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Evidence of metamorphic zircon growth in Zr-depleted nepheline syenite

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On three zircon-biotite pairs we demonstrate the growth of metamorphic zircon by breakdown of Zr-bearing biotite under granulite facies conditions in a Zr-undersaturated environment.

Numerous publications deal with metamorphic zircon formation by processes for which the existence of precursory magmatic zircon is a prerequisite (e.g. crystallization from hydrothermal fluids or anatectic melts, recrystallization, solid-state growth). However, nepheline syenites of the Koraput alkaline complex (Eastern Ghats Province, India) contain metamorphic zircon although magmatic zircon is absent. The nonexistence of magmatic zircon is not surprising with regard to the low Zr content (63-163 ppm) at high rock alkalinity (M = 2.14 with M = [Na +K +2Ca]/[Al*Si]). For such chemical compositions Zr saturation cannot be obtained during magmatic stages. The metamorphic zircon growth can be related to a regional granulite facies overprint recorded in the Koraput complex and the surrounding country rocks.

CL and BSE studies of the sub- to anhedral, partly multi-facetted zircons reveal typical metamorphic features. Blurred planar or rounded structures and large homogeneous crystal domains determine the internal framework. In few cases a poorly evolved sector zoning exists while oscillatory zoning and inherited cores are absent. LA-ICP-MS and conventional U/Pb ages are nearly concordant covering an age range between 700 – 880 Ma indicative of a time interval of repeated crystallisation under high-grade metamorphic conditions rather than a single zircon growth event. REE spectra of zircon show the usual positive Ce anomaly and the preferred enrichment of HREE over LREE. The missing negative Eu anomaly suggests that no magmatic feldspar fractionation occurred during zircon growth and supports the previous observations. As expected for metamorphic zircon the total REE content is low.

The Koraput nepheline syenite contains hornblende, ilmenite and biotite as possible Zr-bearing phases. No Zr was detected in ilmenite. Accessory hornblende is excluded as Zr source mainly because no spatial relationship between hornblende and zircon is observable. Furthermore, hornblende is partly decomposed in favour of secondary biotite, which represents another Zr-substituting phase. The Zr content in biotite is on average 17 ppm (n=11) with a maximum of 30.0 ppm. Zircon often appears in contact with one or more biotite grains. At these contacts, the Zr content in biotite is reduced to 1.2 – 1.3 ppm. With increasing distance from the contact the amount of Zr in biotite increases again from <6 ppm to near to 20 ppm. In our opinion, these observations demonstrate that metamorphic zircon can form through the release of Zr from magmatic biotite in an overall Zr-undersaturated environment.