Thermal History and Differentiation of primitive achondrites

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Introduction: Acapapulcoites and winonaites were heated to significantly higher temperatures than type 6 ordinary chondrites. These primitive achondritic meteorites should have formed at a time when enough ^{26}Al was available. The Hf-W chronometer was applied to the two acapulcoites Monument Draw and Dhofar 125. Resulting ages are compared with published age constraints for chondrites and winonaites [Schulz et al., 2007].

Results: Non- and weakly magnetic fractions of all analyzed acapulcoite separates from the two meteorites define a combined Hf-W isochron with an initial ^{182}W/^{184}W of -3.1 $\pm$ 0.3 ϵ- units and a slope corresponding to an age of 4.6 $\pm$ 1.4 Myr after CAIs. A Hf-W isochron for similar mineral fractions for winonaites yielded a much younger age of 14.5 $\pm$ 2.8 Myr [Schulz et al., 2007]. A comparison of the Hf-W age with published Pb-Pb and Ar-Ar ages of the acapulcoites implies cooling rates of about 100°/Myr between the closure temperatures of the Hf-W and Ar-Ar systems. This is faster than cooling rates for the H5 and H6 ordinary chondrites [Kleine et al., 2008]. The winonaites and IAB meteorites yield cooling rates from 5 to 100°/Myr for the same temperature interval.

Discussion: The Hf-W age given by the combined acapulcoite isochron is similar to ages of ˜ 3-5 Myr after CAI formation obtained for other combined achondrite isochrones (eucrites 4.3 $\pm$ 1.4 Myr [Kleine et al., 2004a] and IAB silicates 2.9 $\pm$ 2.2 Myr [Schulz et al., 2006]). These ages are slightly older than Hf-W ages reported for H5 and H6 chondrites (6.0 $\pm$ 0.9 Myr and 9.6 $\pm$ 1.0 Myr [Kleine et al., 2008]) that were not melted during thermal overprint.
This marked age difference in peak temperatures most likely reflects a higher ^{26}Al content in the acapulcoite parent body compared to the H-chondrite parent body. The apparent age cluster for solidification of eucrites and IAB meteorites of around 3-5 Myr most likely marks a minimum age required for ^{26}Al being the driving force for asteroid differentiation. The younger Hf-W isochron for winonaites (14.5 $\pm$ 2.8 Myr [Schulz et al., 2007]), on the other hand, clearly highlights the role of impacts as a driving force for parent body differentiation later than 5 Myr after CAIs.

References:

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