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EARLY AND RAPID DIFFERENTIATION OF PLANETESIMALS INFERRED FROM ISOTOPE DATA IN IRON METEORITES AND ANGRITES. A. Markowski[1], G. Quitté[1], T. Kleine[1], M. Bizzarro[2], I. Leya[3], R. Wieler[1], K. Ammon[3], A.N. Halliday[4] [1] Institute of Isotope Geochemistry and Mineral Resources, ETHZ, Sonneggstrasse 5, CH-8092 Zuerich, Switzerland (markowski@erdw.ethz.ch), [2] Geological Institute, Univ. of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen, Denmark, [3] Physikalisches Institut, Space and Planetary Sciences, Siedelstrasse 5, CH-8092 Bern, Switzerland, [4] Dept. of Earth Sciences, Parks Road, Oxford, OX1 3PR UK.

Introduction: New high precision W isotopic data obtained for magmatic iron meteorites indicate that they formed very early in solar system history, some being as old as CAIs [1-5]. Recent Al-Mg isotope data in angrites show that differentiation of their parent body also occurred early, within ~3 Myr of the start of the solar system [6-8]. Chondrite parent bodies presumably were either too small to undergo melting, or accreted late, after most ^{26}Al and ^{60}Fe had decayed. Our goal is to further refine the chronology of the early solar system using ^{182}Hf-^{182}W systematics in iron meteorites and angrites, and compare this chronometer with the ^{60}Fe-^{60}Ni, ^{53}Mn-^{53}Cr, ^{26}Al-^{26}Mg and ^{207}Pb-^{206}Pb systemtics studied for angrites by different authors. Angrites formed and crystallized extremely rapidly so that all chronometers potentially should give the same age.

Iron meteorites: The ^{182}Hf-^{182}W isotopic system is an excellent chronometer of core formation, because it has an appropriate half-life of 8.9 Myr and Hf and W strongly fractionate during metal-silicate differentiation. Hafnium is lithophile, whereas W is moderately siderophile. Thus, using the Hf-W chronometer to establish the chronology of iron meteorites appears straightforward. However, iron meteorites have long exposure ages, and the W isotopic composition can be modified by interactions with cosmic rays. This cosmogenic effect can lower the ^{182}W/^{184}W ratio by about 0.5ε units for an exposure age of 600 Myr as modeled by Masarik [9] and Leya et al. [10]. The magnitude of these effects are similar to the precision on W isotopic data obtained at that time [11-13]. Recently, high precision measurements showed that the W isotopic composition is heterogeneous among both irons from one group and different groups [1-4]. These heterogeneities have been interpreted as being due to cosmogenic effects [2-4], which can lower the ^{182}W/^{184}W ratio and thus result in apparently older ages. We investigated in detail the effects of cosmic rays on W isotopes by studying different samples with known shielding depths from two large magmatic iron meteorites, Carbo (IID) and Grant (IIIAB). Based on new nuclear physic parameters we established a physical model to correct for the cosmogenic effect taking into account the shielding depth and the exposure ages of these samples. Details of the model are given in [5]. In Figure 1 the W isotopic composition of several iron meteorites from different groups are shown. These data are corrected for the cosmogenic effect.

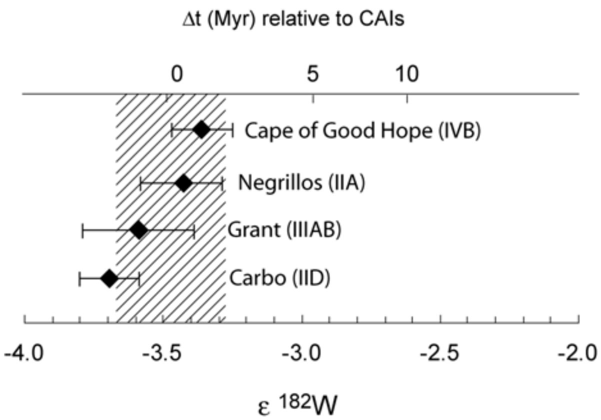

Figure 1: Tungsten isotopic composition of iron meteorites from different groups corrected for the cosmogenic effect using the method described in [5]. The hatched area indicates the initial $\varepsilon\,^{182}$W of Allende CAIs of –3.47±0.20 [3]. $\varepsilon\,^{182}W = [(^{182}W/^{184}W)_{sample}/(^{182}W/^{184}W)_{std} - 1] \times 10^4$. Error bars are standard errors (2σ) of the measurement combined with the error on the bracketing standards. The uncertainty of the model calculations is estimated to be about 50% [5].

Negrillos (IIA) has the lowest exposure age of all magmatic iron meteorites measured so far, hence an only minor correction for the cosmogenic effect is required. The W isotopic data of Negrillos, Grant and Carbo thus provide the currently most reliable estimate of the indigenous W isotopic composition of magmatic iron meteorites. Additionally, we have plotted the W isotopic composition of Cape of Good Hope corrected for the cosmogenic effect. Once corrected for cosmogenic effects, the W isotopic composition of these four irons is similar to the initial W isotopic Allende CAIs. Their weighted average age indicates that they segregated within less than 1 Myr of CAI formation (Figure 1). Thus, there is no resolvable age difference between the segregation of these irons and the formation of Allende CAIs. This result supports the conclusion of [1-4] that core segregation in iron meteorite parent bodies was very rapid.

Angrites: Angrites are also very early differentiated meteorites but they have much shorter exposure ages than most iron meteorites. Their exposure ages range between 5.4 and 56 My [14]. Although the Ta/W ratio of SAH99555 is ~0.53 [15], the correction for the production of ^{182}W by neutron-capture of ^{181}Ta should be insignificant (<0.01 ε units) [10], since the exposure age is only 6.1 Myr [14]. Therefore, the W isotopic data in this angrite require no cosmogenic correction. Sahara 99555 has a basaltic matrix and was found in 1999. It contains 38% anorthite, 32% clinopyroxene, 15% olivine, 14% kirschsteinite and minor Ti-magnetite, troilite and a phosphate phase [14]. SAH 99555 has an igneous texture showing mineralogical and petrographic similarities to Asuka 881371 and D'Orbigny [14-15]. SAH99555 has been studied for Pb-Pb [6], Al-Mg [7,16], and Mn-Cr, Rb-Sr, and Sm-Nd [17] systematics. Pb-Pb and Al-Mg data indicate that differentiation of angrite parent body occurred ≤ 3 Myr after CAI formation. We are now in the process of generating pure mineral separates of this angrite. The isotopic measurement of separate mineral fractions is demanding since the W concentration is generally low in silicates. Preliminary data on three different separated phases - olivine, plagioclase and pyroxene - indicate that W concentration range from 100 to ~300 ppb. Available partition coefficients for Hf and W [18] suggest that there is appreciable Hf-W fractionation among these minerals, facilitating the determination of an internal isochron. The isotopic measurements are still in progress and first data will be presented at the conference.

A major goal in cosmochronology is to intercalibrate several short-lived systems and to anchor them onto an absolute time scale. SAH 99555 is well-suited for this task because it is a precisely dated [6] and rapidly cooled rock. Differences in closure temperatures will thus not result in resolvable differences among the ages obtained from different chronometers. This approach however will also require a careful evaluation of postcrystallization events on the systematics of the several short-lived chronometers.

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