Genesis of zircon and baddeleyite megacrysts from the Mbuji Mayi kimberlite (Central Africa) inferred from trace and RE-element patterns

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Single grains of zircon ($ZrSiO_4$) and baddeleyite (ZrO_2) megacrysts extracted together with diamonds from the Mbuji Mayi kimberlite reveal Cretaceous re-crystallization ages but varying initial Hf isotope signatures ranging between +5.1 and +10.2 (7 individual dates [1]). This observation substantiates crystallisation from mantle reservoirs having several hundred of million year differences in source residence times. It was therefore expected that trace and RE-element patterns of these grains would reveal corresponding differences in their element pattern; however, both zircon and baddeleyite show surprisingly homogeneous patters (LA-ICP-MS; Element-2; standard: zircon # 91500). The 5 baddeleyite grains are by 30 to 120 times chondrite enriched in intermediate to heavy REE, and strongly depleted in the lightest REE, except Ce showing a positive anomaly (Ce^{4+} substitutes Zr^{4+}). Corresponding $(La/Yb)_N$ range between 0.01 and 0.04. On the over-all trace element level they have high Th, U, Ta, and Nb reaching up to 5000 times chondrite values. From intermediate to heavy REE, the 2 zircon megacrysts reach from 1 to 100 times chondrite enrichment, and they are strong depletion in light REE with $(La/Yb)_N$ at 0.0001. Cerium is again an exception having about 20 times chondrite abundance. In individual baddeleyite and zircon grains trace element variations vary by a factor of about two. In addition, europium anomalies are absent, but lead, thorium, and uranium form significant positive anomalies such as hafnium in both phases, and tantalum, and niobium in baddeleyite. Together with the requirement of high Zr in the sources to form zircon and baddeleyite, the chemical patterns and in particular, high Th, U, Ta, and Nb indicate the megacrysts to have crystallized in a highly LILE and HFSE-enriched source. Such sources were most likely basaltic melts produced by low-degrees of partial lherzolite melting. These melts must have resided for long periods of time at great depth ($>$ 200 km) to deliver the megacrysts to the kimberlite magma in Cretaceous times. Crystallization of the baddeleyites and zircon may have occurred either directly from melts or by metamorphic subsolidus diffusion at great depth.

[1] Schärer U., Corfu F., Demaiffe D. (1997). U-Pb and Lu-Hf isotopes in baddeleyite and zircon megacrysts from the Mbuji Mayi kimberlite: constraints on the subcontinental mantle Chemical Geology 143, 1-16

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