6.1.14

^{182}Hf-^{182}W dating of the thermal metamorphism of eucrites

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Basaltic eucrites have been affected by thermal metamorphism [1], the timing and cause of which is enigmatic. The thermal overprint resulted in the formation of metal by reduction of oxidized Fe in pyroxenes [2,3]. The time of formation of these metals can be dated using the extinct ^{182}Hf-^{182}W system. We present Hf-W data for metal and sili-cate fractions of the eucrites Bereba, Bouvante, Camel Don-ga, and Juvinas. The metals have low Hf/W and radiogenic ε_W between 11 and 16 (ε_W is the deviation of the ^{182}W/^{184}W of a sample from the terrestrial value). The whole-rocks and silicate fractions have high Hf/W (usually between 20 and 30) and ε_W between ~15 and ~25, and those of Juvinas and Bouvante plot on or close to the eucrite whole-rock isochron reported previously [4,5]. However, the whole-rocks and silicate fractions of Bereba and Camel Donga plot significantly off the whole-rock isochron and the Hf/W ratios and ε_W values of these samples are intermediate between those of the metals and the samples plotting on the whole-rock isochron.

The Hf-W whole-rock isochron corresponds to the age of the major mantle differentiation in the eucrite parent body at 4563.2±1.4 Ma [5]. The elevated ε_W values of the metals indicate a late re-mobilization of radiogenic W from silicates into metal. The most likely reason for this re-mobilization is thermal metamorphism [2,3]. The metals from Bereba and Bouvante must have formed between 4546 and 4560 Ma and those from Camel Donga and Juvinas between 4500 and 4555 Ma. It is thus clear that the thermal metamorphism of eucrites must have occurred at least ~10 Myr later than the major mantle differentiation in Vesta, and, thus, too late to be driven by decay of short-lived ^{26}Al or ^{60}Fe. Therefore, heating by impacts is the most plausible cause for the thermal metamorphism. These impacts occurred earlier than those that are responsible for the resetting of K-Ar ages of eucrites ~4.1–3.5 Ga ago [6], implying that the later impacts were not energetic enough to reset the Hf-W system.

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6.1.15

W isotope chronology of asteroidal core formation

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Tungsten isotopes are powerful tools in the determination of the timescales of core formation in iron meteorite parent bodies and terrestrial planets. It is commonly assumed that the metal separated from a chondritic parent body in a single event, and two stage model ages for core formation are then calculated for the iron meteorite parent body. However, there is currently disagreement in the literature over the initial Hf and W isotope ratios in the solar system. The most recent values of ^{182}Hf/^{180}Hf$_{SSI}$ = 10^{-4} and εW_{SSI} = -3.5 are derived from regression of whole rock chondritic meteorite data and their metal and silicate fractions [1-2]. These lower ^{182}Hf/^{180}Hf$_{SSI}$ and higher εW_{SSI} values conflict with some published iron meteorite data that results in improbably negative model ages [3-4]. Our data agree with the new chondrite derived values in so far as our W model ages are within error (≤1 million years) of the age of the origin of the solar system.

Iron meteorite parent bodies range in diameter from ~100 to ~1000 km [5], and if larger bodies take longer to form this might result in resolvable differences in their model ages. Thus Kleine et al., [1] noted a correlation between the core model ages and the diameters of the Earth, Mars and the asteroid 4 Vesta. Their modelled age for core formation on asteroid 4 Vesta is ~4 million years after the start of the solar system. However, our preliminary data suggest that metal separated within the first million years for the iron parent bodies, and that there are no resolvable age differences between different iron meteorites. Our results support fast accretion, heating and subsequent metal separation of iron meteorite parent bodies irrespective of their size [4,6].

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