Nd isotopic constraints on the genesis of Archaean tonalitic gneisses from southern Zimbabwe

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We here report Nd isotopic data on selected undeformed archaean granitoids from three locations in the South of Zimbabwe craton. These Masahaba, Chingezi and Shabani areas belong to the Belingwe belt, where the oldest recognised basement of 3.5–2.9 Ga age is exposed. Using elements such as Y and heavy *REE* (Yb) as tracers of garnet in the source because of their high K_d^{garnet} partition coefficient, previous studies have shown that these tonalite-trondhjemite-granodiorite samples have been generated by melting of metamorphosed basaltic source with variable amount of garnet in the residue (Luais and Hawkesworth, 1994). Because of high $K_d^{Sm/Nd}{}_{garnet}$ ($K_d^{Sm/Nd} = 4$), we will evaluate on Nd isotopic ratios the inferences of garnet in the source, as well as the consequences on crustal Nd isotopic evolution.

Nd isotopic data

The Nd isotopic data and Nd and Sm concentrations of samples have been determined on *LREE+MREE* spiked fractions using the Plasma 54, as described in Luais *et al.* (1997). Sm-Nd results are reported together with trace element ratios in the initial ε_{Nd} (T) *vs* Sr/Y diagram below.

These samples have initial ε_{Nd} (T) varying from +3.9 to −2.5, with a large range in Sr/Y ratios from 2 to 200. Initial ε_{Nd} (T) and Sr/Y ratios are negatively correlated, with the high Sr/Y samples having low initial ε_{Nd} (T). Groups defined on the basis of compatible elements (Y, Sr contents, Sr/Y ratios)–incompatible elements (Rb) covariations, are characterized by specific Nd isotopic values: Group I tonalitic samples have low Rb contents (10–40 ppm) and high and constant Y contents. Chingezi samples have positive ε_{Nd} (T) values of 0.25 to 1.13 associated with low Sr/Y (11.5–12.5) and high Y contents (18.7–22.2 ppm), whereas Mashaba samples have lower ε_{Nd} (T) values of 0.2 to −2 and higher Sr/Y(27–40), lower Y contents (8.8–11.9 ppm). Group II trondhjemitic samples from Masaha and Chingezi areas define positive correlation between Rb and Y contents. Negative ε_{Nd} (T) values of −1 to −2 are associated with high Sr/Y ratios (50–200). Group III granodioritic samples from Shabani area have extremely high Rb contents (60–190 ppm). Higher and positive ε_{Nd} (T) values of +0.5 to +3.9 are associated with very low Sr/Y ratios (<40).

Discussion

This negative correlation between ε_{Nd} (T) values and Sr/Y ratios are in agreement with model involving garnet in the source of these granitoids. Considering the high $K_d^{Sm/Nd}{}_{garnet}$ of 4 (Fujimaki *et al.*, 1984), Sm and Y are preferentially retained in the residue of partial melting if garnet is present, comparing with Nd which is more incompatible and is partitioned into the partial melt. This results in low Sr/Y and high Sm/Nd ratios, ε_{Nd} (T) values in the residue, but high Sr/Y and low Sm/Nd ratio in the melt which generates granitoids. Therefore, partial melt resulting from melting of an amphibolitic source will have higher Sm/Nd ratio and consequently granitoids will become increasingly ε_{Nd} (if time ΔT elapsed from source melting to granitoid emplacement is long enough to generate distinct ε_{Nd}. Nd model ages have been calculated from Sm-Nd isotopic results. Group I and II samples have T_{DM} of 3.1–3.2Ga which are older than the 2.9 Ga emplacement age, whereas Group III samples have T_{DM} of 3.4–3.5 Ga similar to emplacement age. In the later case, no change in ε_{Nd} (T) value is expected whether or not garnet is present in the source. An age of 3.1–3.2Ga has not been reported previously from the South Zimbawe craton. However it can be related to a major episode of crustal growth described in the North Zimbabwe craton on the basis of zircon geochronology (Dougherty-Page *et al.*, 1993).

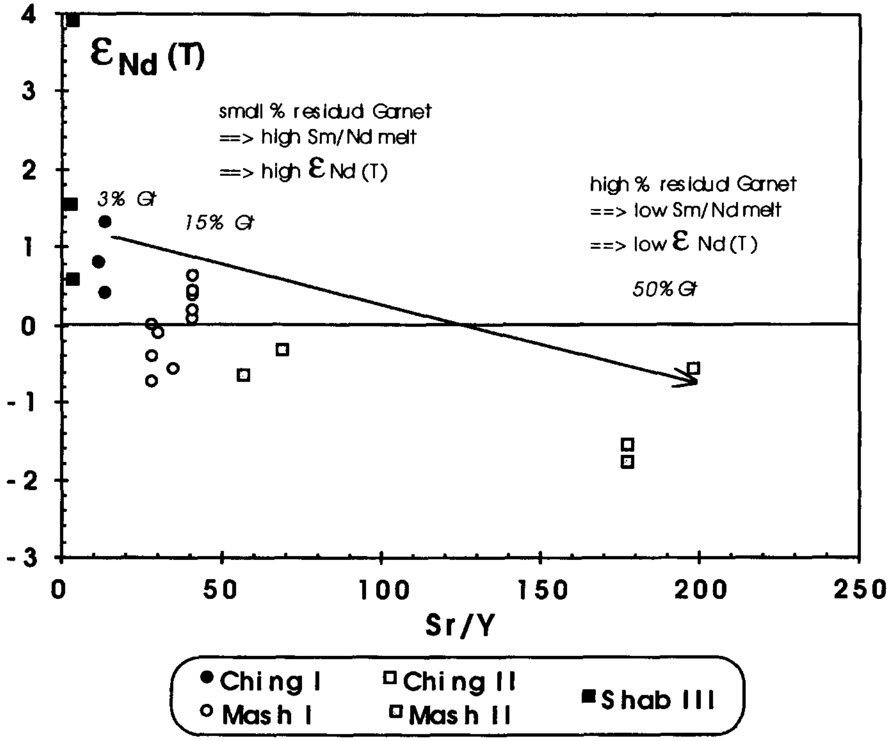

FIG. 1.

Decreasing ε_{Nd} (T) with increasing Sr/Y ratios from Group I to Group II as seen in Fig. 1 demonstrates an increasing amount of garnet in the residue of melting, from a Gt-amphibolite source with 3% Gt and 15% Gt in the residue for Group I samples (Chingezi and Mashaba, respectively), and to an eclogite source with nearly 50% Gt for Group II samples. For Group III samples, ε_{Nd} (T) values alone cannot demonstrate the occurrence or absence of garnet in the source. It is suggested that these granitoids from South Zimbabwe are generated by melting of distinct crustal levels: perhaps upper crust for Group III, to intermediate depth for Group I, and then to the lower crust for Group II where garnet is a major stable phase. They represent sampling of a vertical transect of the archaean crust beneath the Zimbabwe craton.

The Lu-Hf isotopic system is another potential geochemical tool which can enhance this conclusion because of its very high partition coefficient $K_d^{Lu/Hf}{}_{garnet}$ of 28 (Fujimaki *et al.*, 1984). As wit the Sm-Nd system, Lu behaves as a compatible element during partial melting of a garnet-bearing source, and it is preferentially retained in the source whereas Hf behaves incompatibly and is partitioned into the melt. This would imply with time higher ε_{Hf} (T) for Group I samples than for Group II samples. We expect to get results by the time of the conference.

Consequences of garnet-bearing sources on initial Nd isotopic values of archaean granitoids is of the first order. Low Sm, Lu contents in the partial melt with time will lower ε_{Nd} (T) and ε_{Hf} (T) values in granitoids if ΔT is long enough to have an effect on Nd and Hf isotopes. This can drastically modify crustal evolution pattern.

References

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