^{40}Ar/^{39}Ar ages and geochemistry of Maranhão CAMP tholeiites (Brazil): Implications for low and high-Ti basalts sources

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The Central Atlantic magmatic province (CAMP) emplaced at the Triassic-Jurassic boundary, is composed of prevailing low-Ti ($TiO_2 < 2.0$ wt%) and of rare high-Ti basalts ($TiO_2 > 2.0$ wt%). The latter are generally confined to the circum-Atlantic regions of northernmost South America (French Guyana, Surinam and Cassiporé area of Brazil) and of western Africa (Liberia, Sierra Leone). Here we report first data for high-Ti basalts sampled up to 800 km inland in the Maranhão basin of Brazil.

The Maranhão tholeiites are generally evolved basalts to basaltic andesites (MgO = 2.6-7.9 wt%). Three chemical groups are defined: low-Ti ($TiO_2 < 1.2$ wt%; K_2O = 0.6-1.5 wt%), high-Ti (TiO_2 = 3.4-3.7 wt%; K_2O = 1.3-1.5 wt%) and intermediate-Ti tholeiites ($TiO_2 \approx 2.1$ wt%; $K_2O \approx 0.3$ wt%). The three chemical groups display almost flat to very slightly enriched REE patterns precluding a garnet-bearing source. In particular, the intermediate-Ti tholeiites display almost flat REE patterns ($La_{CN}/Yb_{CN} \approx 2.1$) relative to low-Ti ($La_{CN}/Yb_{CN}$ = 3.5-4.0). The high-Ti tholeiites are more enriched in LILE and LREE (La_{CN}/Yb_{CN} = 4.4-5.0). All the low-Ti tholeiites display strong negative Nb and positive Pb anomalies, which are indicative of crustal assimilation. By contrast, such anomalies are negligible for the high-Ti and intermediate-Ti tholeiites.

The new ^{40}Ar/^{39}Ar plateau ages obtained on plagioclase separates for intermediate-Ti (199.7 ± 2.4 Ma) and high-Ti tholeiites (197.2 ± 0.5 Ma and 198.2 ± 0.6 Ma) are indistinguishable and are also identical to previously analyzed low-Ti tholeiites (198.5 ± 0.8 Ma) and to the mean ^{40}Ar/^{39}Ar age of the brazilian CAMP (mean 199 ± 2.4 Ma).

Preliminary initial Sr-Nd isotopic compositions indicate that low-, intermediate- and high-Ti basalts have compositions similar to those of other analogues of the brazilian CAMP (low-Ti: $^{87}Sr/^{86}Sr$ = 0.7047-0.7081, εNd(t) = -4.7 - +2-2; high-Ti: $^{87}Sr/^{86}Sr$ = 0.7032-0.7070, εNd(t) = -1.8 - +5.6). Such strongly distinct isotopic and incompatible element compositions of virtually synchronous basaltic magmas are indicative of a strongly heterogeneous mantle source, beyond the effects of crustal contamination.

Chromitite alteration in serpentinite mélanges of Nurali and Kalan massifs (Russia)

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Studies on the genesis and evolution of Cr-mineralization in ophiolites usually do not consider the metamorphic processes that influenced the mineralization in later stages. Kalkan and Nurali chromitites from Urals mélanges exhibit different alteration. During post-serpentinization reactions Al diffuses out of magmatic spinel leaving behind a ferritchromite and promoting the formation of chlorite aureoles (Mellini, 2005). Kimball (1990) describes the alteration of spinel to ferritchromite and the formation of chlorite by the reaction:

$$MgAl_2O_4{+}4MgO{+}3SiO_24H_2O = (Mg_5Al)(AlSi_3O_{10})(OH)_8$$

with MgO, SiO_2 and H_2O coming from the fluid.
At Kalkan post-serpentinization processes led to the formation of chlorite and ferritchromite by reaction of fluid with spinel and serpentine, with MgO and SiO_2 coming from serpentine. Only rare serpentine relicts testify the serpentinization stage.
At Nurali no evidences of chlorite and ferritchromite formation have been observed and post-serpentinization processes led to partial reabsorption of chromite. Serpentinization did not affect chromite and led to the formation of magnetite as coronae around chromite crystals or as small scattered magnetite grains in the matrix. According to the mineral chemistry of involved phases we propose the following reaction for ferritchromite formation:

$$\begin{aligned}&2(Mg_{0.60}Fe_{0.40})(Cr_{1.30}Al_{0.70})O_4 +\\&3/2(Mg_{2.57}Al_{0.32}Fe_{0.11})Si_2O_5(OH)_4 + H_2O + 1/12O_2 \rightarrow\\&7/6(Fe_{0.60}Mg_{0.40})(Cr_{1.85}Fe_{0.08}Al_{0.07})O_4 +\\&1/2(Mg_{9.18}Fe_{0.34}Al_{1.60}Cr_{0.88})\ (Al_2Si_6)O_{20}(OH)_{16}.\end{aligned}$$

Magnetite formation during serpentinization without involving chromite can be described by the reaction:

$$\begin{aligned}&4(Mg_{1.8}Fe_{0.2})SiO_4 + 2(Mg_{0.9}Fe_{0.1})SiO_3 + 6H_2O + 1/6O_2 \rightarrow\\&3Mg_3Si_2O_5(OH)_4 + 1/3Fe_3O_4\end{aligned}$$

References

Kimball (1990) *Contrib Mineral Petrol* **105**: 337-346
Mellini (2005) *Contrib Mineral Petrol* **149**: 266-275