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On the genesis of zircon and baddeleyite megacrysts from the Mbuji-Mayi kimberlite: trace element patterns (LA-ICP-MS)

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Five 70 Ma old baddeleyite (ZrO2) and two zircon (ZrSiO4) cm-size crystals were measured for 25 trace elements by the laser ablation ICP-MS technique (Element-2 instrument; standard: NIST612 glass, monitor: zircon # 91500). The 25 analyzes reveal surprisingly uniform trace element patterns of both minerals, although the individual megacryst have crystallized within differently fractionated mantle domains that are characterized by initial epsilon Hf values (Hf70Ma) ranging from +5.1 and +10.2 (Schärer et al., 1997). On the over-all trace element level the baddeleyites have high Th, U, Ta, and Nb abundances reaching up to 5000 times chondrite values. In intermediate to heavy REE (HREE) they are by 30 to 120 times chondrite enriched but strongly depleted in the lightest REE (LREE), except Ce showing a positive anomaly (Ce4+ substitutes Zr4+). Corresponding (La/Yb)N range between 0.01 and 0.04. The 2 zircon megacrysts show very similar trace element concentrations also having high Th and U but low, normal Ta and Nb. Intermediate to HREE are from 1 to 100 times chondrite enriched and, LREE are strongly depleted yielding (La/Yb)N at 0.0001. Cerium is again an exception having about 20 times chondrite abundance. Both minerals have high Zr/Hf ratios of 58 for the zircons, and 65 for the baddeleyites (Schärer et al., 1997), compared to crustal zircons (Zr/Hf of 33-36) and both the primitive and MORB mantle (Zr/Hf of 35-36). U concentration in baddeleyite reaches 2000 ppm (Schärer et al., 1997). Together with the requirement of high Zr in the mantle sources to form zircon and baddeleyite, the trace element pattern indicate crystallization of the megacrysts in highly LILE and HFSE-enriched mantle that had already been fractionated to different degrees hundred of million years prior to megacryst formation. This is consistent with the presence of a very old, Precambrian Pb component in all grains (Schärer et al., 1997). Moreover, as deduced from a TEM study, crystallographic properties of these baddeleyites (Kerschhofer et al., 2000), the old source domains were located within the lower mantle at the time of megacryst formation, 70 Ma ago. From there they were extracted by the ascending kimberlite magma, which was necessarily produced at even greater depth, requiring magma and megacryst transfer across the 670 km seismic discontinuity. Since all the xenocrystic megacrysts have the same age they must have been formed in relation to the kimberlite thermal pulse but prior to magma ascent. Overall geochemical characteristics of the baddeleyites and zircons are best explained by crystallization from a magma, derived by very low degrees of partial mantle melting.