Hf-W AGES OF ZIRCONS - NEW CONSTRAINTS ON THE EVOLUTION OF THE EUCRITE PARENT BODY. J. Roszjar[1], G. Srinivasan[2], A. Bischoff[1], K. Mezger[3] and M. Whitehouse[4] [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str.10, 48149 Münster, Germany, julia_roszjar@yahoo.de. [2]Department of Geology, University of Toronto, Toronto, ON, Canada, M5S 3B1, srini@geology.utoronto.ca., [3]Institut für Mineralogie, Westfälische Wilhelms-Universität Münster, [4]Laboratory for Isotope Geology, Swedish Museum of Natural History, SE-104 05 Stockholm, Sweden.

Introduction: Basaltic eucrites are thought to represent products of mantle melting on the eucrite parent body (EPB). Due to their old ages they attest to early magmatic activity on small planetary bodies in the Solar System [1-4]. Here, we present new Hf-W data from eleven zircons found in four basaltic eucrites, including Sahara 98110 (Sah98110), Millbillillie (Mil), Dar al Gani 391 (DAG391) and Dar al Gani 276 (DAG276). An example of the typical occurrence of zircons in eucrites is shown in Fig.1. We used the short-lived ^{182}Hf-^{182}W chronometer, which has a half-life of 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 EPB [5]. It has been shown that the ^{182}Hf-^{182}W chronometer can be used to resolve the relative chronology of early planetary processes with high accuracy [1,6-9]. During crystallization zircon incorporates ~1-2 wt % of Hf (Table 1) but no significant W. However, if a zircon crystallized during the lifetime of ^{182}Hf it will accumulate some ^{182}W in its lattice. 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 [1,3]. This makes zircon an ideal phase for geochronologic studies. The low concentrations of W that are expected in the zircon require an ion microprobe for their accurate detection.

Methods: The chemical composition of the eucrite zircons were determined by EMPA at the Institut für Mineralogie in Münster, Germany. The Hf-W isotopic and elemental compositions of eleven eucrite zircons were measured with the double focusing Cameca 1270 ion microprobe at the Swedish Museum of Natural History, Stockholm using the technique reported in [4]. During single spot analyses the isotopes ^{178}Hf, ^{182}W and ^{184}W were measured. The ^{178}Hf/^{184}W was converted to ^{180}Hf/^{184}W using the factor ^{180}Hf/^{178}Hf = 1.28 [4]. A relative sensitivity factor (RSF) [4] was used to correct for the ionization efficiencies of both Hf and W. Two terrestrial reference materials were used for standardization: NIST610 glass and G-zircon. All samples were measured in one sequence. Instrumental shift is insignificant (see Fig.2).

Samples: The studied eucrite samples are breccias: Sah98110 and Mil are monomict, DAG391 and DAG276 are polymict. DAG391 and Sah98110 are very weakly shocked (S2), while Mil and DAG276 are shocked to S3 according to the scheme for ordinary chondrites [11]. Mil is unequilibrated, rich in lithic clasts and displays a variety of volcanic and metavolcanic textures [12]. The zircons selected for analyses have a diameter ranging from 7-12 µm and are mostly located along interfaces of larger minerals. Some zircons occur in clusters (e.g., Zr-Nest5 in Sah98110). The zircons from all eucrite samples are part of a mineral paragenesis that includes ilmenite, pyroxene, and plagioclase (Fig.1).

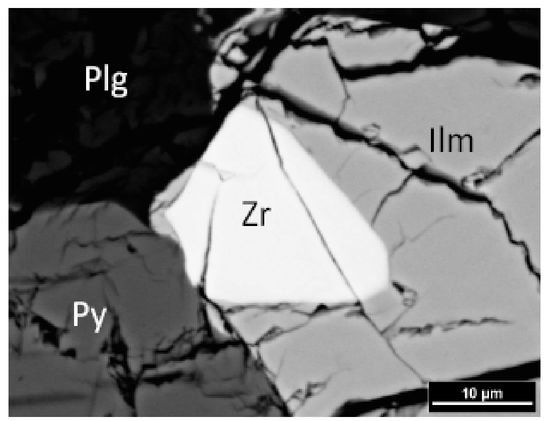

Fig.1 BSE image of a zircon (Mil-Z12) with typical 120° intergrain boundaries for the mineral paragenesis with ilmenite (ilm), pyroxene (py), and plagioclase (plg).

Results: All terrestrial samples have normal W isotope composition, while all meteorites have an excess of ^{182}W, ranging from $\delta(8.22 \pm 2.03)x10^2$ in ZrNest5 Sah98110 to $\delta(8.72 \pm 3.12)x10^3$ in Zr23 Sah98110 (Fig.3). In DAG391 and DAG276 only two zircons were large enough for ion microprobe measurements. The model initial ^{182}Hf/^{180}Hf for these two zircons are $5.84x10^{-5}$ and $7.69x10^{-5}$. For Mil and Sah98110 the calculated initial ^{182}Hf/^{180}Hf is $7.99x10^{-5}$ (Mil) and for Sah98110 it is $7.10x10^{-5}$. The combined ^{182}Hf/^{180}Hf for all eucrite zircons is $7.11x10^{-5}$. Eucrite model ages can be calculated relative to the absolute age of Ca-Al-rich inclusions (CAIs) (4568.3 ± 0.7 Ma) [13] using the following equation:

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

We calculated the relative age difference using the initial Solar System ($^{182}Hf/^{180}Hf)_0$ of 1.07×10^{-4} [14] and $\lambda^{182}Hf = 0.078 \pm 0.002$ Myr^{-1}[15]. The resulting model ages are Sah98110: 4559.6 ± 6.7 Ma; Mil: 4566.1 ± 15.2 Ma; DAG391: 4560.5 ± 5.9 Ma and DAG276 4564.1 ± 8.7 Ma. The results are shown in Fig.3. The age obtained from the combined $^{182}Hf/^{180}Hf$ of all eucrite zircons is 4563.1 ± 9.1 Ma.

Conclusions: The eucrite ages are consistent and equivalent to the ages from two other eucrites that were determined by Srinivasan et al. [4]. Based on the combined zircon isochron (Fig.3), we can deduce that the eucrite zircons formed within a maximum time period of about 8.7 ± 6.7 Ma after core-mantle segregation.

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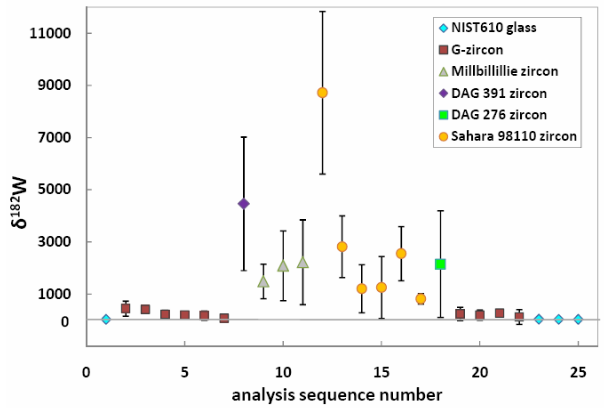

Fig. 2 $\delta^{182}W$ of all measured samples in their order of measurement. All errors are $2\sigma_m$. See [15] for definition of $\delta^{182}W$.

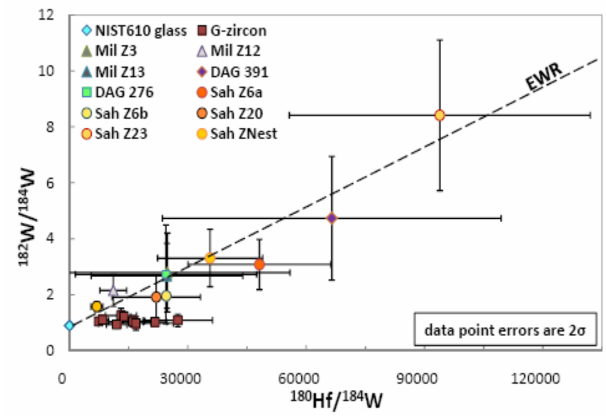

Fig. 3 Isochron plot for all eucrite samples and standard materials. All eucrite zircons show an excess in ^{182}W, while the standards have normal W isotope composition. The dashed line represents the Eucrite Whole Rock (EWR) correlation line with an initial $^{182}Hf/^{180}Hf = 7.11 \times 10^{-5}$.

Table 1. Chemical composition of eucrite zircons. Results are presented in wt%.

Sample	ZrO_2	SiO_2	Al_2O_3	FeO	MgO	CaO	P_2O_5	HfO_2	Y_2O_3	ThO_2	UO_2	Ce_2O_3	Total
DAG 391-Zr1	64.9	29.2	0.01	0.60	n.d.	0.09	0.07	1.26	0.04	n.d.	n.d.	<0.01	96.17
DAG 276-Zr1	65.6	32.4	0.01	0.97	0.01	0.10	0.04	1.61	n.d.	n.d.	n.d.	0.05	100.78
Mil-Zr3	64.9	31.4	0.02	0.66	0.01	<0.01	0.08	1.13	0.07	<0.01	<0.01	n.d.	98.22
Mil-Zr12	65.5	31.9	0.03	0.65	0.01	0.22	0.13	1.14	0.05	0.02	n.d.	n.d.	99.69
Mil-Zr13	65.8	32.1	n.d.	0.83	0.01	<0.01	0.09	1.26	0.04	<0.01	n.d.	n.d.	100.10
Sah98110-Zr6	64.6	32.3	0.02	0.98	n.d.	0.04	0.08	1.47	0.06	n.d.	0.05	n.d.	99.60
Sah98110-Zr20	63.1	32.8	0.01	1.73	0.45	0.16	0.09	1.22	0.03	n.d.	n.d.	n.d.	99.58
Sah98110-Z23	64.4	29.9	n.d.	3.59	0.01	0.08	0.07	1.51	0.03	n.d.	<0.03	n.d.	99.59
Sah98110-ZrNest	64.2	30.5	0.26	2.43	0.02	0.34	0.10	1.52	0.03	n.d.	<0.02	n.d.	99.41
Sah98110-ZrNest5	63.0	32.6	0.12	0.61	0.17	0.08	0.15	1.20	0.07	0.03	n.d.	<0.01	98.03

Nb and Pb values were always below the detection limit. High Fe, Ca and Mg values were determined (especially in zircons from Sah98110) and are probably the result of contamination by surrounding phases. Y and P are in almost all cases above the detection limit.