

GNEISS SEQUENCES IN THE GUAXUPÉ GRANULITE MASSIF, AND THE NATURE OF FLUIDS

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INTRODUCTION

A wide variety of rocks, both on a local as well as regional scale, constitutes the high-grade gneisses of the Guaxupé region (Choudhuri et al., 1992). On the basis of field observations, we have established an approximate and relative chronological sequence for some of the gneisses, while some of the finer features described below were noted from petrographic studies. The relationships between the gneisses can still be recognised by careful examination, although most of the structures have been parallelized by high strain deformation. Furthermore, we have tried to relate these gneisses and their possible position to the nature of the fluids analysed by preliminary fluid inclusion studies.

GNEISS SEQUENCES FIELD RELATIONS HAVE SO FAR REVEALED THE FOLLOWING FEATURES FOR THE HIGH GRADE GNEISSES:

1. a clearly discordant contact between "underlying" coarse grained charnockitic gneiss and finely banded enderbitic gneiss containing thin mafic granulite bands;

2. cross-cutting thin enderbitic vein in granulite facies metagabbro, apparently injected during metamorphism;

3. there are no signs of discordance between enderbitic gneiss and the mafic granulite bands, whatever the thickness of the latter. There are, however, injections of igneous-textured tonalite bands traversing but not cross-cutting mafic granulite;

4. dioritic to tonalitic segregation veins in folded and banded amphibolite and mafic granulites, later crosscut by pink granitic gneiss;

5. largely concordant pink migmatitic injections in banded mafic granulite and enderbitic gneiss with rare, local cross-cutting relations. These injections are mainly igneous-textured granitic bands, while at one outcrop the band cross-cutting the granulite is itself strongly oriented due to high strain;

6. massive, fairly homogeneous, pink granitic gneiss that has been subjected to high strain deformation. These gneisses are found in many places in the granulite belt, and appear to be a late tectonic

feature. Except for the discordance of point 1 above, however, no other relation could be confirmed;

7. pink pegmatitic dykes cutting all the above; late massive grey granitic rocks with pink discolouration veins with fracture filled epidote indicating the passage of late aqueous fluids probably belong to this stage.

Evidently, the gneiss associations in a high grade terrain are complex, and this is the picture that emerges for the structure and composition of the middle-lower crust. The formation of the crust in the area involves different stages that include metamorphic and magmatic processes starting deep down in the granulite facies at P-T estimates: maximum 9.0-8.5 kb / 860-840 °C and minimum 6.6-5.5 kb / 720-650°C (Iyer et al. in prep.). One of the mafic granulites for which P-T estimates were obtained (in two samples - A and B - of mafic granulites) is intercalated with migmatitic pelitic garnet gneiss and sillimanite-garnet quartzite, implying the same metamorphic grade for these latter rocks. This process ends with the injection of pink granitic material at shallower levels in the course of uplift.

FLUID-INDUCED ALTERATION

Although alteration of granulite facies parageneses has as yet not been assessed on a regional scale, our observations can be summarized for the moment by grouping these effects into high temperature and low temperature types. Fluid-induced high temperature effects are those by which hornblende forms at the cost of pyroxenes and continues to be stable in the granulite facies. Another mineral that forms in the granulite facies is scapolite (Ca-rich, high birefringence), possibly at the expense of plagioclase by the action of CO₂-rich fluids; where it occurs, scapolite has recrystallized and is stable with the granulite facies minerals. High CO₂ activity has been proposed for the occurrence of scapolite in granulites by Moecher and Essene (1991). Low temperature transformations result in the formation of biotite, carbonate veins in ferromagnesian minerals, late rare chlorite, and finally epidote in hydrothermal veins and fractures. At one place we have observed profuse injections of quartz veins that have, however, caused little retrogression in the enderbites which they traverse. The quartz was

possibly deposited from high temperature hydrothermal solutions, since silica shows high solubility in aqueous fluids at high temperatures and pressures (Kennedy, 1950). All these alteration effects

are incipient, granulite facies assemblages being largely preserved in most cases, indicating lack of large quantities of fluids as well as absence of pervasive fluid flow.

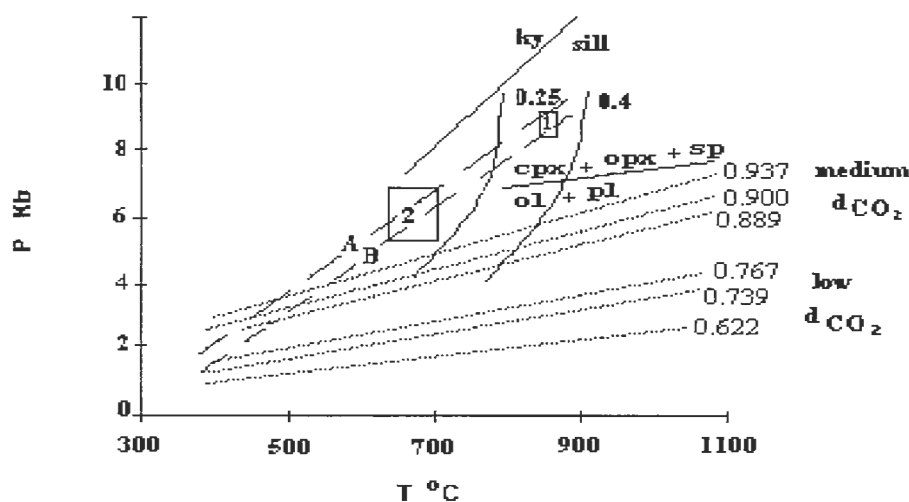


Fig.1 - P-T diagram showing: isochores for CO_2 fluid inclusions in granulites (dotted lines), isochores are for low and medium CO_2 density ($d\text{CO}_2$) fluid inclusions; boxes (1&2) for maximum and minimum P-T estimates for two Guaxupé mafic granulites (A & B); dashed lines A & B represent possible uplift paths from box 1 to box 2, from granulite to amphibolite facies; kyanite-sillimanite boundary from Pattison (1992); curves 0.25 and 0.4 are $X_{\text{H}_2\text{O}}$ for hornblende breakdown from Wells (1979); and the reaction olivine + plagioclase = orthopyroxene + clinopyroxene + spinel from Kushiro and Yoder (1966).

Isochore (density curve in P-T space) determinations were made using Holloway equations in software - FLINCOR - (Brown, 1989). The results show no isochores crossing peak P-T box, and so far no CO_2 -rich peak metamorphic fluids have been detected, and a case may be made for fluid-absent granulite formation (Stevens and Clemens, 1993). However, the nature of fluids can be related to a retrograde amphibolite facies stage in the granulite belt (Fig.1), and the fluid inclusion data can be summarized as follows (densities in g/cm^3):

1. medium density pure CO_2 in banded enderbites 0.937; low density pure CO_2 inclusions in the same enderbites 0.767 (Fig. 1);
2. medium density CO_2 0.90 (Fig.1), pure aqueous and N_2 inclusions as well as $\text{CO}_2 + \text{N}_2$ inclusions in charnockitic gneiss - 0.889.
3. low density CO_2 - 0.739 and 0.622 (Fig.1), and H_2O inclusions in charnockite;
4. late stage grey granite gneiss with aqueous-brine inclusions with saturation crystals - possibly a metapelitic source (see e.g. Touret and Dietvorst, 1983; Newton, 1986).

Separate CO_2 and N_2 inclusions may represent different fluid pulses as both of them are otherwise miscible. The trapping of these fluids might also reflect a residual fluid that remained after the dissolution of water in partial melts under high grade conditions. Some of the charnockitic gneisses may have formed this way - by syntectonic emplacement of such partial melts at depth, as suggested previously (Choudhuri et al., 1992). On the whole, the nature of

fluids can be related to high or low temperature alteration effects. Further studies require that we integrate our observations over a large area and look for peak metamorphic fluids.

ACKNOWLEDGEMENTS

A.C. is grateful to CNPq for financial support received during this investigation. We thank Roberto P. Xavier for confirming nitrogen by Raman spectroscopy.

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