Hf-W ANALYSES OF EUCRITE ZIRCON: NEW CRYSTALLIZATION TIMESCALES FOR THE EUCRITE PARENT BODY. J. Roszjar[1], G. Srinivasan[2], M. Whitehouse[3], A. Bischoff[1], and K. Mezger[4]
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Introduction: We used the short-lived ^{182}Hf-^{182}W chronometer with a half-life of 8.9 Myr to determine the timing of crystallization of basaltic eucrites. The formation of these basaltic melts is related to planetary differentiation processes on the eucrite parent body (EPB) [1]. If a zircon crystallizes during the lifetime of ^{182}Hf it will accumulate an excess of ^{182}W (Fig. 1). Due to the low diffusivity of ions in the zircon lattice, it can be expected that the Hf-W system remains closed after zircon growth under most geologic conditions [2]. This makes zircon an ideal phase for geochronologic studies. In this study a total of 19 zircon grains from five eucrite samples were investigated for their chemical and Hf-W isotopic composition. Investigated basaltic eucrite samples include Dhofar (Dho) 182, Northwest Africa (NWA) 1908, NWA 4523, NWA 5073, and Hammadah al Hamra (HaH) 286.

Methods: A JEOL 6610-LV SEM equipped with energy dispersive spectrometers (EDS; INCA; Oxford Instruments), a JEOL JXA 8900 Superprobe EPMA, and optical microscopy at WWU Münster were used for mineralogical and chemical characterization. For W isotope analyses on small individual phases with low W concentrations, an ion microprobe is required. Thus, *in situ* Hf-W isotope analyses of 19 eucrite zircon grains were performed at high mass resolution using a large radius magnetic sector multi-collector Cameca IMS-1280 ion microprobe at the Swedish Museum of Natural History, Stockholm using the method reported in [3]. ^{178}Hf, ^{182}W, ^{183}W, and ^{184}W were measured in single spot analyses, by running 24 cycles, 30 s counting times each, and using electron multipliers. Magnet field values were locked using a nuclear magnetic resonance (NMR) field sensor. The ^{178}Hf/^{184}W was converted to ^{180}Hf/^{184}W using ^{180}Hf/^{178}Hf = 1.28 [3]. A relative sensitivity factor, presented in [3], was used to correct for ionization efficiencies of both Hf and W. Three terrestrial reference materials were used for standardization: NIST610 glass, G-zircon, and 91500 zircon. Due to an unresolvable interference of ^{174}Hf^{12}C on ^{186}W, the isotope ^{184}W was measured. Carbide might occur as natural inclusion, or as polishing and/or carbon coating artifacts particular on the G-zircon standard.

Results and conclusions: Zircon grains from all studied eucrite samples typically occur in mineral paragenesis with ilmenite, pyroxene, plagioclase, ± chromite (Fig. 2). The selected grains have diameters ranging from 5-30 µm. EPMA analyses on zircon grains used for SIMS analyses yield HfO_2 contents ranging from 0.85 wt% in NWA 1908 to 2.11 wt% in HaH 286, with a typical value of ~1.2 wt%. All analyzed grains contain ≤0.01-0.14 wt% Y_2O_3, 0.07-0.16 wt% P_2O_5, and 0.04-0.20 wt% CaO.

G-zircon has ^{180}Hf/^{184}W ratios from 2.2×10^3-4.6×10^5, and normal W isotope compositions within experimental errors (Fig. 1). The ^{180}Hf/^{184}W ratios of zircon grains deriving from different eucrite samples range from 1.3×10^4-4.6×10^5 (Fig. 1). All eucrite zircon grains show significant ^{182}W excess and a positive correlation between ^{182}W/^{184}W and ^{180}Hf/^{184}W. The initial ^{182}Hf/^{180}Hf ratios for each sample (Table 1) was calculated using *Isoplot* software. Eucrite ages were calculated relative to the absolute age of the D`Orbigny angrite (4563.4 ± 0.3 Ma) [4]. Relative ages were calculated using the initial CAI $(^{182}Hf/^{180}Hf)_0$ of $(9.72 \pm 0.44)\times10^{-5}$ [5], initial D`Orbigny $(^{182}Hf/^{180}Hf)_0$ of $(7.15 \pm 0.17)\times10^{-5}$ by [4], and $\lambda^{182}Hf = 0.078 \pm 0.002\ Ma^{-1}$ [6], using the following equation:

$$\Delta t = 1/\lambda \ln\, (^{182}Hf/^{180}Hf)_0/(^{182}Hf/^{180}Hf)_t.$$

Dho 182 has the best defined Hf-W age. HaH 286 is within error indistinguishable from D`Orbigny, whereas all remaining samples are significantly younger. The resulting model ages are given in Table 1 and shown in Fig. 3. The Hf-W systematic of zircon grains from NWA 5073 is disturbed, which fits to the complex thermal history of this sample [7]. The corresponding Hf-W age is a model age, which has a slightly larger error compared to other eucrites analyzed here.

Table 1. Model initial ^{182}Hf/^{180}Hf values, age differences relative to CAI [5] and D`Orbigny [4], and Hf-W ages, calculated relative to D`Orbigny absolute age. Absolute ages are shown within 2σ confidence.

Samples	inital ^{182}Hf/^{180}Hf	Δt CAI [Myr]	Δt D`Orbigny [Myr]	Absolute ages[Myr]
Dho 182	$(4.22 \pm 0.70)\times10^{-5}$	10.7	6.8	4556.6 ± 1.1
HaH 286	$(3.33 \pm 3.10)\times10^{-5}$	13.7	9.8	4553.6 ± 9.1
NWA 1908	$(2.09 \pm 0.94)\times10^{-5}$	19.7	15.8	4547.6 ± 7.1
NWA 4523	$(2.86 \pm 0.12)\times10^{-5}$	15.7	11.8	4551.6 ± 4.9
NWA 5073	$(0.91 \pm 0.61)\times10^{-5}$	30.5	26.6	4536 ± 18
Combined zircon grains	$(2.91 \pm 0.56)\times10^{-5}$	15.5	11.5	4551.9 ± 2.2

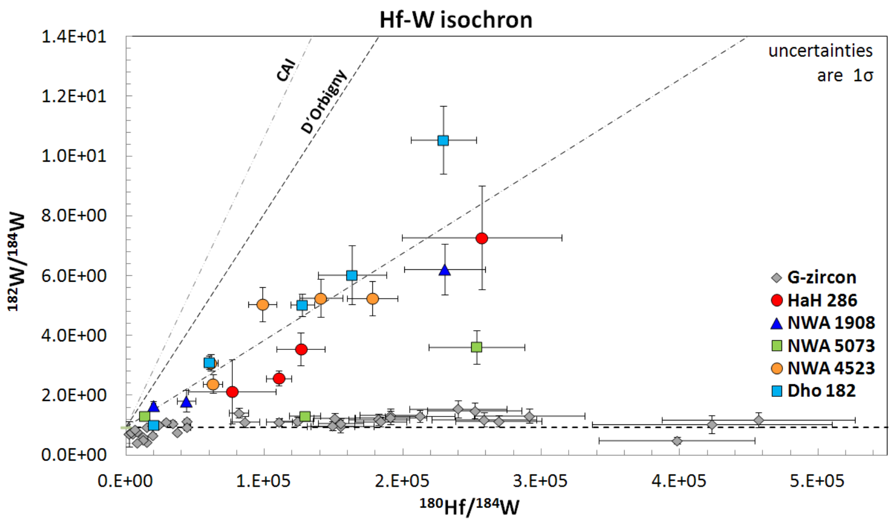

Fig. 1 Isochron plot for Hf-W isotopic composition of all analyzed eucrite samples and G-zircon standard. All eucrite zircon grains show an excess in ^{182}W, while the standard has normal W isotope composition. For comparison, Hf-W isotope trends for the D`Orbigny angrite [4] and CAI [5] are shown as dashed lines. Eucrite zircon grains exhibit a measurable $^{182}W$ and are significantly younger compared to D`Orbigny and CAI.

The mean ages suggest late crystallization of zircon grains (except Dho 182) when ^{26}Al was ineffective as a heat source [8]. This would require early formed magma(s) to survive sufficiently deep inside the parent body for effective insulation. Later extraction of melt and formation of basalt (and zircon grains) could result in the age pattern that we observe. Alternatively zircon grains crystallized from impact generated melt(s) and therefore ^{26}Al had limited or no role to play.

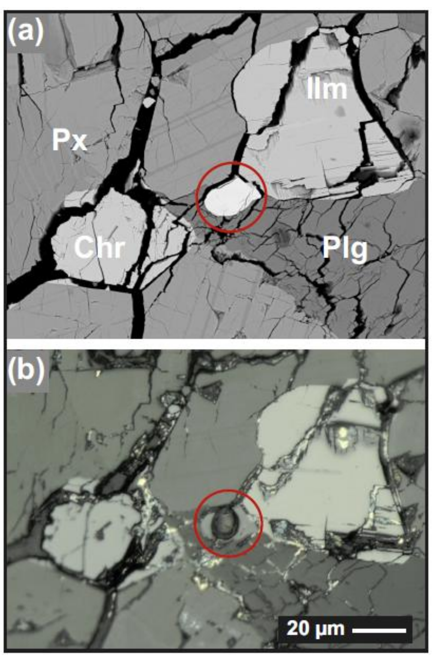

Fig. 2 (a) BSE image of a zircon grain (red circle) found in Dho 182 in a typical mineral assemblage with ilmenite (Ilm), pyroxene (Px), plagioclase (Plg), and chromite (Chr). (b) Optical photomicrograph of the same area, centered SIMS spot on the zircon grain is shown.

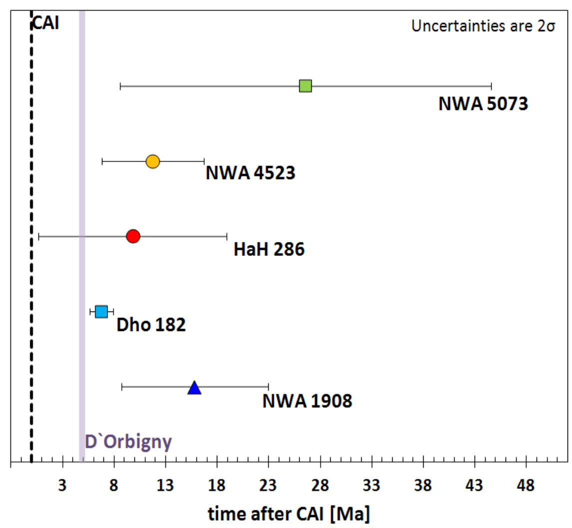

Fig. 3 Hf-W ages of eucrite samples relative to Solar System initial value, represented by the D`Orbigny angrite [4] and CAI [5]. As seen in this figure, all analyzed eucrite samples crystallized at different time periods, and are significantly younger (6.8-26.6 Myr) than angrites.

References: [1] Ireland T. R. and Bukovanská M. (2003) *Geochim. Cosmochim. Acta*, *67*, 4849-4856. [2] Lee J. K. W. et al. (2000) *Nature*, *390*, 159-161. [3] Srinivasan G. et al. (2007) *Science*, *317*, 345-347. [4] Kleine T. et al. (2012) *Geochim. Cosmochim. Acta*, *in press*. [5] Burkhardt C. et al. (2008) *Geochim. Cosmochim. Acta*, *72*, 6177-6197. [6] Vockenhuber C. et al. (2004) *Phys. Rev. Lett.*, *93*, 172501. [7] Roszjar J. et al. (2011) *Meteoritics & Planet. Sci.*, *46*, 1754-1773. [8] Srinivasan G. et al. (1999) *Science*, *284*, 1348-1350.