ZIRCONS AND BADDELEYITES FROM DIFFERENTIATED METEORITES — BASALTIC ACHONDRITES: ION PROBE DATING AND REE SYSTEMATICS

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Basaltic achondrites, mainly eucrites and howardites are the oldest known basalts in the solar system and it is commonly assumed that they have solidified early on the surface of the HED parent body, which has experienced a very complicated history with multiple stages: core formation, formation of primary basaltic magma, fractionation and shock deformations, local impact melting, disruption and reassembly.

We detected small grains of zircon — Zr silicate and baddeleyite — Zr oxide, within more than 11 basaltic achondrites, both non-Antarctic and Antarctic, using scanning and electron microprobe (MPI Heidelberg) for the chemical analyses from which Zr/Hf ratio was calculated. The most precise age determination was possible with SHRIMP 1 ion microprobe. With this ion microprobe very accurate isotope measurements can be carried out *in situ* on zircons and baddeleyites, grains 5–30 microns in diameter. U–Th–Pb isotopic and REE abundances were determined in Stannern, Padvarninkai, Pasamonte, Cachari, Jonzac, Juvinas, Bereba, Millbillillie and three Antarctic basaltic achondrites.

The U concentration of zircon from the non-Antarctic eucrites is around 50–100 ppm, high U was found in Pasamonte. The baddeleyite has about 60 ppm of U and extremely heavy REE-enriched zircon patterns and slightly light REE-enriched pattern (La 1800 x CI, Lu 800 x CI) with a large Eu depletion. All U–Pb analyses are either concordant or reverse discordant, having excess of radiogenic Pb. The weighted mean $^{207}Pb/^{206}Pb$ age of Juvinas, Cachari, Jonzac, Millbillillie and Pasamonte is 4560, Bereba 4534, Padvarninkai 4553 ± 13 and Stannern 4550 ± 10 Ma. Within the set of seven baddeleyites from Antarctic basaltic achondrites ALHA 80102, ALHA 83232 and EETA 81006 (Fig. 1) the U–Pb ratios of all grains appear concordant and the weighted mean $^{207}Pb/^{206}Pb$ age is 4549 ± 18 Ma. The REE patterns were measured in four baddeleyites; the other three had apparently been consumed during the U–Pb measurements. Baddeleyite 83232.1 shows a relatively flat REE pattern (500 x CI for La to 1100 x CI for Lu) with a large depletion in Eu.

Baddeleyite 80102.4 is similar, but baddeleyite 80102.3 is more fractionated (La 20 x CI, Lu 330 x CI) with a large Eu depletion (Eu/Eu * < 0.1) but also a Ce excess (Ce/Ce* = 4.8). This is the first example of a Ce excess that we have found in meteoritic zircon and baddeleyite. It is a common feature of terrestrial zircons where the higher oxygen fugacity stabilizes Ce^{4+} which is preferentially incorporated into the zircon structure relative to Ce^{3+}. The more fractionated pattern of this grain suggests that it may be a zircon–baddeleyite intergrowth. The surface exposure as analyzed by electron microprobe is solely baddeleyite but zircon may be present at depth and eventually sputtered by the primary beam. Baddeleyite 81006.8 has low overall abundances (La 8 x CI, Lu 270 x CI) and does not have a Eu anomaly. Both minerals, zircon in the set of non-Antarctic eucrites, and baddeleyite in the set of Antarctic basaltic achondrites, primarily record the initial formation of the rock and have either not been disturbed by any subsequent thermal process, or the thermal processing occurred only a short time after their crystallization. Thus, none of the measured grains show any indication of a younger degassing event apparent in Ar–Ar dating of many achondrites.

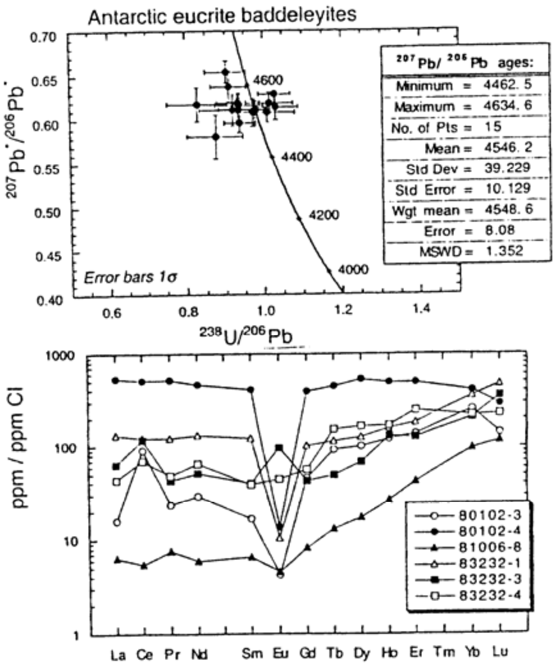

Fig. 1: $^{207}Pb/^{206}Pb$ ages and REE in Antarctic eucrite baddeleyites