Sm-Nd isochron ages from Southern Granulite Terrain, South India: Age of protolith and metamorphism

RAJNEESH BHUTANI, S. BALAKRISHNAN, C.G. NEVIN AND S. JEYABAL

Department of Earth Sciences, Pondicherry University, Pondicherry-605014, India (rbhutani@gmail.com)

Temporal correlation of metamorphsim and deformation in the poly-metamorphic and poly-deformed Southern Granulite Terrain (SGT) in south India is of primary importance to understand the evolution of continental lithosphere and tectonics. However, because of intensive overprinting of succesive metamorphic and deformation events the time correlation could not be unambiguously acieved for SGT. We used an approach of analysing the carefully selected whole rock samples and mineral-separates for Rb-Sr and Sm-Nd systems to retrieve and resolve different tectono-metamorphic events experienced by these samples.

A sample from the eastern part of the SGT and north of Cauvery Shear Zone, near Namakkal town yielded a good seven point Sm-Nd mineral isochron, for minerals garnet-1, garnet-2, diopside, ortho-pyroxene, plagioclase, biotite and whole-rock with an age of 879 ± 9 Ma (MSWD = 1.6). We have interpreted this to be an age of granulite facies metamorphism. Whereas, a regression line for the same minerals in Rb-Sr isotope evolution diagram corresponds to an age of ~ 524 ± 80 Ma. Furthermore, pairs of whole-rock – biotite and biotite-plagioclase yielded identical Rb-Sr ages of 540 ± 21 Ma and 543±21 Ma respectively with initial $^{87}Sr/^{86}Sr$ ratio of ~ 0.7023. We, therefore interpret that this sample of granulite has experienced two tectono-thermal events. The older event at ~ 880 Ma completly re-equilibrated all the minerals for Sm-Nd system and therefore, has provided time of granulitization. Another younger event did not disturb the Sm-Nd system but reset the minerals for Rb-Sr system to variable extent at ~ 540 Ma. The four point Sm-Nd isochron for the whole-rock samples of granulites from the same region yielded isochron age of 2208 ± 130 Ma with MSWD 1.6. The Nd T_{CHUR} model ages for the granulite samples from this region range from 2369 to 2935 Ma. This indicates that the formation of protolith of these granulites completed by ~2208 Ma ago which had undergone granulite facies metamorphism at ~ 880 Ma ago when the Sm-Nd radio-chronometer remained un-affected as the equilibration took place only at mineral scale.

The above results provide important time constraints for the protolith formation and two subsequent tectono-thermal events. The older at 880 Ma corresponds to Rodinia supercontinent period which caused the granulite facies metamoprhism and younger at 540 Ma could be related to intensive regional deformation during Pan-African assembly of Gondwanaland.

REE pattern and Oxygen isotopes in zircons from different rocks (the Fennoscandian and Ukrainian Shields) as indicators of their genesis

E. BIBIKOVA[1], A. FEDOTOVA[1] AND S. CLAESSON[2]

[1]Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow, Russia (bibikova@geokh.ru)
[2]Swedish Museum of Natural History, Stockholm, Sweden

There are different views on the role of REE distribution in zircons as indicator of the rock genesis. Recent studies have shown deviations from the crystallochemical REE pattern typical for zircons of magmatic genesis: in high-pressure rocks (eclogites) -deficiency in HREE, and in so called "hydrothermal" zircons [1] –enrichment in LREE. The role of oxygen isotopes in zircons has been discussed in many publications.

We have studied the distribution of REE and oxygen isotope composition in zircons from Archaean sanukitoids (Karelia, the Fennoscandian Shield) and from ancient enderbites (Dniestr-Bug region, the Ukrainian Shield). The REE distribution was determined on a Cameca 4F SIMS instrument in Yaroslavl, the oxygen isotope composition on a Cameca 1270 SIMS instrument in Stockholm.

A detailed study of Karelian sanukitoids is given in [2]. Sanukitoid zircons which have been dated to 2740 Ma are enriched in LREE with $(Yb/Sm)_N$=10-50, $(Yb)_N$=1200-2700 and have heavy oxygen isotope composition of about +7 per mil. These features could be explained as the growth of zircons with primary imperfect structure corresponding to "hydrothermal zircons" [1]. We have connected the genesis of sanukitoids with subduction processes that involve fluids or melts from a subducted slab in a mantle wedge [2].

Enderbites from the Dniestr-Bug region are the oldest rocks of Ukrainian Shield. They contain two zircon generations. The first one of magmatic genesis is as old as 3.65 Ga, the second, metamorphic generation is about 2.85 Ga old and was grown during granulitic metamorphism overprint on magmatic tonalities [3]. The distribution of REE elements in the early zircon generation is typical for magmatic zircons having chondrite-normalized REE pattern with positive slope from La to Lu and positive Ce and negative Eu anomalies. The second, "granulitic" zircon generation has much lower concentration of REE elements with deficiency in HREE $(Yb/Gd)_N$=2-8, $(Yb)_N$=300-400. This deficiency is not as pronounced as in eclogitic zircons, but still it indicates crystallization of zircon during metamorphism along with garnet enriched in heavy REE.

Our study has confirmed the indicator role of REE and oxygen isotopes in zircons in establishing the mineral genesis highly important for geochronological studies.

References

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