SECULAR VARIATION IN THE COMPOSITION OF BRAZILIAN MAFIC DYKE SWARMS - PRELIMINARY RESULTS

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The chemical composition of mafic dykes in continental areas is an important tool to understand the nature of the subcontinental mantle and its possible variation with time. The widespread occurrence of highly magnesian komatiitic lavas in the Archaean and their nearly total absence in the Phanerozoic is generally regarded as the result of higher geotherms prevailing in Archaean than in more recent times. Also, Archaean low-K tholeiites are more enriched in Ni, Cr and Co, and depleted in Ti, Zr and P than their modern counterparts (CONDIE, 1985). It is still a matter of controversy, however, whether Archaean tholeiites represent high extents of melting, compatible with the assumed high geotherms, or their chemistry reflects high contents of base metals in their mantle sources (e.g. high abundance of disseminated nickel sulphides).

Several studies on basaltic rocks from the ocean basins have shown that the suboceanic mantle is heterogeneous and variably depleted in incompatible trace elements. The current interpretation is that this depleted MORB-type of mantle has resulted from continuous extraction of basaltic magmas since the Archaean to form the continental crust.

Intra-oceanic island-arc magmas and ocean island basalts provide, on the other hand, evidence for processes that might lead to mantle enrichment as also do mantle xenoliths entrained in volcanics and kimberlites in continental settings (see HAWKESWORTH et al., 1984). Enrichment of the oceanic lithospheric mantle in low-field strength elements (LFSE) (e.g. K, Rb, Sr, Ba) by fluids emanating from the downgoing slab in subduction-related environments and subsequent melting of that mantle provide a good explanation for the geochemical signature of most island-arc magmas. Ocean island basalts are characterized by enrichment in all incompatible trace elements including the high-field strength elements (HFSE) Nb, Ti, Zr, P, and most of the rare-earth elements. Veining of the suboceanic and subcontinental lithospheric upper mantle by trace element enriched magmas, whose composition does not differ significantly from alkaline basalts, has been suggested or observed elsewhere (e.g. Le ROEX et al., 1983; MENZIES & HAWKESWORTH, 1987 and references therein).

Mixing between several end-members, recycling of continental sediments, degree of melting, fractional crystallization, crustal contamination and nature of the mantle source and residue have been envisaged to explain the chemical differences within and between basaltic suites worldwide. It is, thus, not easy to place constraints on mantle sources of basaltic rocks in continental areas, where magmas are prone to contamination during their ascent through the crust and to alteration or metasomatism after their emplacement as is possibly the case of most Brazilian dyke swarms. Nevertheless, the seven dyke swarms studied here, which range in age from the early Proterozoic to the Mesozoic, show contrasting compositional variation with time that appears to be primarily controlled by the nature of their mantle sources.

Samples from the early Proterozoic Uauá, Goiás and Aroeira swarms, the middle Proterozoic Pará de Minas and Curaçá, and the Mesozoic Amapá (Cassiporé dykes) and Jari swarms

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were analysed for major, trace and rare-earth elements (REE). The location of each swarm, field relationships and age dating can be found in SIAL et al. (1987). Comparison with basaltic suites worldwide, whose petrogeneses are relatively well constrained on the basis of isotopic and trace element data, has been done after excluding the Brazilian samples that show indications of crustal contamination or post-emplacement metasomatism. The following conclusions can be drawn:

Dykes from the *Uauá swarm* form three compositionally distinct groups in terms of light REE enrichment: depleted tholeiite (La/Yb_n = 0.85), enriched tholeiite (La/Yb_n = 1.4) and norite (La/Yb_n = 4.2). It is not clear if the two tholeiitic groups represent different extents of melting from the same depleted mantle or whether they are derived from distinct sources. The norites probably represent a high extent of melting from an enriched lithospheric mantle source as suggested by their strong negative Nb anomaly on mantle-normalized multi-element diagrams.

The *Goiás swarm* can also be separated into two tholeiitic groups which were derived from distinct mantle sources — group 1 from a less enriched source (La/Yb_n = 1.2-1.3) and group 2 from a more enriched one (La/Yb_n = 4.7-5.5).

The *Aroeira swarm* is more homogeneous (La/Yb_n = 2.4-2.6) and inter-dyke variation can be explained either by fractional crystallization or different extents of melting from a garnet-bearing lherzolitic source in the subcontinental lithospheric mantle.

The *Pará de Minas* swarm has been divided into two main groups according to their incompatible element abundances (especially Ba and Sr), namely high-barium-strontium (HBaSr) and low-barium-strontium (LBaSr); different extents of melting, fractional crystallization and source heterogeneity can explain the chemical variation within each group — both groups are likely to have been derived from distinct parts of an enriched subcontinental lithospheric mantle (La/Yb_n = 2.6-2.8 for LBaSr and 5.6-7.6 for HBaSr) — the HBaSr source is unique, however, and appears to have undergone an enrichment event by fluids that are not very different in composition from those suggested for island-arc magmas as indicated by the high K_2O/TiO_2, Ba/La, Ba/Nb, Ba/Zr and Nb/La ratios observed in samples from this group.

The *Curaçá dikes* are by far the most interesting among all the studied swarms; their chemistry shares many features in common with ocean-island basalts (OIB), with some trace element ratios (e.g. Ba/Zr, Ba/La, and Ba/Nb) between those for DUPAL and non-DUPAL OIB. The Curaçá dykes are also heterogeneous regarding other trace elements (e.g. Zr/Nb = 3.5-9.0, Zr/Y = 2.7-7.7, Nb/La = 0.8-2.0) and have REE fractionation (La/Yb_n = 4.4-12.6) strongly controlled by a garnet-bearing assemblage in their mantle source. These dykes also provide evidence for magma chamber processes with intra-dyke compositional variations indicating feeding of the dyke conduit by progressively more primitive liquids. Chilled margins, therefore, do not necessarily represent "the parental liquid". The Curaçá dykes appear to be the product of hot-spot magmatism which in turn may be related to the Espinhaço-Chapada Diamantina rifting event in the São Francisco Craton (OLIVEIRA, in prep.). An ongoing research project on other mafic dykes along the Espinhaço cordillera will show how far to the south this geochemical signature can be traced and whether there is a relationship between the Pará de Minas and Curaçá swarms.

The *Amapá* and *Jari dykes* are related to the opening of the Atlantic Ocean during the separation of Africa from South America. Samples from both swarms can be assembled into two main groups — group 1 from each swarm is less enriched in LFS and HFS elements than group 2, and are less REE fractionated (La/Yb_n = 1.8-2.46 for Amapá 1, 3.5-4.6 for Amapá 2, 2.3-2.5 for Jari 1 and 2.7-3.6 for Jari 2). The two Jari groups can linked to each other by either fractional crystallization or different extents of melting from a relatively homogeneous mantle source of the T-MORB type. The same is not valid for the Amapá dykes which show wider variation in trace element ratios, such as Zr/Nb (19-11 for group 2 and 18-14 for group 1), which suggests source heterogeneity. These dykes may have originated from a mantle source similar to T-MORB possibly mixed with, or also derived from, an enriched part of the subcontinental lithospheric mantle to account for some trace element ratios that approach bulk continental crust values.

Overall, early Proterozoic dykes have higher Ni and Cr, and lower incompatible element contents (e.g. Ba, Zr, Nb, TiO_2, P_2O_5 and REE) than younger at a similar mg-number (Fig.1a, b). The middle Proterozoic dykes are the most enriched in incompatible elements amongst all studied swarms, whereas the Mesozoic dykes have abundances between the least enriched middle Proterozoic and the most enriched early Proterozoic samples.

It is suggested that the mantle sources for early Proterozoic dykes are more refractory than those for younger dykes and that the geochemical signatures of middle Proterozoic dykes record possible influence of mantle plumes associated with the middle Proterozoic Espinhaço aulacogen.

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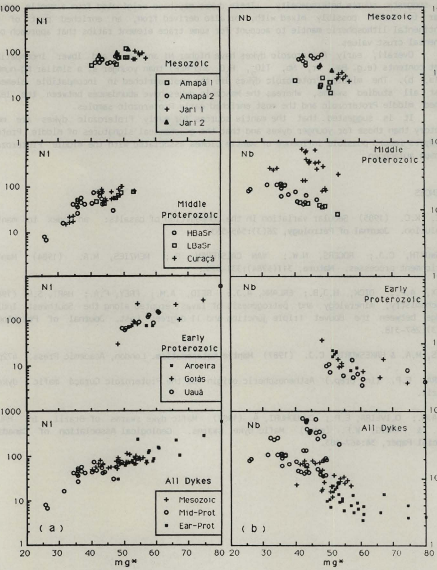

Figure 1a, b - mg* (mg-number in mole proportion) versus Ni (a) and Nb (b) for the Brazilian dyke swarms.