GEOCHEMISTRY OF CHARNOCKITIC ROCKS FROM ITAPERUNA REGION, RIO DE JANEIRO, BRAZIL

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ABSTRACT

The studied area, in the Juiz de Fora Complex, consists mainly of orthogneissic-migmatitic noritic to charnockitic rocks with subordinate lenses of gray gneissic rocks of similar composition. Two intimately associated calc-alkaline sequences can be characterized: a low-K calc-alkaline and a Fe-Ti-LILE-enriched calc-alkaline sequence.

The Juiz de Fora Complex has been subjected to two high grade metamorphic events, at about 2.2 Ga and 580 Ma, but the age of the plutonic protoliths is yet uncertain, being either Late Archean or Paleoproterozoic. The last high grade event promoted charnockitization by a CO_2 front leaving relicts of gray gneisses-migmatites.

INTRODUCTION

In the Ribeira Belt in northern Rio de Janeiro State, SE Brazil, occurs three distinct crustal domains, related to the evolution of two main orogenic systems (e.g., Campos Neto & Figueiredo 1990). The Juiz de Fora and Paraíba do Sul thrust belts were affected by the Brasiliano event and transported towards northwest over the stable domain of the São Francisco Craton. The Costeiro Domain correspond to a Neoproterozoic III-Cambrian northwestward subduction-related cordilleran-type magmatic arc (Serra do Mar microplate) formed during the Rio Doce Orogeny (Campos Neto & Figueiredo 1992), followed by collision with the Congo Craton.

The Juiz de Fora domain is composed by two major lithologic associations: the predominant one is composed of calc-alkaline orthogneissic-migmatitic dark green charnockitic rocks and subordinate gray gneisses and migmatites; the second association is made up by peraluminous gneissic diatexitic granites and associated retrogressed rocks. These garnet-rich peraluminous migmatites and granites appear to correspond essentially to partial to whole melting of metasediments of graywacke-pelitic composition.

It is of interest to note that, in Tupi-Guarani language, Itaperuna means "dark stone" which is a fairly good description of the ubiquitous charnockitic rocks of the region.

In the calc-alkaline metaplutonic association, besides the main regional foliation, essentially steep-dipping SW-NE, there is evidence of two previous deformational episodes, while in the peraluminous granites the regional tectonic foliation is primary.

The calc-alkaline association contains a metamorphic transition between upper amphibolite to granulite facies (e.g.,

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Figueiredo & Campos Neto 1989). Most of the area consists of dark green, hypersthene-bearing charnockitic rocks with subordinate lenses and portions of gray gneisses-migmatites with similar fabrics and composition. Calc-silicatic xenoliths and lenses are common and recrystalized quartzites also occur.

The charnockitic rocks are mainly enderbite-charnoenderbite-charnockites with enclaves and bands of gabbro-norites, in a mostly banded structure, with an interlobate and polygonal granoblastic texture. They are composed of plagioclase, quartz, K-feldspar, orthopyroxene, clinopyroxene and amphibole, with subordinate red biotite and garnet, and accessory opaque minerals, titanite, zircon and apatite. The gray gneissic rocks have the same fabrics and similar mineralogy with the distinction of having more biotite and the rarity or absence of hypersthene.

Geochronological data for the Juiz de Fora domain yield mainly Paleoproterozoic values. A Rb-Sr reference isochron (Cordani et al. 1973) defined an age of about 2.2 Ga with $^{87}Sr/^{86}Sr$ initial ratio of about 0.71. A Pb/Pb isochron in gneissic charnockitic rocks yielded 2,071 +138 -153 Ma with μ_1 of 8.079 (Koji Kawashita, personal communication). Zircon U/Pb data (reinterpretation of data from Delhal et al. 1969) define a discordia with an upper and lower intercepts at about 2.2 Ga and 580 Ma, respectively. Recent zircon U/Pb data (Söllner et al. 1991), for a charnockitic rock from near Cataguases, in Minas Gerais State, also yielded a discordia with upper intercept at 2,220 $\pm$ 27 Ma and lower intercept at 577 $\pm$ 18 Ma, but an inherited Pb component of the pink, euhedral prismatic zircons point to an age of more than 2.5 Ga. All these data indicate a strong high grade metamorphic event at about 2.2 Ga followed by another at 580 Ma. The emplacement age of the igneous protoliths is not yet well defined, but it is possible that the Paleoproterozoic metamorphic event affected Late Archean lithologies.

Field evidence, such as charnockitic late-kinematic pegmatites and euhedral orthopyroxene crystals, suggests that this high grade event is related to the 580 Ma metamorphism. This charnockitization appears to be related to a CO_2 front, considering that it affects a very large region (over 15,000 km^2 in the Juiz de Fora Complex) and several distinct lithologies, leaving some relict lenses of upper amphibolite facies gray gneiss-migmatite precursors. This charnockitization affected rocks that were already in the upper amphibolite and granulite facies, probably due to the 2.2 Ga metamorphic event.

GEOCHEMISTRY

Major and trace element analyses of about 40 samples of charnockitic rocks and 16 samples of gray gneiss-migmatites indicates that these rocks are geochemically very similar. Both in the granulite and amphibolite facies rocks two distinct sequences occur: one is richer in Mg, Ca, Na, Sr and Cr and is a typical low-K calc-alkaline sequence (CA); while the other is enriched in Fe, Ti, Mn, K, P, Rb, Ba, Nb, Zr and REE, being characterized as a Fe-

Ti-LILE-enriched calc-alkaline sequence (LILE-CA) or a middle to high-K calc-alkaline sequence (Table 1).

These two sequences, ranging from basic to acid terms, occur intimately associated, from regional to outcrop scale, both in the charnockitic or gray gneissic rocks, and are very difficult or even impossible to distinguish in the field. The occurrence of these two calc-alkaline sequences has been detected only after geochemical work. They appear to correspond to highly deformed multi-intrusive rocks.

Oliveira (1982) had suggested, based in geochemical data, that the granulitic rocks of the Juiz de Fora domain consisted of calc-alkaline granitoids and tholeiitic basic rocks. Geochemical data for the Itaperuna region was obtained for the 1:50,000 scale geological mapping of Rio de Janeiro State and it was interpreted (Sad & Barbosa 1985) as indicating that the basic rocks were magmatic, while the charnockitic rocks would be, at least partly, metasedimentary. But it must be stressed that a reinterpretation of that data set also allows a clear separation of the two calc-alkaline sequences defined by Figueiredo & Campos Neto (1989) and whose typical compositions are here published (Table 1).

The CA sequence has lower contents of REE and less fractionated patterns, compared with the LILE-CA sequence. The CA sequence presents slight to absent Eu anomalies and increasing fractionation with differentiation, while in the LILE-CA sequence the total REE content decreases with increasing silica and decreasing Fe and Mg, and the small negative Eu anomalies of the basic-intermediate terms change to positive anomalies in the more differentiated rocks. The REE distribution of the LILE-CA sequence is very similar to other granitoids (Arth et al. 1978) and charnockitic rocks (Condie et al. 1982) considered as produced by hornblende-controlled fractional crystallization of basaltic magmas or partial melting of mafic rocks. It may be possible that the decreasing REE content with increasing silica is at least in part due to feldspar-quartz accumulation, even if only as a dilution effect. For the CA sequence the REE fractionation with differentiation may be controlled by hornblende separation.

The basic members of both the CA and LILE-CA sequences are already fractionated and LREE enriched indicating that they were derived from partial melting of enriched mantle sources.

The two sequences, particularly the CA one, have clear geochemical subduction zone components, such as LILE enrichment and negative anomalies of Nb, P and Ti, suggesting their derivation in a subduction related environment.

About 20% of the charnockitic samples show evidence of remobilization of several elements, including LILE, REE and HFSE, compared with the gray gneissic precursors. This remobilization has been confirmed by repeated analyses in different laboratories with distinct analytical methods.

However, most of the samples of the charnockitic types have similar compositions to the gray gneiss-migmatites, indicating their close genetic link. Some of these charnockitic samples that

do not have other indications of remobilization, have much lower values of Rb, compared with the amphibolite facies rocks, indicating that this element was depleted during the last high grade metamorphism, at least for about one third of the samples.

In the southwestern part of the Juiz de Fora Complex two calc-alkaline sequences have been described (Heilbron 1993) associated to tholeiitic and alkaline basic rocks. The low-K calc-alkaline sequence has fractionating REE patterns and decreasing Eu with increasing silica, while the LILE-enriched calc-alkaline sequence has decreasing total REE and positive Eu anomalies in the more evolved rocks, and is poorer in HREE.

Table 1. Typical compositions of Itaperuna region charnockitic low-K calc-alkaline (1 to 4) and Fe-Ti-LILE-enriched calc-alkaline (5 to 8) sequences (total iron as Fe_2O_3; nd = non detected).

	1	2	3	4	5	6	7	8
SiO_2	50.50	62.54	66.41	72.41	49.62	59.20	62.44	70.90
TiO_2	0.90	0.71	0.38	0.30	2.03	0.77	0.90	0.80
Al_2O_3	15.00	15.74	14.58	14.28	14.38	17.02	15.58	14.26
Fe_2O_3	11.00	6.56	4.99	2.90	15.19	7.74	6.54	2.91
MnO	0.17	0.12	0.08	0.05	0.21	0.12	0.14	0.04
MgO	8.80	3.53	2.90	0.90	5.87	3.67	3.22	1.00
CaO	10.00	5.14	3.60	2.50	8.10	5.40	4.62	2.51
Na_2O	2.80	3.83	3.99	3.60	3.14	3.67	3.52	3.11
K_2O	0.70	1.61	3.00	3.00	1.01	2.04	2.71	4.32
P_2O_5	0.11	0.22	0.07	0.08	0.46	0.37	0.32	0.14
Cr	210	45	50	nd	87	51	75	nd
Ni	80	14	28	4	71	25	22	4
V	210	96	60	25	284	112	75	41
Pb	10	13	20	20	19	22	15	20
Zn	125	93	88	65	142	122	101	68
Rb	3	61	65	70	14	71	56	88
Ba	140	807	999	679	405	673	1046	1476
Sr	310	585	350	370	197	571	462	311
Ga	17	20	22	27	26	24	21	13
Nb	6	6	4	3	14	10	11	9
Zr	65	136	107	180	203	107	282	261
Y	14	22	10	10	59	17	23	5
La	13.40	21.38	19.47	22.37	35.64	38.21	26.95	12.25
Ce	38.00	54.47	51.93	64.92	94.17	90.69	68.87	28.52
Pr	5.80	6.76	6.99	6.49	12.25	11.72	7.84	2.75
Nd	25.00	27.74	24.97	26.37	48.81	41.27	37.40	14.76
Sm	4.80	5.04	4.19	4.29	11.14	7.64	7.24	2.93
Eu	1.50	1.41	0.90	0.90	1.49	0.85	1.71	0.93
Gd	4.70	4.44	2.80	2.80	11.64	5.40	6.03	2.42
Dy	3.60	4.03	1.70	1.60	12.05	4.18	4.83	1.30
Er	2.00	1.82	0.90	0.80	6.48	1.63	2.41	0.83
Yb	1.30	1.61	0.90	0.70	5.16	1.43	1.71	0.72

The plutonic granulites of the Jequié Complex, with zircon SHRIMP ages of 2.7-2.8 Ga, also show two calc-alkaline sequences: one with higher Mg, Al, Na and Sr; and the other enriched in Fe, Ti, K, Mn, P, Rb, Zr, Y and REE (Fornari & Barbosa 1992). These sequences are so similar to those of Itaperuna region that a common origin is suggested. In this case the age of the plutonic protoliths of Itaperuna could be Late Archean.

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