographic aspects of the silicic magmatism and associated tin mineralization at the Bom Futuro district.

THE BOM FUTURO DISTRICT

Two small hills and a flat area around them are the topographical features of the Bom Futuro district. The Palanqueta hill shows a dome-shaped form and a semi circular outline. This hill is build up by three granitic facies with greisen bodies associated with them (Silva et al., 1995) (Figure 16). The dominant facies (albite granite) has a pink colour and porphyritic texture, with subhedral to euhedral phenocrysts (2-5 mm) of quartz, microcline, and more rarely of albite and topaz, in a fine-grained matrix composed of albite, quartz, microcline, topaz, greenish gray to brownish mica, fluorite, opaque minerals, and cassiterite. The greisens is composed mainly of quartz, Li-mica, topaz, fluorite in varied proportions, with minor sulphides (galena, sphalerite, chalcopyrite), cassiterite, and locally wolframite. At 500m to the southwest occurs the Bom Futuro hill that consists of a boomerang-shaped residual relief, measuring around 100 hectares in area, with maximum differences in elevation on the order of 100 m, where the cassiterite has been exploited intensively since 1987 (Figure 17). The structure comprises two subvolcanic centers hosted in NNW-trending gneisses and amphibolites, which define two-pipe system linked by a conduit nearly 25 m wide (Villanova & Franke, 1995). A dyke-like body of topaz-quartz-feldspar (rhyolite) porphyry occurs mainly in the eastern pipe. Tin is most associated with quartz veins and veinlets disposed generally in a ring pattern dipping outward ca. 35°, and locally in a stockwork structure.

Stop 4.1 - Topaz-lithium-mica albite granite and greisen bodies

Location: Eastern side of the Palanqueta hill.

Description: Pink to grayish porphyritic alkali-feldspar granite with subhedral to euhedral phenocrysts (2-5 mm) mainly of quartz and microcline showing snow ball texture. The matrix exhibits a fine-grained texture and is composed by albite, quartz, microcline, Li-micas, topaz, fluorite, with minor cassiterite and opaque minerals. Greisens form centrimetric to decimetric discontinuous bodies. They show massive structures, coarse to fine-grained textures, and a mineralogical composition based principally on quartz, topaz, Li-mica, and fluorite. Shoots of coarse-grained galena or cassiterite and wolframite are observed locally.

Problems to be discussed: magmatic vs. metassomatic origin of the albite granite, styles of hydrothermal alteration and mineralization.

Stop 4.2 Gneiss and amphibolite

Description: The gneiss is banded, sometimes highly deformed. Quartz-feldspar leucocratic bands are intercalated with mesocratic bands containing biotite as the main mafic mineral. The amphibolite is closely related to the gneiss, constituting discontinuous layers with abrupt lateral contacts. The rocks show NNW-trending with vertical to subvertical dips.

Stop 4.3 - Subvolcanic breccia

Description: The breccia shows a clast-matrix-supported or matrix-supported textures and a polymict character. It mainly consists of angular to subangular fragments of gneisses, amphibolites, granites, and subvolcanic acid rocks ranging in size from few centimeters to several meters. The fragments are partially or completely involved by a matrix of topaz-quartz-feldspar porphyry.

Problems to be discussed: intrusive vs. non-intrusive nature.

Stop 4.4 - Topaz-quartz-feldspar (rhyolite) porphyry

Description: The rock has a whitish gray colour and a microporphyritic texture. The subhedral to anhedral phenocrysts (0.5 cm in general) of albite, quartz, and microcline are immersed in fine-grained groundmass mainly composed of albite, quartz, microcline, topaz, fluorite, and greenish gray to brownish yellow mica. Flow structure and granitic enclaves have been observed in some places.

Problems to be discussed: genetic correlation with the albite granite, hydrothermal alteration and ore mineralogy.

Stop 4.5 - Quartz veins

Description: Quartz veins of variable thickness (2 m of width) crosscut all the above-mentioned rock types, with general dips of ca. 35° away from the central part of the structure. These veins are made up of quartz, greenish mica, and cassiterite, with minor feldspar and wolframite. The salbands are normally enriched in mica, topaz, fluorite, and cassiterite.

Problems to be discussed: structural pattern and internal zoning.

FRIDAY 08.22.97 (fifth day)

Departure: 7:00 a.m. Ariquemes Hotel. Ariquemes town.
Route: Ariquemes-Santa Bárbara- Porto Velho - 220 km.
Overnight: Porto Velho city. Ho tel Vila Rica
(Phone: 069-224.3433).
Jorge Silva Bettencourt -Universidade de São Paulo, São Paulo, Brazil.
Washington B. Leite Jr. - Universidade Estadual Paulista, São Paulo, Brazil..
Bruno Leonello Payolla - Centrais Elétricas do Norte do Brasil S.A.

The morning will be spent inspecting the rocks of São Carlos and Caritianas massifs. We hope to arrive at Santa Bárbara mining district at 12:00 noon, where we will have lunch. Departure from Santa Bárbara towards Porto Velho at 16:00.

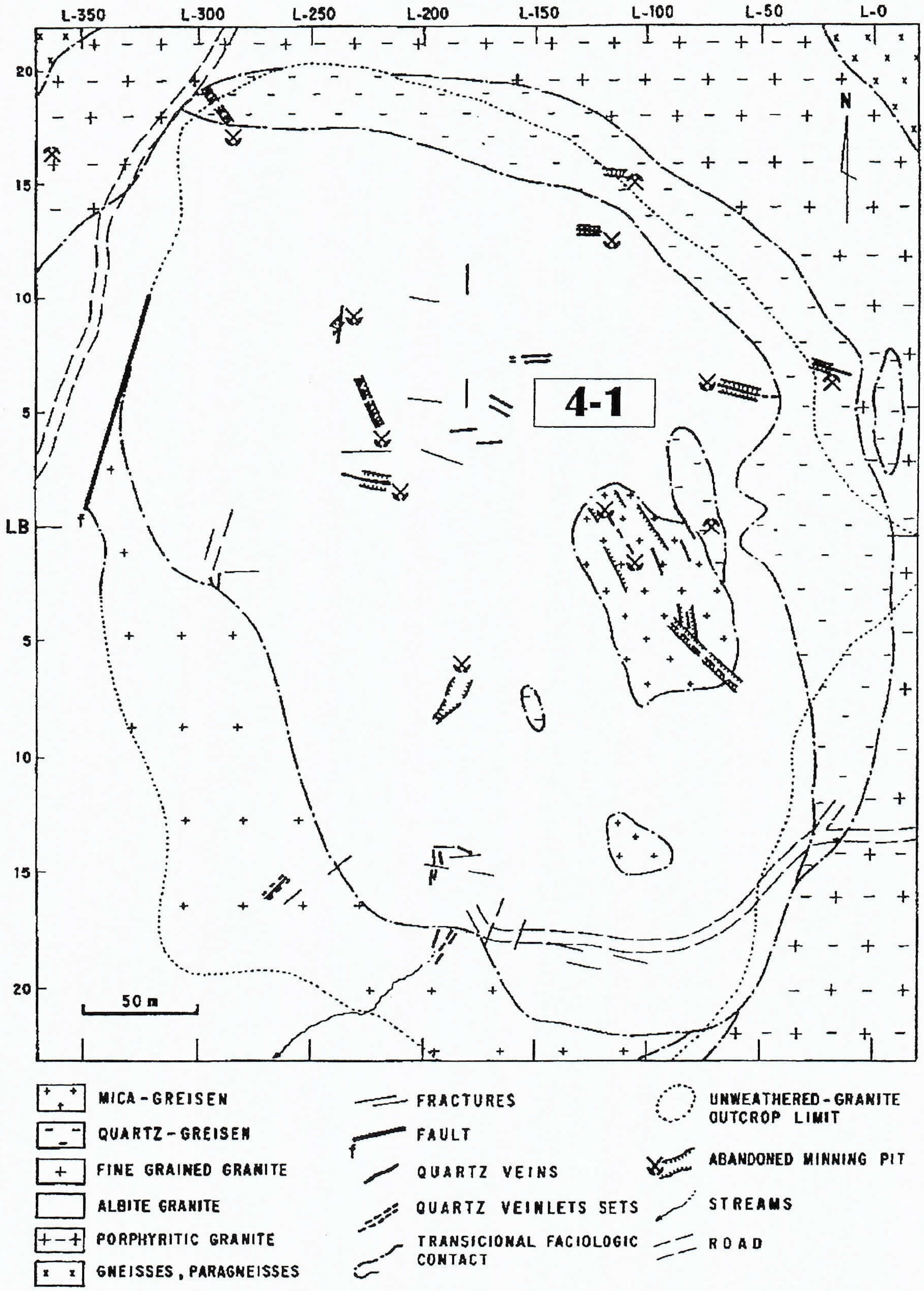


Figure 16 - Geological map of the Palanqueta hill (modified from Silva et al., 1995), showing the excursion site.

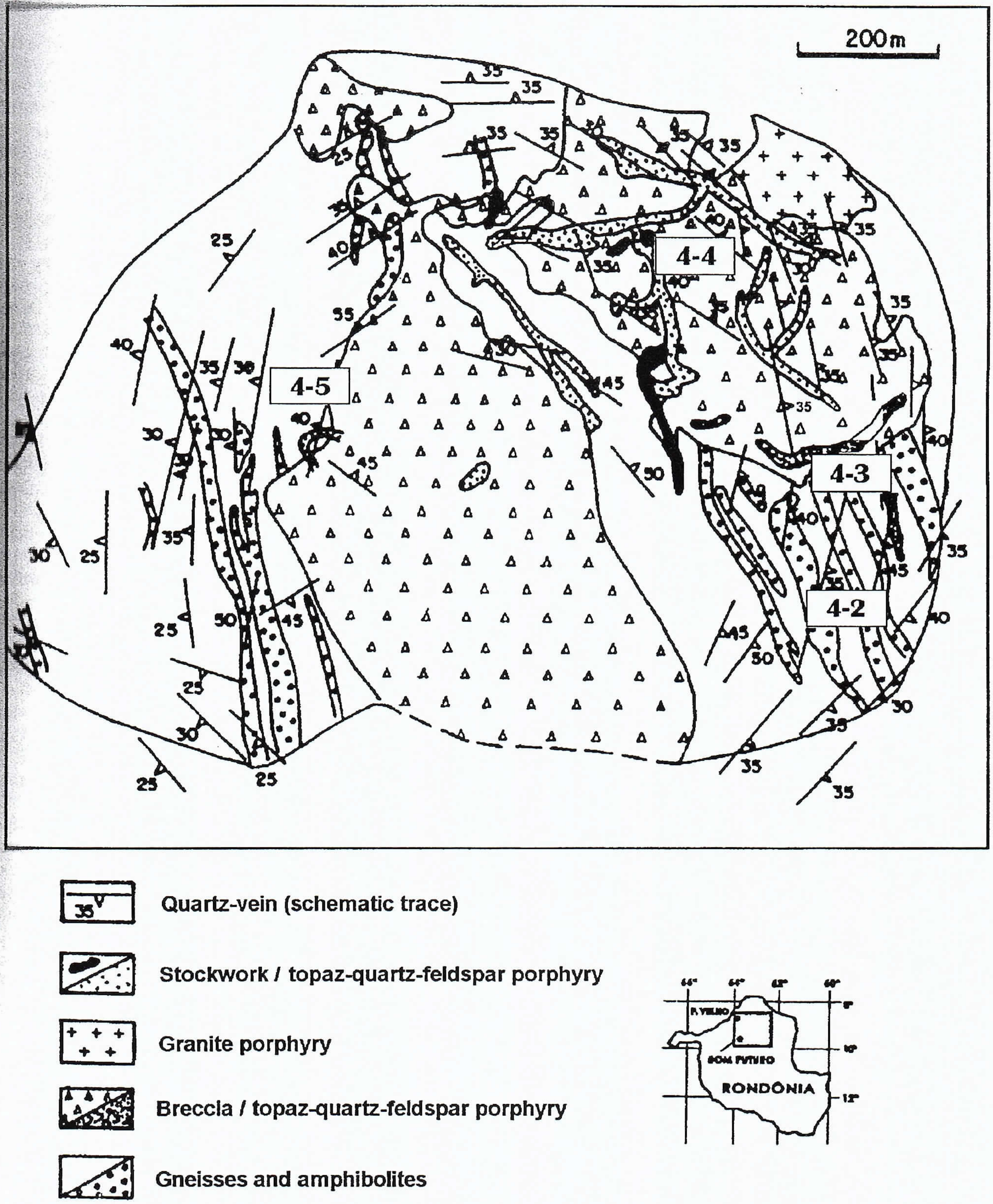


Figure 17 - Geological map of the Bom Futuro Hill (modified from Villanova & Franke, 1995), showing the excursion sites.

THE SÃO CARLOS MASSIF

The São Carlos massif (ca. 290 km^2) has an oval shape elongated parallel to NNE regional trends (Figura 18). The massif comprises at least three subalkaline granitic units: medium- to coarse-grained equigranular biotite-hornblende alkali-feldspar granite, equigranular to porphyritic biotite syenogranite, and medium- to fine-grained biotite syenogranite. At the center of the massif occurs a partially preserved cauldron collapse structure that is 10 km in diameter. This structure is made up of an outer and discontinuous ring-dyke of quartz-feldspar porphyry, surrounding a central body consisting mainly of subvolcanic alkaline rocks and roof pendants of granites and gneisses. The alkaline rocks are represented by medium- to fine-grained pyroxene-amphibole alkali-feldspar syenite, pyroxene microsyenite, and biotite alkali-feldspar microgranite. The action of post-magmatic process is shown mainly by diffuse greenish alteration zones, usually overprinted by reddish zones (hematitization) on subalkaline granitic facies at the western border of the massif.

Stop 5.1 Alkaline and subalkaline rocks

Location: L-75 secondary road, ca. 5.0 km from BR-364 road.

Description: A hill at margin of the cauldron structure. A continuous profile uphill will show us rocks of the inner portion of the cauldron structure, ring-dyke, and country rock: greenish gray medium- to fine-grained equigranular hornblende-hedenbergite syenite with enclaves of microsyenite, dark gray pyroxene microsyenite with quartz xenocrysts mantled by pyroxene, quartz-feldspar porphyry veining by microsyenites, and coarse-grained biotite-hornblende alkali-feldspar granite. Downhill, at the base of the electric tower, occurs an alkali-feldspar microgranite with enclaves of microsyenite.

Problems to be discussed: cauldron structure, style of magma emplacement, magma mingling and mixing.

Stop 5.2 – Nova Mina Quarry

Location: BR-364 road, ca 5.2 km from Ariquemes town.

Within the quarry the predominant rock is a pink-greyish porphyritic granite which is composed of rounded quartz crystals (<1.0 cm), pink FK phenocrysts (<2.5 cm), grey-greennish plagioclase, hornblende (hastingsite), biotite and mafic aggregates, as important components.

Rounded porphyritic granite enclaves (cm) in diameter and fine-grained granite dykes 40 cm wide with pegmatoid layers, are found in many parts if the porphyritic granite. The contacts of the dykes with the host rocks are commonly diffuse but are sometimes sharp.

Most of the rocks of the quarry are affected by diffuse greyish hydrothermal alteration which, at the southern part of the quarry, is over-printed by brick-red diffuse alteration zones, probably fracture controled.

Problems to be discussed: hydrothermal alteration

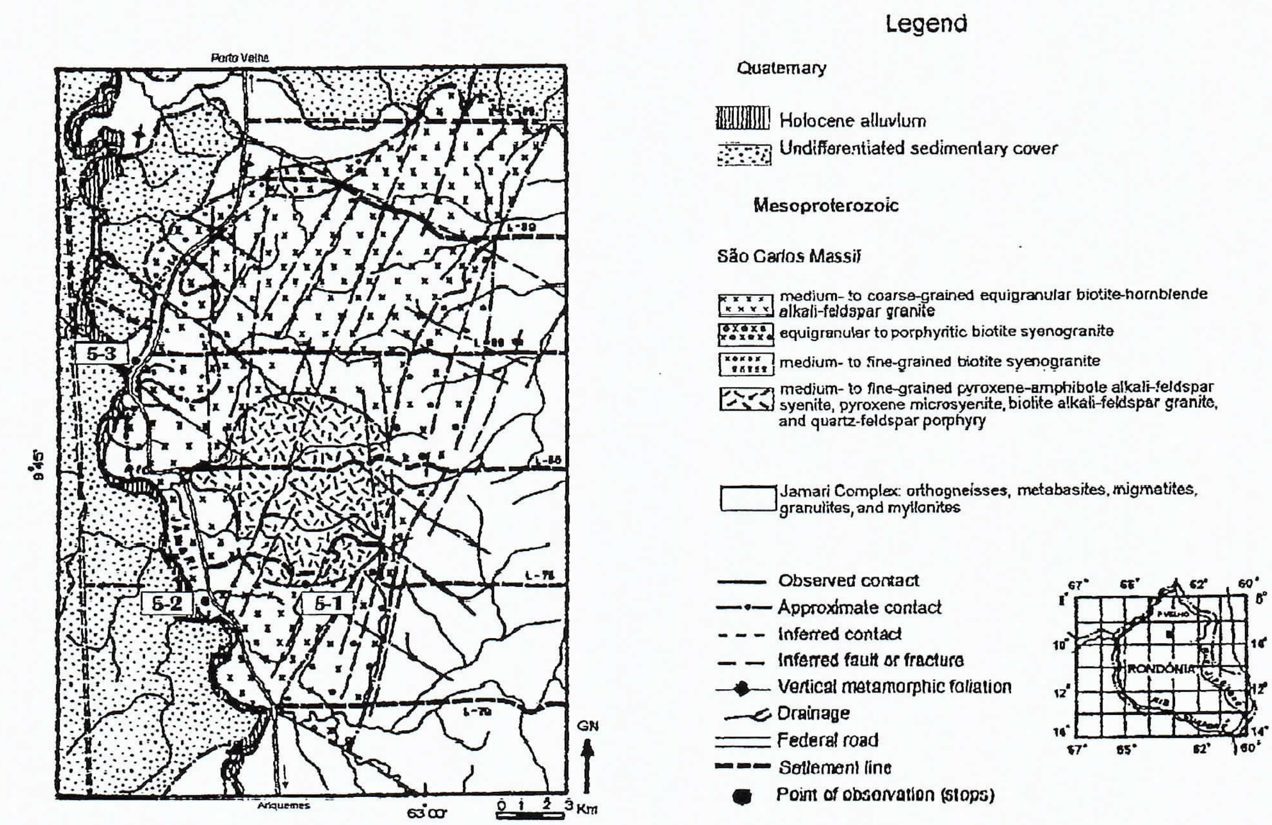


Figure 18 - Geological map of the São Carlos massif (from Bettencourt, J.S. et al., 1989), showing the excursion sites.

Stop 5.3 Contact breccia (agmatite)

Location: BR-364 road, ca. 26.0 km from Ariquemes town.
Description: Biotite syenogranite intrudes augen gneiss. The contact is sharp and blocky, with many fragments of the augen gneiss in the biotite syenogranite. The fragments are angular, decimetric to metric, and some are displaced from their original positions.
Problems to be discussed: magmatic stoping and country rocks.

THE CARITIANAS MASSIF

The Caritianas massif comprises an area ca. 200 km2, being part of a much larger pluton covered by Quaternary sediments (Figura 19). This massif is composed of two major granitic units: medium-grained equigranular biotite alkali-feldspar granites, with microgranular enclaves of granodioritic compositon, and porphyritic biotite alkali-feldspar granites (Pinho, 1987). These granites exhibit miarolitic cavities and are cut by dyke-like bodies of microgranites, aplites and pegmatites. Primary tin mineralization is spacially related to even-grained alkali-feldspar granites as greisen bodies and quartz veins with cassiterite.

Stop 5.4 - Even-grained biotite alkali-feldspar granite

Location: EMBRATEL transmission tower, ca 4.0 km from BR-364 road.
Description: Pink, medium-grained equigranular biotite alkali-feldspar granite with rounded microgranular enclaves (up to 10 cm) of granodioritic composition, and sparce miarolitic cavities composed by K-feldspar, quartz, and green biotite.

Problems to be discussed: nature and significance of the enclaves, comparision with Massangana and São Carlos even-grained biotite granites.

Stop 5.5 - Porphyritic biotite alkali-feldspar granite (optional).

Location: Closed 5° BEC quarry, left side of BR-364 road, 60 km from Ariquemes town.
Description: Porphyritic biotite alkali-feldspar granite with miarolitic cavities and dykes of pegmatites containing beryl and molybdenite, and microgranites. The granite shows diffuse and fracture-related alteration characterized by greenish zones composed mainly of micas and reddish zones with disseminated fine crystals of hematite (hematization).
Problems to be discussed: styles of hydrotermal alteration.

José Antônio Jerônymo Vian - Companhia Estanífera do Brasil S.A.
Jorge Silva Bettencourt - *Universidade de São Paulo, São Paulo, Brazil.*

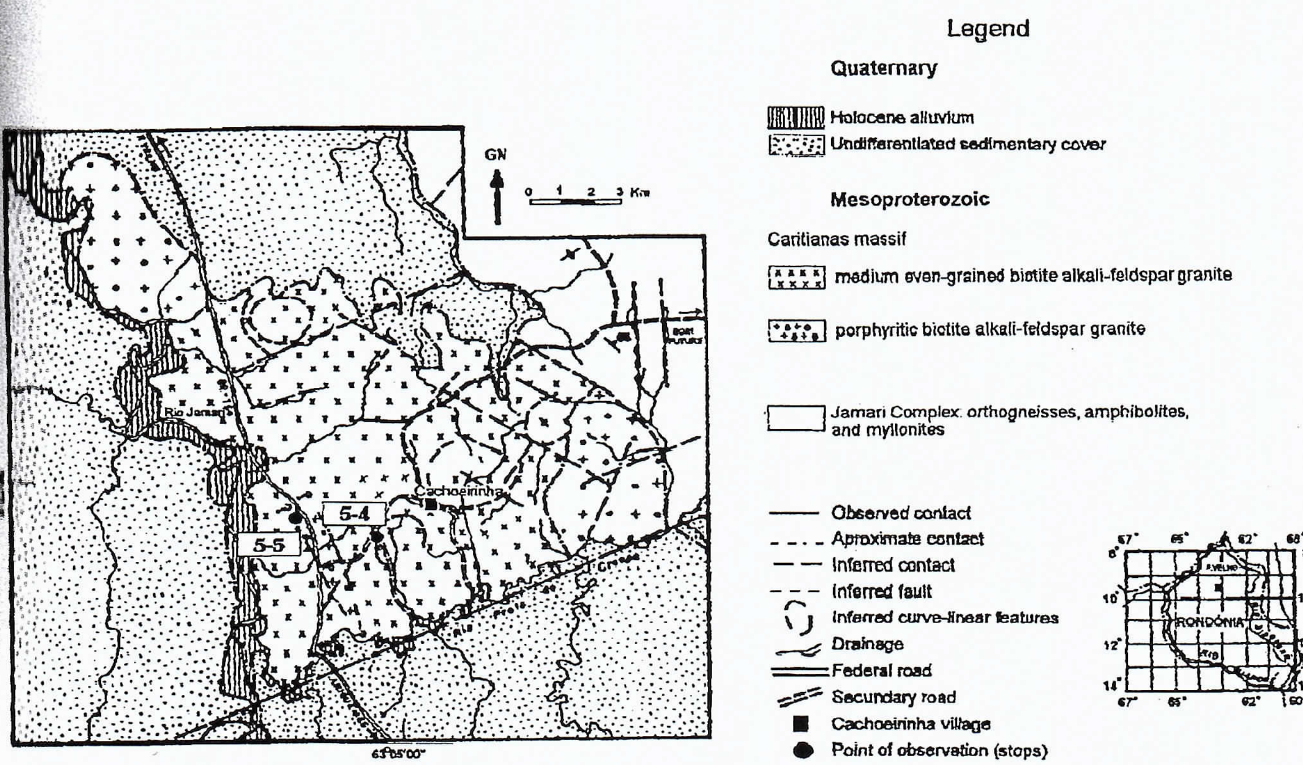


Figure 19 - Geological map of the Caritianas massif and adjacent area (after Pinho, 1987), showing the excursion sites.

THE SANTA BÁRBARA MASSIF

The Santa Bárbara massif has a subrounded shape with a diameter of 5 km and is composed of three main granitic units (Frank, 1990): medium to coarse grained equigranular biotite alkali-feldspar granite (Serra Azul granite), porphyritc biotite alkali-feldspar granite (Serra do Cícero granite), and medium to fine grained equigranular biotite alkali-feldspar granite (Santa Bárbara granite) (Figures 19, 20). Several types of late to post-magmatic alteration such as microclinization, albitization, greisenization, silicification, and argillization are recognized mainly in the latter unit at Santa Bárbara hill. Primary tin mineralization is spatially related to Santa Bárbara granite and occurs mainly as greisen bodies with cassiterite, quartz veins with cassiterite, and minor wolframite.

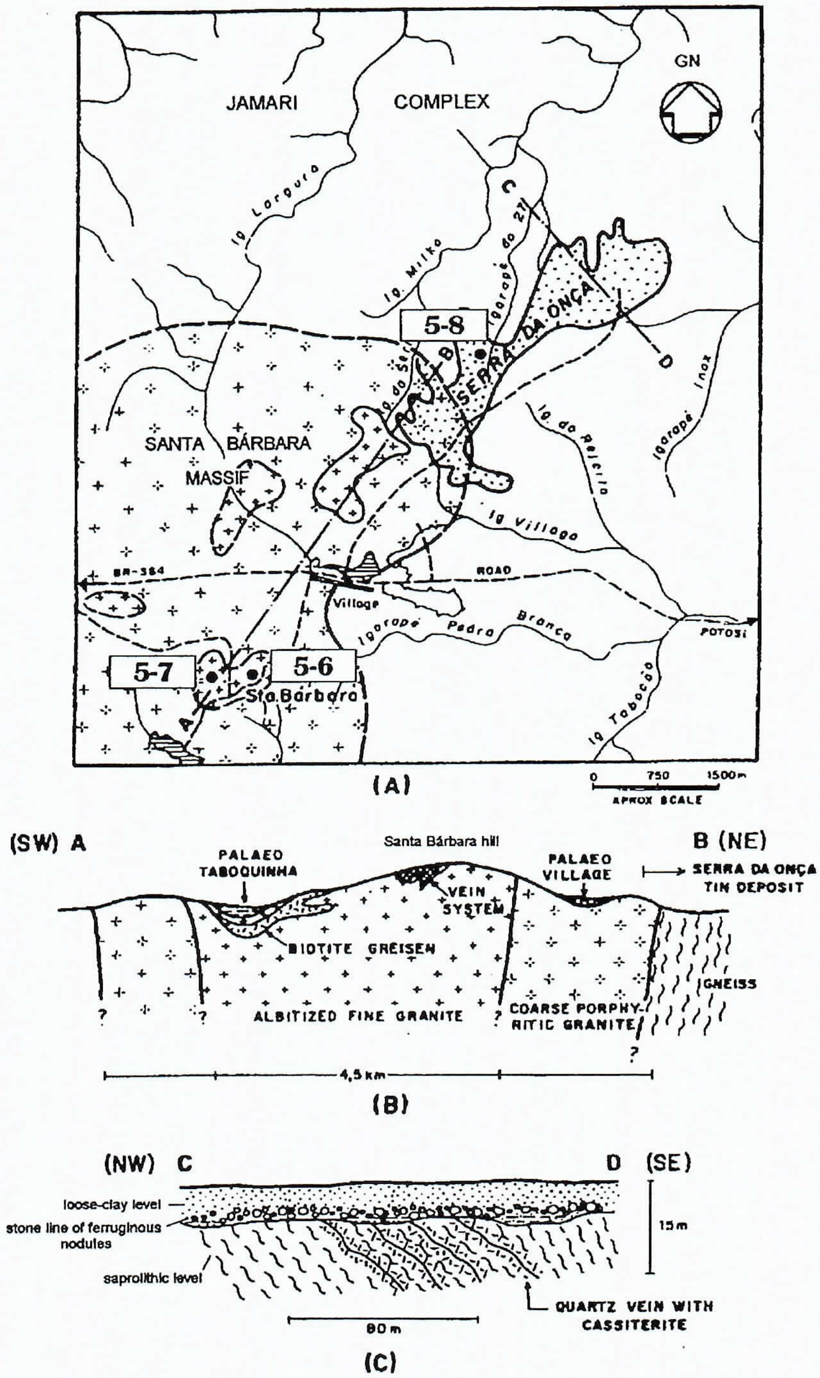


Figure 20 - (A) Geological map of part of the Santa Bárbara massif and adjacent area, (B) Cross-section of the Santa Bárbara massif, illustrating its geologic features and the primary and secondary tin mineralizations (A and B after the exploration staff of the Cesbra), and (C) - Stratigraphic cross-section of the Serra da Onça deposit (adapted from the exploration staff of Cesbra and Oliveira & Valenti, 1993).

Stop 5.6 - Even-grained biotite alkali-feldspar granite

Location: Santa Bárbara village.

Description: Boulders of coarse to medium-grained equigranular biotite alkali-feldspar granite (Serra Azul granite). This is the dominant granitic rock in the Santa Bárbara pluton, and it is mainly of microcline, albite, quartz, and brown biotite. The common accessory minerals are zircon, apatite, monazite, allanite, and opaque minerals.

Stop 5.7 - Even-grained biotite alkali-feldspar granite, greisens, and quartz veins

Location: Santa Bárbara hill and Taboquinha greisen.

Description: Greisen and quartz veins cutting light pink medium to fine-grained equigranular biotite alkali-feldspar granite (Santa Bárbara granite). The greisen occurs as millimetric to centimetric subvertical veins, with dominant NE and subordinate NW trends, forming local pockets at the intersections of veins. The greisen is mainly composed of quartz, Li-micas, topaz and minor cassiterite. The quartz veins (2-30 cm wide) show a dominant subvertical NE orientation and consist of milk, quartz, Li-micas, and minor cassiterite. Stockworks of millimetric white kaolin veins are also observed.

Problems to be discussed: styles of hydrothermal alteration and mineralization.

Stop 5.8 - Exogreisen and elluvial tin placer

Location: Serra da Onça mining pit.

Description: There are occurrences of primary cassiterite in greisen and quartz veins that cut the gneissic country rocks of the Santa Bárbara massif. These veins are similar to those described for the Santa Barbara hill, although sulphides (pyrite, sphalerite and bismuthite) in quartz veins have been recognized in drill core. The alluvial placer is a lateritic weathering profile comprised, from bottom to top, by a saprolitic level, a stone line of ferruginous nodules, and loose-clay level. The higher cassiterite concentrations occur in the upper two horizons of the lateritic profile.

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