Reconstruction of crustal genesis in a high-grade gneiss terrane using Sm/Nd-whole rock systematics and Pb-isotopes of leached feldspar

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Introduction

Sm/Nd whole rock and Pb-feldspar data each provide important information on the history of old continental crust. However, the combination of both data sets allows new insights that prove most valuable in high-grade and polymetamorphic terranes, where a lot of information is lost during metamorphism. The data set from Tanzania comprises granitoid rocks from the Archaean craton and granulite and eclogite facies rocks from the polymetamorphic Mozambique Belt (MB) in Eastern Tanzania.

The evolution of the Mozambique Belt in eastern Africa (Holmes 1951) has been a matter of discussion for a long time, with essentially two contrasting models: the older one proposing an ensialic orogeny with reworking of older crustal material (Watson 1976; Kröner 1980) while the second, new model is based on plate tectonics involving continent-continent collision (Shackleton 1976; Muhongo 1989) with generation of new crust. However, the amount of new crust added during metamorphic events to pre-existing Archaean material and its distribution within the metamorphic belt was hitherto unknown. Some U-Pb zircon data on the granulites showed either evidence for Proterozoic (Maboko *et al.*, 1985) or Archaean (Coolen 1982) precursors. Several zircon samples just yielded upper intercepts around 700Ma that were interpreted as the age of Panafrican metamorphism.

Although Nd model ages are not unequivocal in their interpretation due to mixing effects in the crust and possible fractionation of the Sm/Nd ratio during high-grade metamorphism, they provide first order constraints on age provinces within metamorphic belts. Whereas the Sm/Nd ratio suffers most severe fractionation during melt extraction from the mantle i.e. the forming of new crust, changes in Th/Pb and U/Pb ratios occur afterwards during crustal processes such as metamorphism, sedimentation and weathering. Pb isotope systematics of leached feldspars from the same samples, therefore, give complementary results to Nd systematics because they reveal the time integrated effects of the crustal history and preserve information on the time of present parent-daughter fractionation.

Geological setting

The Mozambique Belt consists in Tanzania of Proterozoic rocks partly metamorphosed under granulite facies conditions (Bagnall 1963, Sampson and Wright 1964, Coolen 1980) during the Panafrican orogeny (Coolen 1982, Maboko *et al.*, 1985, Möller *et al.*, unpubl. data). The Belt makes up much of the eastern part of the country. The Archaean Tanzania Craton constitutes the Belts western border, in the east it is overlain by Phanerozoic sediments. Our main study areas are the Pare-, Usambara- and Uluguru-Mts granulites in the eastern and central Mozambique Belt and the Yalumba Hill area in the western Usagaran mountains which border the Tanzania Craton to the east. Additional samples were collected from the Craton itself and from granulites and migmatitic gneisses in the lowlands adjacent to the granulite areas mentioned above.

In the Usagaran Mts. eclogite- and amphibolite-facies rocks occur in a narrow zone between the Mozambique Belt *s.s.* and the south-eastern edge of the Tanzania Craton. Whittingham (1959) described Yalumba Hill area as belonging to the Mozambique Belt, but biotite (and muscovite) mineral ages suggest a decreasing Panafrican influence towards the Craton (Wendt et al. 1972) on a previous metamorphic event of Usagaran age (2 Ga, Möller *et al.*, unpubl. data).

The granulites investigated in the Mozambique Belt exhibit surprisingly similar peak metamorphic conditions, although the sampled areas are several hundreds of km apart (Appel *et al.*, 1993). Their counterclockwise P-T path is typical for regions where magmatic underplating caused heating and subsequently thickening of the crust, which then cooled down at low crustal levels (Wells, 1980; Bohlen, 1987).

Results

Pb isotopes were measured on leached feldspar separates from the Mozambique Belt of Tanzania and the Archaean Tanzania craton. K-feldspar was preferred over plagioclase where available. Sm and Nd isotope analyses were performed on whole rock powders of the same samples. Nd model ages were calculated using the model parameters of Milisenda *et al.* (1994).

The Nd and Pb data allow distinction of three groups of basement rocks in eastern Tanzania. The first group, with Archaean model ages between 2.6 and 2.9 Ga is formed by granitoids of the craton together with eclogite- and amphibolite-facies rocks from the Usagaran domain. These old model ages are supported by the strongly retarded common Pb of the feldspars. Craton, as well as Usagaran samples, lie above the Stacey & Kramers (1975, S&K) Pb-evolution curve, suggesting evolution with a higher l-value from a common source at or before 3 Ga. The Usagaran samples have Nd model ages that are indistinguishable from the Archaean Craton and thus these rocks are probably derived from this source by melting or by erosion and sedimentation without the addition of major amounts of newly formed crust. This is in accord with their $^{206}Pb/^{204}Pb$ ratios shifted to higher values as would be expected from rocks that show last recrystallisation of Fsp during metamorphism at 2 Ga.

The second group of Nd model ages clusters tightly between 0.9 and 1.4 Ga and is restricted to the granulite areas of NE-Tanzania (Pare, Usambara, Umba, Wami) and the eastern Uluguru Mts. granulites. In the $^{207}Pb/^{204}Pb$ *vs.* $^{206}Pb/^{204}Pb$ diagram these granulites plot below and to the right of the 1 Ga point on the S&K curve. This group of granulites can be explained as juvenile addition to the crust at or just after 1.4 Ga or alternatively as a product of mixing of juvenile material during the Panafrican metamorphic event with some pre-existing crustal material possibly from the Craton and/or the Usagaran Mts.The third group shows the effect of mixing more clearly. Regionally restricted to the western part of the Uluguru Mts. they show Nd model ages between 1.8 and 2.4 Ga and plot on or above the S&K curve in the $^{207}Pb/^{204}Pb$ *vs.* $^{206}Pb/^{204}Pb$ diagram. This may be interpreted as a product of their derivation from cratonic and/or Usagaran material reworked during the panafrican orogeny.

Conclusions

Nd model ages and Pb isotopes on leached feldspars reveal clearly distinct terranes within the Mozambique Belt in Tanzania that had not been clearly recognized in the past. The best example is the Uluguru Mts. granulites where a single granulite terrain may be subdivided in terms of crustal residence time, whereas structural and petrological evidence can not be of any help in this assessment.

Long crustal residence times for lowland migmatites in between the panafrican granulite mountains suggest a more complex regional distribution of crustal terranes within the Mozambique Belt. This complexity is essential to recognize when attempting a conclusive explanation for the plate-tectonic history of the Panafrican belt.

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