PETROGRAPHY AND GEOCHRONOLOGY OF AMPHIBOLITIC ROCKS IN THE SÃO JOSÉ DOS QUATRO MARCOS AREA, SOUTHWESTERN MATO GROSSO, BRAZIL

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INTRODUCTION

The Amazon craton in the São José dos Quatro Marcos region in southwestern Mato Grosso State (Fig. 1) consists of gneissic terrains (mostly tonalitic and granodioritic composition) with a Rb/Sr isochronic age of 1971 ± 70 Ma (R_o = 0.7017) and K/Ar ages around 1500 Ma (biotites and hornblendes) (CARNEIRO, 1985; CARNEIRO & ULBRICH, in prep.). These terrains (Fig. 2) are intruded both by granitoids with a Rb/Sr isochronic age of 1472 ± 19 Ma (R_o = 0.7037) (CARNEIRO et al., 1989) and several amphibolitic rocks (ortho- and para-derived). The ortho-amphibolitic rocks are classified tentatively in two generations (CARNEIRO & ULBRICH, in prep.). The first generation corresponds to rectangular and angular disrupted xenoliths within gneissic rocks (Fig. 3). Their internal structures are concordant with the gneissic foliation. The second generation amphibolites are found as xenoliths within the granitoid rocks (Fig. 4). They frequently show angular and polygonal shapes, sometimes resembling true agmatitic structure.

PETROGRAPHY

The ortho-amphibolitic rocks are meso-melanocratic, and dense, with dark greenish black color and fine to medium grain size. Their textures are predominantly grano-nematoblastic with schistose structure. These rocks are formed mainly by hornblende (Table 1), although in some cases plagioclase can be more abundant. The plagioclases make up oriented polycrystalline aggregates with associated polygonal crystals of quartz and diopside. Quartz-feldspathic and hornblende layers can occur locally. The ortho-amphibolitic rocks can be classified as hornblende amphibolites, diopside-hornblende amphibolites and hornblende amphibolites with diopside.

MINERALOGY

Hornblende occurs as subhedral to anhedral crystals, sometimes porphyroblastic. Other times it occurs as small inclusions within other minerals. Poikiloblastic hornblende crystals can be found too, with few plagioclase, diopside and hornblende idiomorphic inclusions. Hornblende pleochroism is mostly green or more rarely brown. Plagioclase (with albite and Carslbad twinning) occurs as subhedral to anhedral crystals of irregular shapes and andesitic to labradoritic composition with hornblende (idiomorphic-subidiomorphic), diopside

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and apatite inclusions. Diopside can reach significant amounts rarely (Table 1). Normally, the diopside is colorless to pale green, mostly as small anhedral inclusions within hornblende and plagioclase or associated with plagioclase in the quartz-feldspathic layers. Quartz is subordinate but can reach as much as 10-20% in some samples. This mineral shows polygonal crystals in quartz-feldspathic layers, sometimes associated with mafic minerals. Quartz can occur as bleb inclusions within plagioclase and hornblende. Brown biotite was found only once, associated with hornblende. Opaques, allanite, zircon, titanite and apatite are accessory minerals, frequently associated with hornblende. Carbonate, epidote and sericite are alteration products of plagioclase. Altered hornblende shows granular inclusions of epidote.

GEOCHRONOLOGY

Nine samples of hornblende from ortho-amphibolites of the São José dos Quatro Marcos region (Fig. 5) were dated by the K/Ar method and provide a coherent age pattern at 1500 Ma (Table 2). This K/Ar age pattern is similar to the available K-Ar regional cooling ages on biotites and hornblendes of the gray gneissic terrains of the area (CARNEIRO, 1985; CARNEIRO & ULBRICH, in prep.). A Rb/Sr isochronic age on intrusive granitoids of slightly younger than 1500 Ma (CARNEIRO et al., 1989) is consistent with the regional cooling history of the metamorphic rocks.

CONCLUSIONS

The field data and available isotopic results (CARNEIRO, 1985; CARNEIRO et al., 1989; CARNEIRO & ULBRICH, in prep.) on the São José dos Quatro Marcos region indicate at least two regional events, with generation and/or crustal emplacement of three rock assemblages (gneisses, ortho-amphibolites and granitoids). The first event of Transamazonic age is reported as a homogenization of the Rb/Sr system of the gray gneisses under amphibolite facies. The first generation of ortho-amphibolites may also have been related to this event although this is not well constrained geochronologically. The emplacement of granitoids corresponds to the second event, of late to post-tectonic character, at 1472 $\pm$ 19 Ma ago and was approximately contemporaneous with the regional cooling of the ortho-amphibolites and gneissic rocks, as demonstrated by their K/Ar ages around 1500 Ma..

Finally, concerning the origin of the ortho-amphibolites, those of the first generation can be tentatively interpreted as mafic dykes (or dyke-swarms) probably broken and deformed during the regional Transamazonic tectonic event. However, the origin of the second generation ortho-amphibolitic rocks is not quite clear yet. In this respect, CARNEIRO et al. (1989) believe that the parental magmas could have been generated by "basaltic magma underplating" type processes (e.g. FURLONG & FOUNTAIN, 1986). This process may involve early basaltic magmas which were emplaced at subcrustal levels or in the lower crust (with quartz-feldspathic composition). During such magma intrusion, partial fusion of the crust favors the generation of granitoid magmas which sometimes include early basaltic magmas as amphibolitic rock xenoliths.

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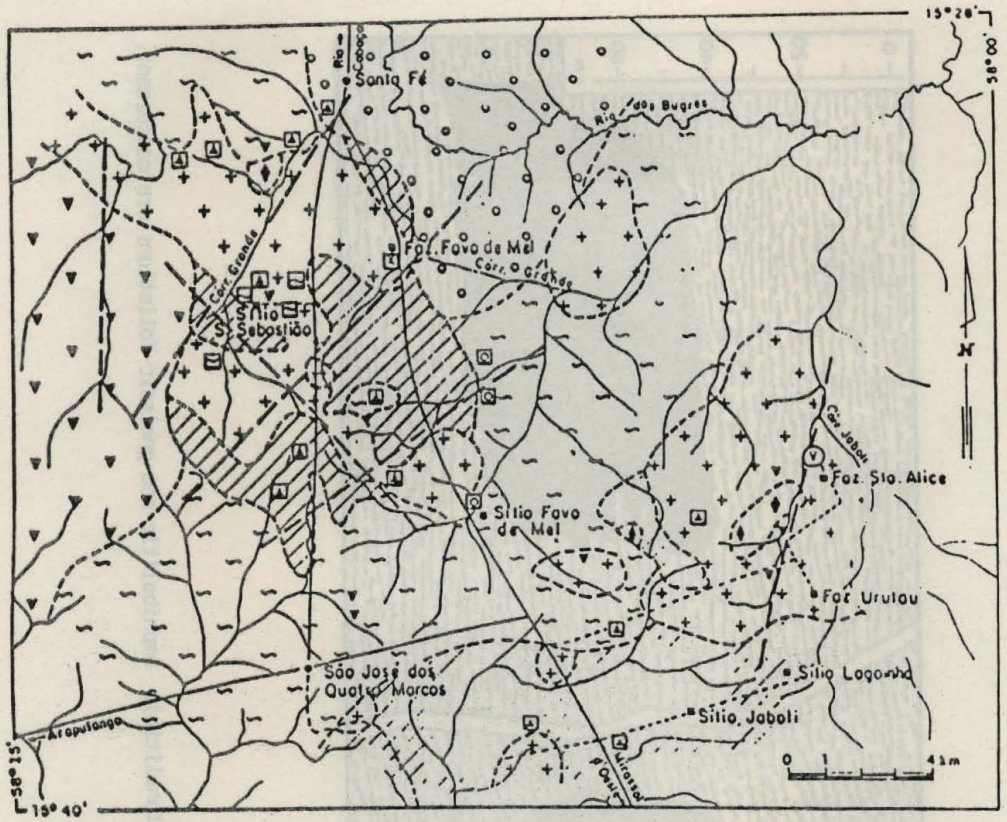
Figure 1 - Locality map: I - Amazon Craton, II - Paraguay-Araguaia Belt.



LEGEND

Petrographic Domains

Fractures

Rb/Sr Ages

K/Ar Ages

Age (m.a.)

1

1500 2 Diorites

3

4 Enclaves

5

6

2000(?) 7 Enclaves Granulites

Figure 2 - Petrographic domains of the São José dos Quatro Marcos area (CARNEIRO & ULBRICH, in prep.). Units: 1. Volcanites; 2. Massive granitoids; 3. Oriented granitoids; 4. Amphibolitic rocks; 5. Calc-silicate rocks; 6. Pink gneisses; 7. Gray gneisses.

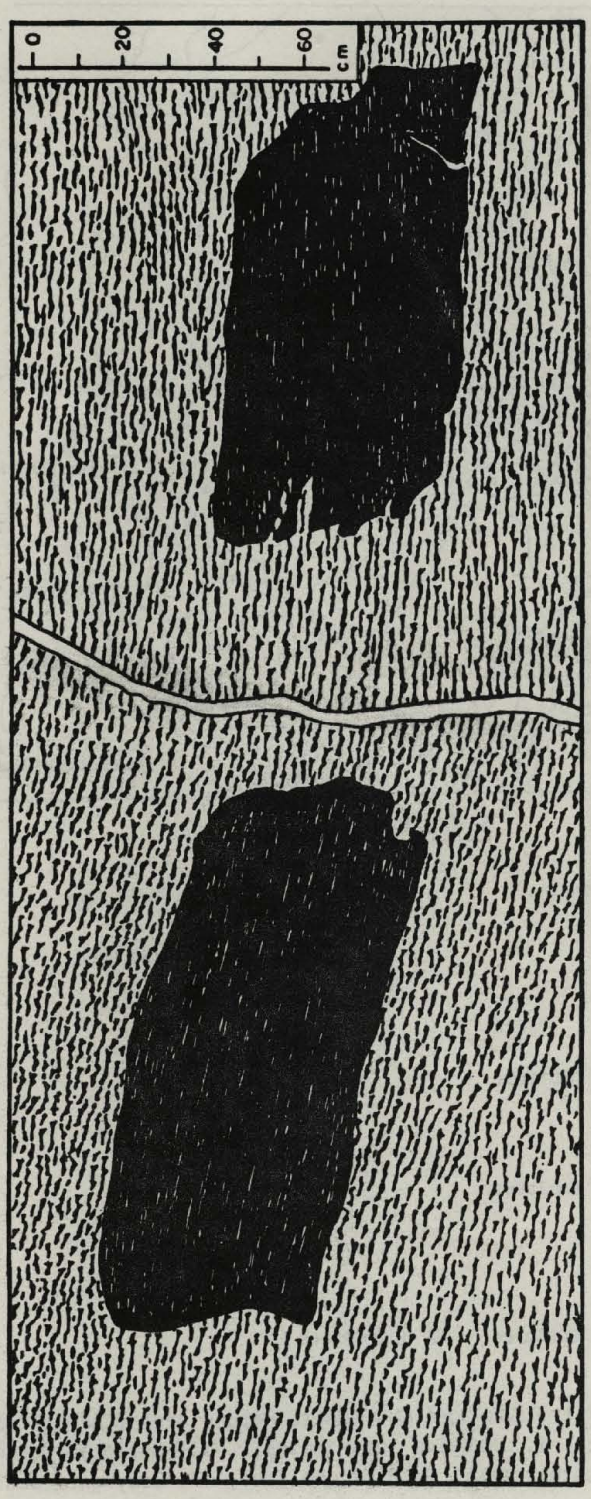


Figure 3 - Amphibolite xenoliths within gray gneisses (tonalitic). Amphibolitic and gneissic foliations are concordant.

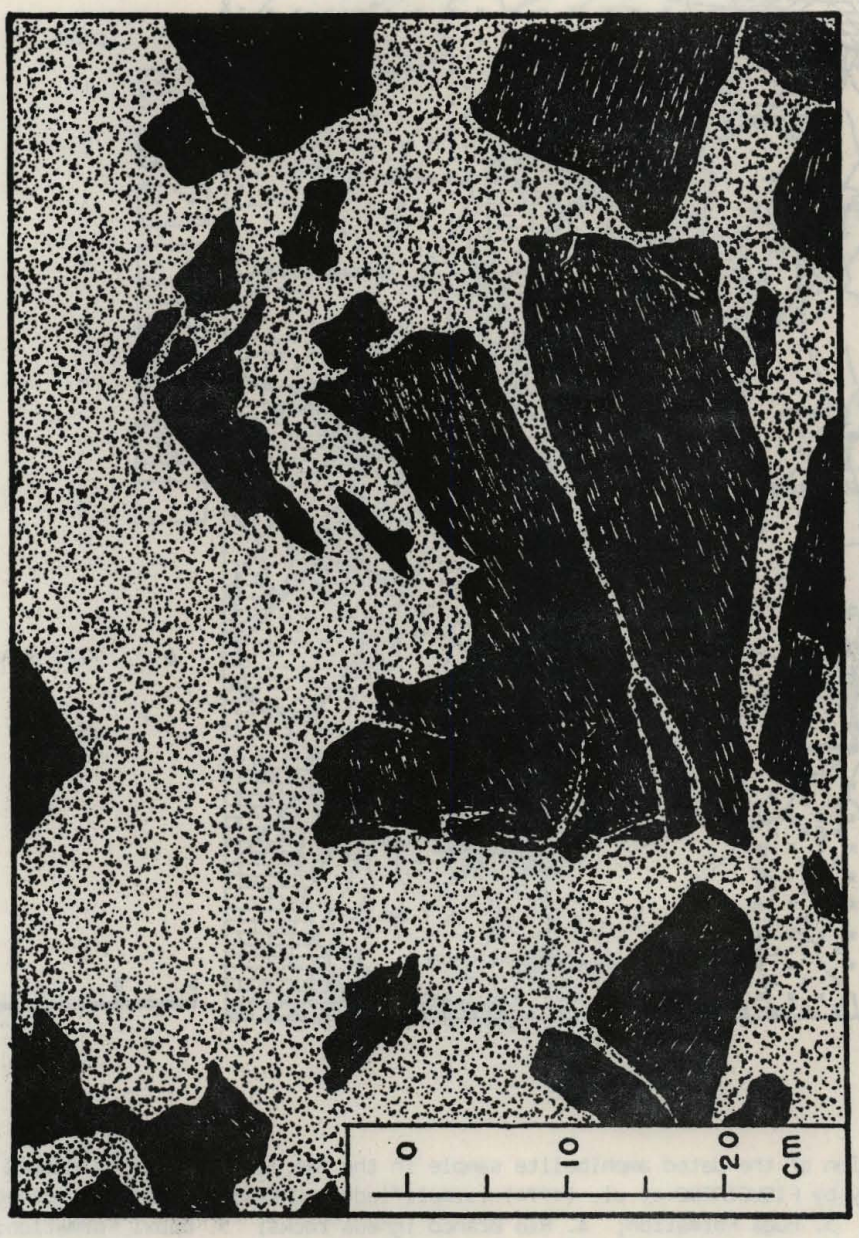


Figure 4 - Agmatitic structure: amphibolite xenoliths within granitoid matrix.

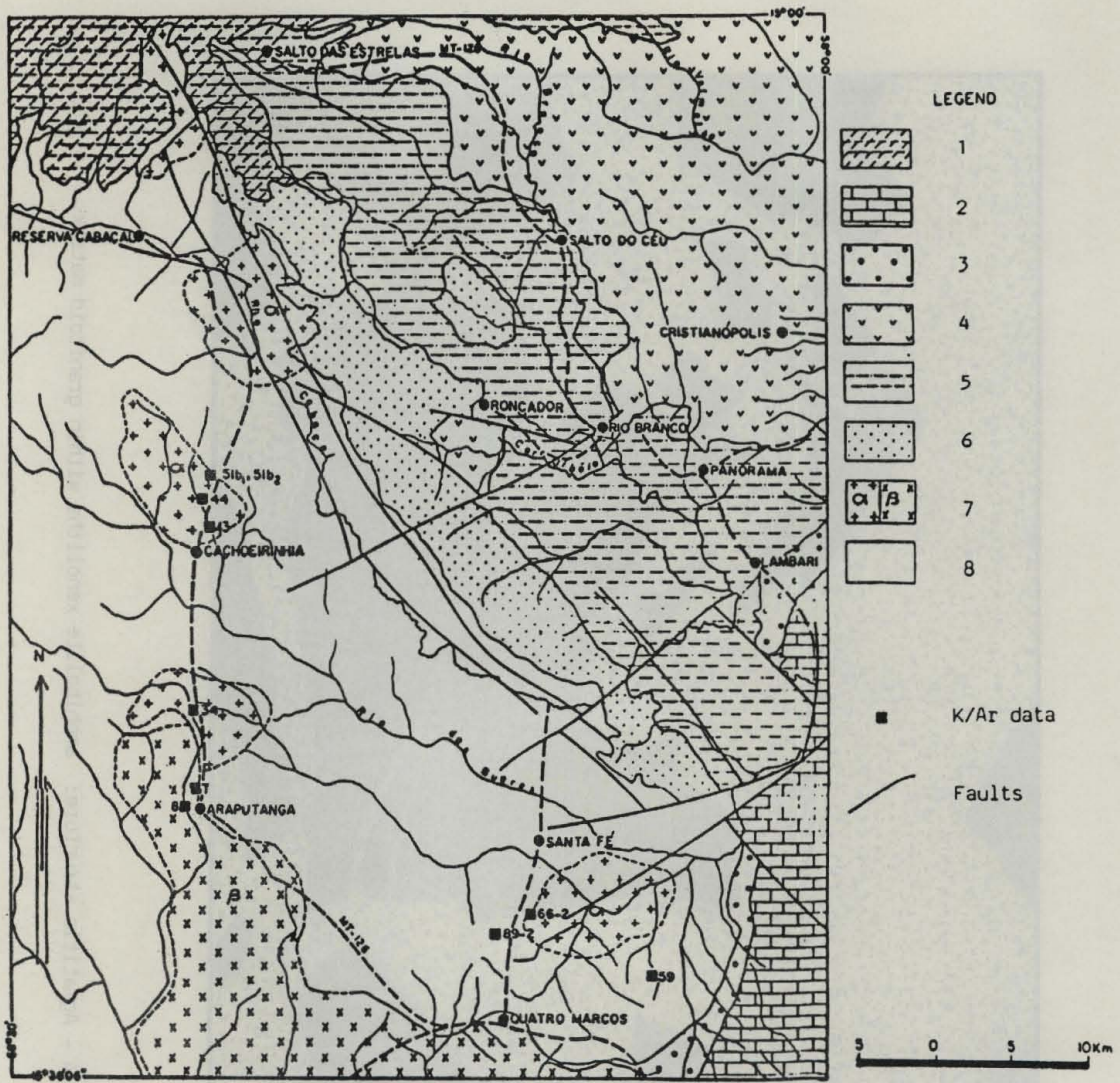


Figure 5 - Localization of the dated amphibolite sample in the São José dos Quatro Marcos area (K/Ar ages). Geology by FIGUEIREDO et al. (1974) (simplified). Units: 1. Parecis Formation; 2. Araras Formation; 3. Puga Formation; 4. Rio Branco igneus rocks; 5. Bauxi Formation; 6. Aguapeí Formation; 7. Acid (α) and basic (β) intrusive rocks; 8. Basement Complex.

Table 1 - Modal analyses of the amphibolites of the São José dos Quatro Marcos region.

MINERALOGY	SAMPLES											
	7	8	34d	44	51b1	51b2	59	66.2	89.1	102.2	124.1	124.8
Plagioclase	37.4	57.7	39.6	55.5	19.0	39.5	54.5	39.9	36.2	38.0	44.0	59.4
Hornblende	56.0	33.7	49.5	37.0	66.7	49.6	36.3	47.1	61.9	42.8	52.0	39.0
Diopside	tr	tr	tr	tr	9.5	tr	tr	tr	tr	-	tr	tr
Epidote*	4.6	3.8	1.0	4.6	1.9	tr	tr	tr	tr	tr	tr	tr
Quartz	2.0	4.8	9.9	2.9	2.9	9.9	9.2	13.0	1.9	9.1	4.0	1.6
Biotite	-	-	-	-	-	-	-	-	-	10.1	-	-
Opaques	-	tr	tr	tr	tr	1.0	tr	tr	tr	tr	tr	tr
Titanite	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Allanite	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Apatite	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Zircon	-	-	tr	tr	tr	-	tr	tr	tr	-	-	tr
Carbonate*	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Sericite*	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr

*alteration minerals

Bol.IG-USP, Sér.Cient., 20:47-56, 1989.

Table 2 - K/Ar isotopic dates on amphibolites from the São José dos Quatro Marcos region (hornblende ages).

Sample	Geographic coordinates	Laboratory number	Petrographic classification	K (%)	^{40}Ar rad (cc STP/g) x 10^{-6}	^{40}Ar atm (%)	Age (Ma)
07	58°23'07" W / 15°27'36" S	4970	hornb amphibol w/diops	0.7309	68.67	4.18	1535 ± 47
08	58°23'31" W / 15°28'16" S	4972	hornb amphibol w/diops	0.3311	30.20	15.79	1503 ± 42
34d	58°23'07" W / 15°24'49" S	4973	hornb amphibolite	0.7472	65.45	4.51	1463 ± 41
51b1	58°22'34" W / 15°16'51" S	4976	diops-hornb amphibolite	0.2192	18.98	21.53	1453 ± 50
51b2	58°22'34" W / 15°16'27" S	4977	hornb amphibolite	0.3070	27.90	11.47	1503 ± 82
44	58°22'50" W / 15°17'23" S	4996	diops-hornb amphibolite	1.0646	99.39	3.28	1527 ± 35
66.2	58°10'23" W / 15°34'03" S	5126	hornb amphibolite	0.6604	60.97	2.80	1516 ± 40
59	58°03'45" W / 15°36'20" S	5127	hornb amphibolite	0.2692	22.23	7.33	1404 ± 42
89.2	58°11'32" W / 15°35'05" S	5128	diops-hornb amphibolite	1.2180	111.48	1.97	1507 ± 37

% ^{40}K in total K = 1.167×10^{-2}; $\lambda\beta = 4.962 \times 10^{-10}$ years^{-1}; $\lambda K = 0.581 \times 10^{-10}$ years^{-1}