EXTENDED ABSTRACTS

ISUM

INTERNATIONAL SYMPOSIUM ON THE PHYSICS AND CHEMISTRY OF THE UPPER MANTLE

AUGUST 14 - 19, 1994
SÃO PAULO - BRAZIL

sored by

CPRM
O Serviço Geológico do Brasil

FAPESP

Xenocrysts in mafic dikes from the Fernando de Noronha Archipelago

M.N.C. Ulbrich, V. Maringolo & S.R.F. Vlach (Instituto de Geociências, Universidade de São Paulo, Brazil).

Ultramafic and mafic alkaline rock bodies may carry xenocrysts and xenoliths of cogenetic, crustal or mantle materials together with typical phenocrysts. Xenocrysts commonly appear as megacrysts (larger grains with 1 cm or more; Schulze, 1987).

In the dike rocks of Fernando de Noronha larger grains are rare, but among the macrocryst assemblage (grains with less than 0.5 cm; Dessai et al., 1990), xenocrysts of mafic or felsic minerals in chemical and/or textural disequilibrium with their host appear to be quite common.

The dikes belong to the oldest unit (the Remédios Formation; Almeida, 1955) of the Fernando de Noronha volcanic sequence. The Remédios Formation represents a poorly exposed "Igneous Central Complex" composed of a basal pyroclastic unit and subvolcanic bodies belonging to two different trends: a sodic one characterized by numerous ultramafic-mafic dikes of basanitic to tephritic compositions including alkaline lamprophyres (monchiquites, camptonites), a sill of essexite porphyry and phonolite domes, and a subordinate mildly potassic trend mostly represented by plugs and dikes of evolved trachyandesites to trachytes with rare alkali basalt (Almeida, 1955; Ulbrich et al., in press).

Basanites, limburgites (basanites with glassy matrix) and some monchiquitic lamprophyres are the more primitive rock types of the exposed sodic series. They are generally composed of variable amounts of olivine (#mg=78-85) and yellow salitic clinopyroxene (#mg=75-83) phenocrysts, accompanied by kaersutitic amphibole in the lamprophyres. Glomerules of olivine and/or pyroxene are common in some rocks. They also carry xenoliths of alkaline rocks such as clinopyroxene and amphibole gabbros, nepheline syenites, etc., probably belonging to the underlying plutonic complex.

The pyroxene grains of some basanites and of the lamprophyres may exhibit idiomorphic or resorbed zoned green cores of variable size. The compositions of the different zones and of the whole green cores vary from dike to dike; they may show normal or inverse zoning and sometimes have #mg values varying from 80 to 40 in the same grain. In general they are ferrosalitic pyroxenes with higher Ti and slightly higher Na content than the yellow salitic rims and matrix pyroxenes. These green clinopyroxenes are xenocrysts derived from more evolved melts; they constitute a common feature in alkali basalts, basanites and lamprophyres (Bédard et al., 1988; Dobosi and Fodor, 1992). Sparse xenocrysts of felsic minerals (more or less sodic plagioclase, alkali feldspar, nepheline) are also commonly found.

A small group of mafic dikes presents a different macrocryst suite. One of them, studied in detail (sample #38), contains 35 to 40% of macrocrysts (<0.5 cm, rarely up to 1.0-1.5 cm in size) set in a fine-grained matrix composed of salitic clinopyroxene, titanomagnetite, ferro-kaersutite and sparse alkali feldspar laths with interstitial glass. The macrocyst assemblage includes olivine (±12%), dark yellow salitic clinopyroxene (±3-5%), green ferrosalitic clinopyroxene (±4-6%), almost colorless magnesium-rich augite (<1%), ferro-kaersutite (7-8%), nepheline (±7-9%), nosean (3-4%) and minor titanite and Mg-Al-chromite, together with xenoliths of plutonic and subvolcanic alkaline rocks.

The textural features and the chemistry of the macrocysts, particularly those of olivine and pyroxenes, are described below and also shown in Figure 1.

The *olivine* appears to belong to two different groups, with different texture and composition.

The OL1 group, most abundant, consists of isolated rounded grains (#mg=79-85; NiO=0.09-0.12%), rarely associated with salitic clinopyroxene (CPX1 group), forming composite macrocrysts. They present a seriate size distribution (up to 1.5 cm), are partially broken along the borders and show strain features, varying from undulose extinction to subgrain formation. The crystals are surrounded by a thin corona of tiny kaersutite prisms.

The OL2 group is composed of unstrained small grains (#mg=88; NiO=0.39%), set closely together but separated by fine amphibole grains; they are occasionally accompanied by Mg-Al-chromite (Cr/Cr+Al=0.52-0.56).

The *salitic clinopyroxenes* (CPX1 group; #mg=73-80; TiO_2=±2.5%, Al_2O_3=6.5-8%) appear as subidiomorphic to rounded grains slightly zoned and variably strained. The salite macrocrysts have compositions close to the matrix clinopyroxene (Fig. 1) except for the alumina content that is lower in the matrix pyroxenes (Al_2O_3=±4.0%).

The *magnesium-rich augites* (CPX2 *group;* #mg=86; TiO_2=±0.8%, Al_2O_3=±5.0%, Cr_2O_3=±0.5%, Na_2O=±0.8%) occur as isolated crystals. They are subidiomorphic, unzoned, unstrained, and show sieve texture.

The green *ferrosalitic clinopyroxenes* (CPX3 *group*; #mg=35-42; TiO_2=±1.7%, Na_2O=±1.8%) are also idio-to subidiomorphic, slightly zoned, and contain inclusions of titanite and titanomagnetite. They appear mostly as isolated crystals but a cluster composed of several pyroxene grains associated with titanite and nosean was observed.

Some larger *ferro-kaersutite* grains (#mg=±70; TiO_2= 5.0%) with irregular shape are unzoned, except for a narrow rim of iron-richer amphibole (#mg=±57). This rim has the same composition as the matrix amphibole.

The felsic minerals appear with different sizes and shapes. The *nosean* crystals are small and idiomorphic while the *nepheline* grains are larger, full of fluid inclusions, and rounded.

Discussion

The most common xenocrysts in the mafic dikes are the green ferrosalitic pyroxenes with variable #mg values, derived from more evolved alkaline melts; they appear either as "green cores" of salitic pyroxenes or as isolated crystals (as in sample #38). They may have titanomagnetite, titanite and other mineral inclusions. Common felsic minerals, also xenocrystic, are feldspars and feldspathoids. The relatively Na-poor green clinopyroxenes and the felsic minerals (alkali feldspars and/or nepheline) certainly come from different magma batches, where they possibly constitute the phenocryst suite.

The other mafic minerals of the macrocryst assemblage displayed by sample #38 require additional discussion:

1 - OL1 and CPX1 have the same compositional range shown by the phenocrysts of other mafic dikes from the Remédios Formation. Both mineral groups, however, show strain features and the CPX1 macrocysts have high alumina contents suggesting high pressure of crystallization. They may come from disaggregated deep-seated cumulates.

2 - The textural appearance and composition of OL2 are compatible with those of disrupted dunite (or spinel peridotite?) xenoliths.

3 - The composition and textural features of CPX2 point to a xenocrystic origin. CPX2 has lower alumina than the Al-rich augites (with 8->10% Al2O3) commonly found as high pressure megacrysts in alkaline rocks (Righter and Carmichael, 1993; Schulze, 1987). On the other hand, they are relatively rich in TiO2 and Na2O indicating alkaline affinity; they may have crystallized from a melt of alkali basalt composition.

4 - The larger, homogeneous, irregular shaped ferro-kaersutites may or may not be xenocrysts. Kaersutites may be deep-seated phenocrysts in alkalic basaltic magmas, being stable up to ±31kb and 1100°C (Schulze, 1987). Our data are insufficient to discuss the problem further.

Conclusions

Many mafic dikes from Fernando de Noronha Remédios Formation carry xenoliths and xenocrysts, most of them of cogenetic origin, accompanying typical phenocrysts. The xenocrysts are generally small (macrocrysts); megacrysts, apparently common in other alkaline suites, are rare. Some mafic dikes (sample #38) on the other hand, almost only contain xenocrysts and xenoliths, representing more than 40% of the rocks. These features suggest that a mainly liquid mafic magma incorporated pieces of wallrock and also crystallizing phenocrysts from magma chambers in its rapid ascent to higher levels.

REFERENCES

Almeida, F.F.M. (1955) Geologia e petrologia do Archipelago de Fernando de Noronha. Div. Geol. Mineral., Dep. Nac. Prod. Miner., Rio de Janeiro, Monografia 13.

Bédard, J.H.J., Francis, D.M. and Ludden, J. (1988) Petrology and pyroxene chemistry of Monteregian dykes: the origin of concentric zoning and green clinopyroxenes from alkali basalts and lamprophyres. Can. J. Earth Sci., 25, 2041-2058.

Dessai, A.G., Rock, N.M.S., Griffin, B.J. and Gupta, D. (1990) Mineralogy and petrology of some xenolith-bearing alkaline dykes associated with Decan magmatism, south of Bombay, India. Europ. J. Mineral., 2, 667-685.

Dobosi, G. and Fodor, R.V. (1992) Magma fractionation, replenishment, and mixing as inferred from green-core clinopyroxenes in Pliocene basanite, southern Slovakia. Lithos, 28, 133-150.

Righter, K. and Carmichael, I.S.E. (1993) Mega-xenocrysts in alkali olivine basalts: Fragments of disrupted mantle assemblages. Am. Mineral., 78, 1230-1245.

Schulze, D.J. (1987) Megacrysts from alkalic volcanic rocks. In: P.H. Nixon (Editor), Mantle Xenoliths, Wiley, New York, pp. 433-451.

Ulbrich, M.N.C., Maríngolo, V. and Ruberti, E. (1994) The geochemistry of alkaline volcanic-subvolcanic rocks from the brazilian Fernando de Noronha Archipelago, southern Atlantic Ocean. Geochim. Brasiliensis (in press).

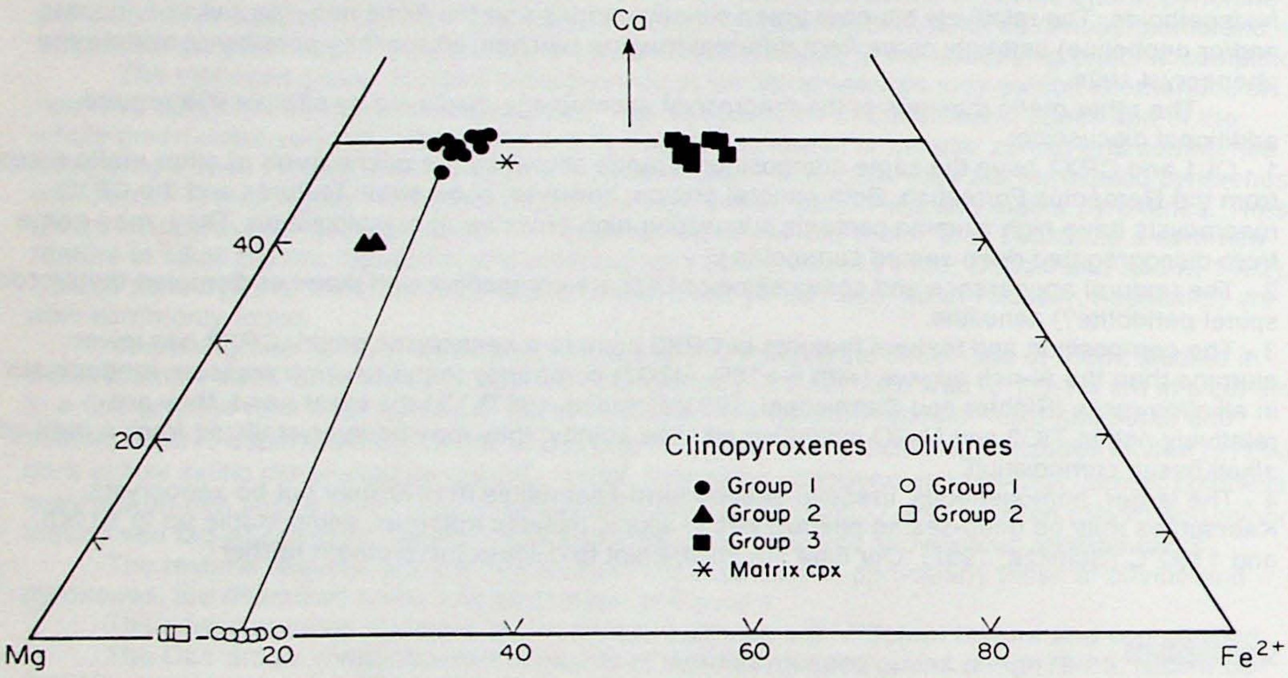

Fig. 1 - Olivines and clinopyroxenes from sample #38 plotted in the Ca-Mg-Fe diagram (wt. %; total Fe as Fe^{2+}). Tie-line joins the olivine and the clinopyroxene of a composite macrocryst. See text for descriptions and other chemical data.