sym=094766

Charnockitic magmatic rocks from the Várzea Alegre massif, State of Espírito Santo, southeast Brazil: conditions of formation

Julio C. Mendes[1], Cristina M. Wiedemann[1] and Ian McReath[2]

(1) Federal University of Rio de Janeiro, Dept. of Geology, Ilha do Fundão, 21910, Rio de Janeiro, RJ, Brazil; email: projes@igeo.ufrj.br; (2)Institute of Geosciences, University of São Paulo, C.P. 11.348, 05422-970, São Paulo, SP, Brazil

The Várzea Alegra intrusive massif is situated in the central portion of the State of Espírito Santo, southeast Brazil. It is an example of the late to post-tectonic magmatic activity related to the development of the Brasiliano-age magmatic arc in this region, corresponding to an inversely zoned pluton with an almost circular shape[1]. Its enclosing rocks are ortho and paragneisses of high metamorphic grade.

The Várzea Alegre massif has a gabbroic center surrounded by diorites/quartz diorites, monzodiorites and megaporphyritic granites. The contact between the megaporphyritic granites and the gabbros/diorites is a mixed zone where contrasting lithotypes interfinger with each other. All these rocks are involved by a large and irregular ring of green megaporphyritic charnockitic rocks (opdalites, jotunites, opx-quartz diorites and quartz mangerites)[2].

The charnockites are composed of plagioclase, perthitic alkali feldspar/mesoperthite, orthopyroxene, biotite, hornblende, ilmenite, magnetite, pyrite, apatite, zircon and rare allanite and hematite. The texture is porphyritic with megacrysts of alkali feldspar, plagioclase as well as quartz. The matrix is medium- to coarse-grained and it may be finer-grained when compressed against and partially recrystallized around the megacrysts. The chemical composition of these rocks points towards a high-K calc-alkalic magmatism enriched in LIL and HFS elements. These features indicate a mantle contribution associated to crustal melts in the genesis of the rocks. Fractional crystallization and magma mixing possibly were the mainly differentiation process during the evolution of the charnockitic suite[3,4].

All the major mineral phases, including opaque minerals, were analyzed by means of an electron probe microanalyser (JEOL Superprobe JXA-8600), at the Institute of Geosciences, University of São Paulo.

Orthopyroxene is partly replaced by biotite, amphibole and opaque minerals. Their compositions vary from $Wo_{1.57-2.49}$, $En_{30.42-41.18}$ to $Fs_{56.99-67.43}$. Restricted variations in the element contents are observed for most of them, except for Ca (0.55 - 1.14%). The X_{Mg} of orthopyroxene (around 0.40), amphiboles and biotites are larger than those calculated for host whole rocks.

No evidence of variation in composition of biotites and amphiboles, that could point towards the presence of a primary generation of these phases, was detected. In general, amphiboles show lower X_{Mg} than coexisting biotites (around 0.38). Small quantities of amphiboles are found in the charnockites. They are Mg-hastingsitic hornblendes and magnesian hastingsites (Fig. 1a, Leake's classification[5]). The Al-contents show small variations (Fig. 1b). Ti and the A-site occupancy show a positive correlation with Al^{iv} (Fig. 2a). This is common for the hastingsitic compositions, which in turn result from edenite and tschermackite type substitutions.

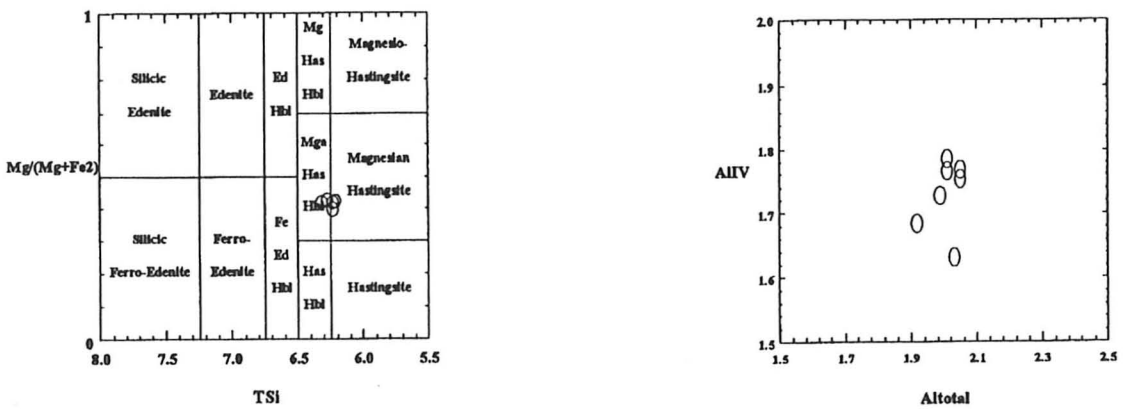
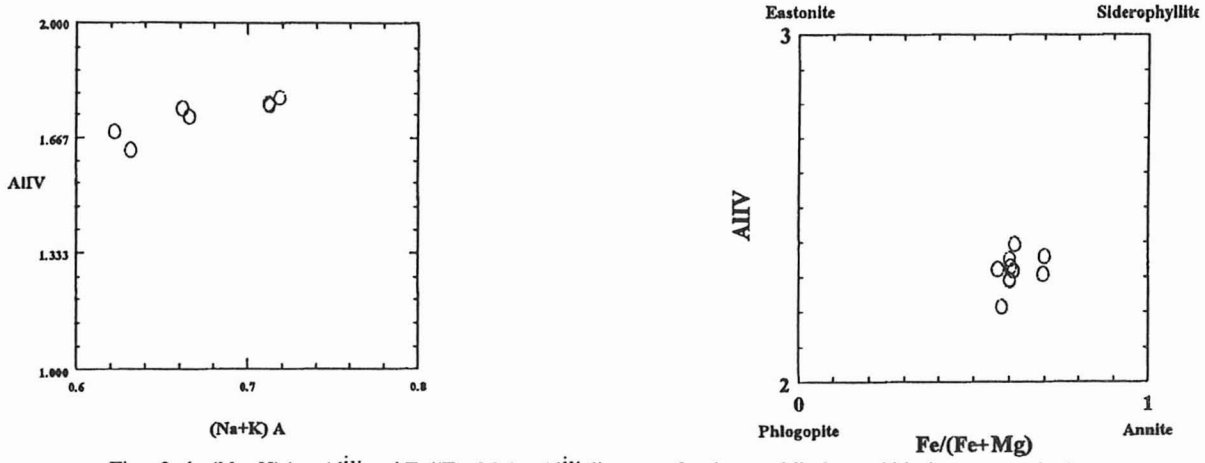


Fig.s 1a,b. Classification of calcic amphibole and Al(total) x Al^{iv} diagram for amphiboles from Várzea Alegre charnockites.

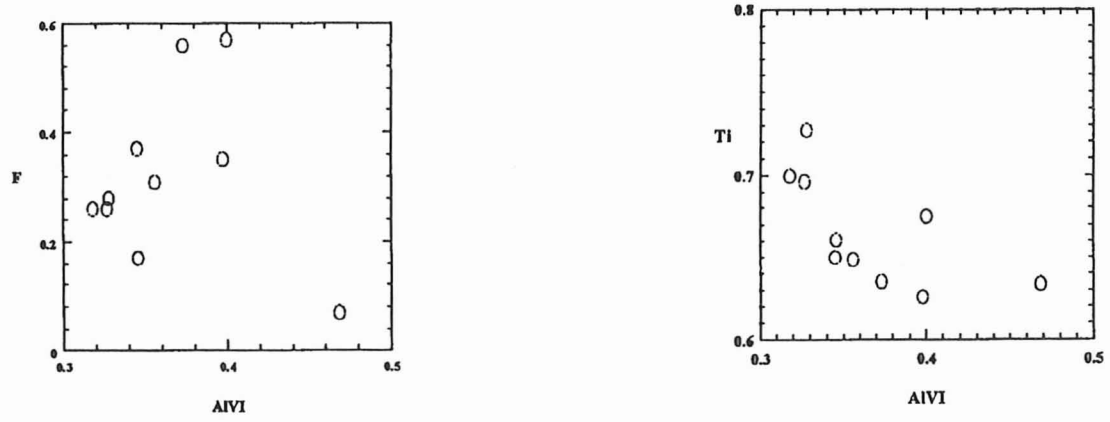
1997, Salvador, Abstracts.

Biotites show high Ti-contents (0.63 to 0.73 atoms p.f.u.), which are proportional to their Fe-contents. The Al^{iv}-contents do not correlate with X_{Mg}. Concerning the end members, the biotites from the Várzea Alegre charnockites are close to annite, as showed in Fig. 2b. Ti is inversely proportional to F-contents and shows a negative correlation with Al^{vi} (Figs. 3a,b).

Plagioclase and alkali feldspar show very tenuous signs of zoning. The irregular distribution of perthitic lamellae may characterize a zoned pattern in some grains of alkali feldspar, which in turn may replace plagioclase. The megacrysts and matrix grains present an almost equal compositional variation. The plagioclases vary from $Ab_{65}An_{32}$ to $Ab_{57}An_{40}$, with small changing on the Or molecule. Compositional variations in the alkali feldspar are associated to an unequal exsolution of the Na component. For that reason, the composition vary from $Or_{89}Ab_{11}$ to $Or_{69}Ab_{31}$. Only two samples show significant variation. Ba contents are high, up to 4.2% of the celsian component (0.17 atoms p.f.u.) and show an inverse relation with Na.



Figs. 2a,b. (Na+K)A x Al^{iv} and Fe/(Fe+Mg) x Al^{iv} diagrams for the amphiboles and biotites, respectively.



Figs. 3a,b.- Al^{vi} x F and Al^{vi} x Ti diagrams for biotites from Várzea Alegre charnockites.

Through the calibration curves of Watson & Harrison[6,7], the Zr and P_2O_5 saturation level of the Várzea Alegre charnockites indicates magma crystallization temperatures of about 950°C. The subsolidus temperatures obtained for the pairs ilmenite-magnetite[8] and plagioclase-alkali feldspar were respectively close to 550°C and 630°C. The values calculated for the $f O_2$ are consistent with highly reducing conditions, which is confirmed by the low Mg/(Mg+Fe) ratios of the rocks. Estimatives of the crystallization pressure range from 6.5 to 7 Kb (Al-i- hornblende contents[8]), lower than those obtained for the regional metamorphism (8-8.5 Kb).

According to these data it is possible to summarize the general conditions for the evolution of the Várzea Alegre charnockites: (a) a primary paragenesis (orthopyroxene, plagioclase, ilmenite, alkali-feldspar and biotite(?), plus accessory phases) crystallized at high temperatures, pressures and reducing conditions; (b) subsolidus reactions, due to hydration of the system, took place under lower temperatures. They provoked replacement of the orthopyroxene, plagioclase and ilmenite (by biotite, amphibole, alkali-feldspar and magnetite respectively), an intensive growing of hydrous minerals and exsolution in the orthopyroxene and alkali-feldspar.

References

1. Medeiros, S.R. et al., *Bol. resumos expandidos do 38° Congr. Bras.Geol.* 1:140-141 (1994)
2. Mendes, J.C., *Caracterização petrogenética das bordas charnoquitóides dos maciços de Venda Nova e Várzea Alegre, ES.* Doctoral Dissert., Institute of Geosciences, University of São Paulo. 238pp. (1996)
3. Mendes, J.C. *et al.*, *Boletim IG/USP*, Publicação especial n° 8: 71-73 (1996)
4. Mendes, J.C. *et al., Rev. Bras. Geociências,* v. 27 (in press) (1997)
5. Leake, B., *Mineral. Magaz.*, **42**: 533-563 (1978)
6. Watson, E.B. & Harrison, T.M., *Earth and Planet. Sci. Letters*, **64**: 295-304 (1983)
7. Andersen, D. *et al.*, *Computers & Geosciences*, **19** (9): 1333-1350 (1993)
7. Watson, E.B. & Harrison, T.M., *Physics of the Earth and Plan. Inter.*, **35**: 19-30 (1984)
8. Schmidt, M.W., *Contrib. Mineral. Petrol.*, **110**: 304-310 (1992)