Thermal History and Differentiation of primitive achondrites

Schulz, Toni1 Münker, Carsten1 Palme, Herbert2 Mezger, Klaus3

1-Petrologisches Institut Universität Bonn, Poppelsdorfer Schloss, D-53115 Bonn 2Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicherstr. 49b, D50674, Köln 3Zentrallabor für Geochronologie, Institut für Mineralogie, Universität Münster, Corrensstr.24, D48149 Münster

Introduction: Acapulcoites 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 \(^{182}\text{W}/^{184}\text{W} = -3.1 \pm 0.3 \epsilon\) 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\(^\circ\)/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\(^\circ\)/Myr for the same temperature interval.

Discussion: The Hf-W age given by the combined acapulcoite isochron is similar to ages of \(\sim\) 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:
Schulz T, Münker C., Mezger K, Palme H (2007). 38th LPSC #1760