

GEOCHEMICAL MODELLING FOR THE LOW-TiO₂ BASALTS (THE COSTA AZUL SUITE) IN THE EASTERN PORTION OF THE SERRA DO MAR DYKE SWARM, RIO DE JANEIRO: EVIDENCE FOR THE CONTRIBUTION OF A DEPLETED MANTLE SOURCE

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INTRODUCTION

The main events related with the South American Platform reactivation include widespread tholeiitic basalt magmatism and the formation of rift basins along the Brazilian continental margin. These events are associated with the rifting of the West Gondwanaland which started in Early Cretaceous times (ca. 137 Ma; Ar-Ar, whole-rock and plagioclase, Turner et al., 1994) or even earlier (ca. 193 Ma; K-Ar, whole-rock, Guedes et al., 2005). Such magmatism is mostly represented by the extrusion of basaltic flows in both Paleozoic (Paraná) and Mesozoic basins (Pelotas, Santos, Campos and Espírito Santo). Coeval dyke swarms, namely the Serra do Mar Dyke Swarm, the Ponta Grossa (and East Paraguay) Dyke Swarm and the Florianópolis Dyke Swarm occur associated with those basaltic flows.

The geochemical provinciality is one of the most relevant aspects concerning the continental basalt provinces. Such provinciality has been attributed by many authors to either distinctive partial melting degrees of a single mantle source or derivation from different mantle sources (e.g., Gibson et al., 1995). In this paper we suggest that depleted mantle sources seem to have been involved in the petrogenesis of the low-TiO₂ basalts of the Serra do Mar Dyke Swarm as opposed to contributions of enriched and plume-like components that have been associated with the high-TiO₂ basalts that occur westwards in the swarm (Corval, 2005).

THE COSTA AZUL SUITE

The Serra do Mar Dyke Swarm (Valente et al., 1998) is located in Southeastern Brazil and comprises tholeiitic basalts of Early Cretaceous age (ca. 132 Ma; Turner et al., 1994). The dykes intrude gneisses and granitoids of the Upper Proterozoic/Cambro-ordovician,

Ribeira Orogen (Heilbron et al., 2004, Schmitt et al., 2004). The dolerites are included in a transitional tholeiitic series that can be divided in low- and high-TiO₂ suites, on a geochemical basis, indicating geochemical provinciality within the swarm.

Two main low-TiO₂ suites have been discriminated within the eastern portion of the Serra do Mar Dyke Swarm, namely the Serrana (e.g. La/Nb > 1,5) and Costa Azul (e.g. La/Nb < 1,5) suites. Proposed petrogenetic models for the Costa Azul suite pointed out that they evolved solely by fractional crystallization without changing of the fractionating assemblage (Dutra, 2006). The Costa Azul suite have La/Yb_(N) and La/Nb_(N) ratios higher than unity indicating at least a contribution from the subcontinental lithospheric mantle in the generation of these basalts (Dutra, 2006.)

BINARY MIXING MODELING: CONSTRAINING THE LOCAL SCLM

Binary mixing models were done to evaluate the involvement of distinctive mantle components in the generation of Costa Azul basalts. As aforementioned, parental compositions of the Costa Azul basalts seem to have been associated with an enriched source. Such component is likely to be represented by the subcontinental lithospheric mantle (SCLM) taken as a major enriched reservoir (e.g., Hawkesworth et al., 1992). Nevertheless, the low La/Yb_(N) ratios (average 2.6) of the Costa Azul basalts do not preclude the participation of depleted components in their genesis. As such, the other end-member used in the model was a depleted asthenospheric component (D-MORB, Salters & Stracke, 2004). Results pointed to the involvement of ~80% of the D-MORB component in the mixing (Fig.1).

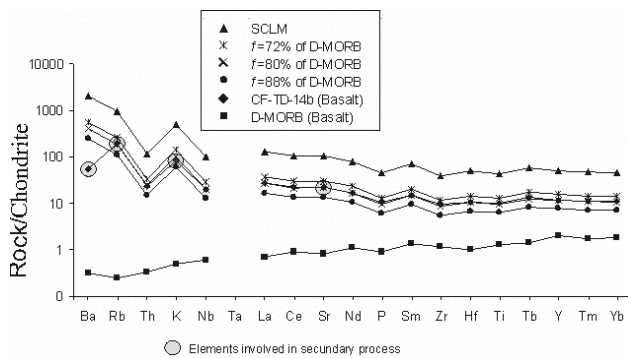


Figure 1: Chondrite-normalised multi-element diagram (Thompson, 1982) showing the results of a binary model for the Costa Azul basalts. Sample CF-TD-14b represents a parental composition. Curves for selected *f* (ie, the amount of D-MORB component) values are shown.

Discrepant results for Ba, Rb and K were largely attributed to alteration processes (Dutra, 2006). Appropriate lithospheric compositions would have $La/Yb_{(N)}=2,9$ and $La/Nb_{(N)}=1,3$ and as such the lamprophyre dykes that occur widespread in Rio seem not to represent the local SCLM. It is noteworthy that the constrained SCLM presents the typical Nb negative anomaly of lithospheric components.

SR-ND ISOTOPE DATA

Sr-Nd isotope data were obtained for the Costa Azul basalts (Fig. 2).

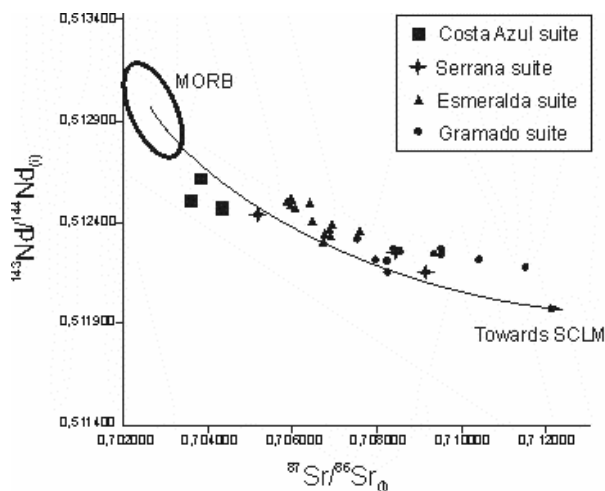


Figure 2: Sr-Nd isotope data for the low-TiO₂ Costa Azul and Serrana basalts of the Serra do Mar Dyke Swarm and the Gramado and Esmeralda basalts of the Paraná-Etendeka province (Peate & Hawkesworth, 1996). The field for MORB (Thompson et al., 1983) is also indicated.

Measured values were corrected for 132 Ma. The preferred age for the tholeiitic dykes in Rio (Turner et al., 1994). Values for $^{87}Sr/^{86}Sr_i$ range from 0.703577 to 0.704301 and those for ϵNd_i are between 0.0 and 2.7. As such, the Costa Azul basalts plot close to the MORB field

in the $^{87}Sr/^{86}Sr_i$ versus $^{143}Nd/^{144}Nd_i$ diagram (Fig 2) pointing to a major contribution of a depleted mantle component in the petrogenesis of these basalts as inferred by the binary mixing modeling showed in the previous section. On the other hand, the more radiogenic Sr ($^{87}Sr/^{86}Sr_i > 0.705$) and negative ϵNd_i values (-0.9 to -6.4) shown by the Serrana low-TiO₂ basalts are largely attributed to possible crustal contamination processes.

REGIONAL COMPARISONS

The compositions of the Costa Azul basalts were compared with those of the low-TiO₂ basalts that occur in the Paraná-Etendeka province. Figure 3 shows that the Costa Azul samples (Dutra, 2006) plot within the field of the Esmeralda basalts in the Ti/Y versus Ti/Zr discriminant diagram (Peate, 1997) although spanning over a wider Ti/Y range.

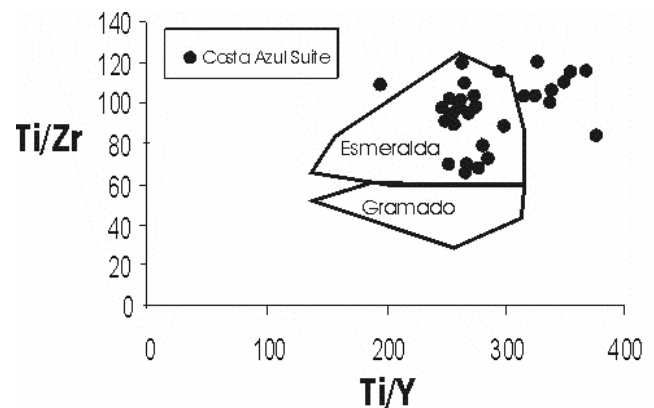


Figure 3: The Costa Azul basalts plotted in the Ti/Y versus Ti/Zr discriminant diagram. The Esmeralda and Gramado low-TiO₂ basalt fields (Peate, 1997) are shown for comparison.

CONCLUSIONS

Elemental and Sr-Nd isotope data and binary mixing modeling show that the Costa Azul low-TiO₂ basalts that occur in the eastern portion of the Serra do Mar Dyke Swarm are related with a large (~80%) contribution of a depleted mantle source. Mafic-ultramafic, potassic-ultrapotassic dykes, mostly represented by alkaline lamprophyres in Rio, seem not to represent the compositions of the underlying SCLM. The Costa Azul basalts seem to be largely uncontaminated as opposed to the low-TiO₂ Serrana basalts that occur elsewhere in the swarm. Finally, the Costa Azul basalts show elemental and Sr-Nd isotope compositions that close correlate with the Esmeralda low-TiO₂ basalts that occur in the Paraná-Etendeka province. The latter are thought to represent also largely uncontaminated compositions and their petrogenesis has also been attributed to contributions of a depleted mantle source (Peate & Hawkesworth, 1996). As such, if the Sr-Nd isotope compositions of the Costa Azul and Esmeralda basalts are not to be attributed to crustal contamination, a larger contribution of a depleted component is to be expected for the former than for the latter.

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RESUMO

Os principais eventos relacionados com a reativação da Plataforma Sul Americana incluem amplo magmatismo basáltico e a formação das bacias de rifte ao longo da margem continental brasileira. Estes eventos encontram-se associados com rifteamento do Supercontinente Gondwana Oeste durante o Cretáceo Inferior (ca. 137 Ma) ou mais cedo (ca. 193 Ma). Este magmatismo é representado principalmente pela extrusão de lavas basálticas em bacias Paleozóicas (Paraná) e Mesozóicas. O Enxame de Diques da Serra do Mar ocorre associado com estes derrames basálticos. Neste trabalho, sugerimos que fontes mantélicas empobrecidas contribuíram na petrogênese dos basaltos de baixo-TiO₂ da Suíte Costa Azul do Enxame de Diques da Serra do Mar em oposição aos componentes enriquecidos e do tipo pluma, que foram associados com os basaltos de alto-TiO₂ que ocorrem na porção oeste do enxame. Dados elementais e isotópicos (Sr-Nd) e modelos de mistura binária mostram que a Suíte Costa Azul, que ocorre na porção leste do enxame, encontram-se relacionados a uma grande contribuição (~80%) de uma fonte mantélica empobrecida. Os basaltos da Suíte Costa Azul mostram, comparativamente, composições elementais e isotópicas (Sr-Nd) correlacionáveis com os basaltos de baixo-TiO₂ da Suíte Esmeralda da Provincia Paraná-Etendeka. A petrogênese da Suíte Costa Azul também têm sido atribuída a contribuições de fontes mantélicas empobrecidas. As composições isotópicas dos basaltos Costa Azul não são associadas à contaminação crustal.