COSMOCHEMICAL FRACTIONATION OF HF AND W IN THE SOLAR NEBULA: EVIDENCE FROM W ISOTOPES IN CHONDRITES. T. Kleine[1], M. Touboul[1], H. Palme[2], J. Zipfel[3], and A.N. Halliday[4], [1]Institut für Isotopengeologie und Mineralische Rohstoffe, Departement für Erdwissenschaften, ETH Zürich, Clausiusstrasse 25, 8092 Zürich, Switzerland (touboul@erdw.ethz.ch), [2]Institut für Mineralogie und Geochemie, Universität zu Köln, Zülpicherstr. 49b, 50674 Köln, Germany, [3]Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main, Germany, [4]Department of Earth Sciences, Oxford University, Parks Road, Oxford OX1, United Kingdom

Introduction: Variations in the abundances of elements in primitive meteorites can provide constraints on the physical and chemical conditions prevailing in the early solar nebula. There are varations in the total abundance of Fe in chondritic meteorites, probably reflecting incorporation of variable amounts of FeNi metal into precursor materials . Such metal-silicate fractionations should be accompanied by fractionations of Hf and W and, hence, their timing can be studied with the ^{182}Hf-^{182}W chronometer. Here we present Hf-W data for 15 bulk ordinary chondrites with the ultimate goal to date the early metal-silicate fractionation process in the solar nebula.

Methods: About 1 g aliquots from 3-5 g whole-rock powders were dissolved in precleaned 60 mL Savillex vials at ~200°C on a hotplate using HF-HNO_3-$HClO_4$. After digestion the samples were dried and redissolved in 6 M HCl-0.06 M HF. At this step total sample dissolution was achieved. A ~10% aliquot of the sample was spiked with a mixed ^{180}Hf-^{183}W tracer that was calibrated against pure Hf and W. Total spike-sample equilibration was achieved in 6 M HCl-0.06 M HF on a hotplate over night. Both aliquots of the samples were dried and Hf and W (in the spiked aliquot) and W (in the unspiked aliquot) were separated from their sample matrices using standard ion exchange techniques as described in Kleine et al. [1] All isotope measurements were performed on a Nu Plasma MC-ICPMS at ETH Zurich.

Results: Our new Hf-W data for 15 ordinary chondrites are shown in Fig. 1. In this plot of ε_W vs. ^{180}Hf/^{184}W the three groups of ordinary chondrites plot in three distinct fields (ε_W is the deviation of the ^{182}W/^{184}W from the terrestrial standard value in parts per 10,000). H chondrites have the lowest Hf/W ratios and correspondingly the lowest ε_W values (–2 to –2.8). L chondrites have Hf/W ratios and ε_W values indistinguishable from average carbonaceous chondrites, whereas LL chondrites have the highest Hf/W and most radiogenic ε_W values (-1 to –1.7) among the chondrites. Although the three ordinary chondrite groups are distinct in their Hf-W systematics, there is substantial variations in the Hf/W ratios within the H and LL chondrite groups. This variation is almost entirely caused by variations in the W contents. For instance, within the group of H chondrites investigated here, W contents vary by ~30% (2σ), whereas Hf contents vary by only ~5% (2σ).

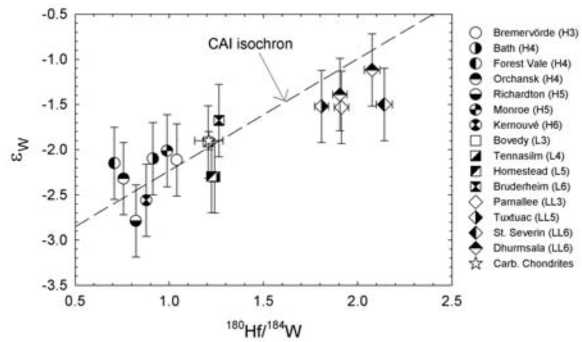

Fig. 1: Hf-W isochron diagram for bulk chondrites. Data for carbonaceous chondrites are from [1].

Discussion: The variations in Hf/W ratios within the H and LL chondrite groups hamper application of Hf-W chronometry to date the early Hf-W fractionation among the chondrites. A regression through all the chondrite data corresponds to an age of 6±4 Myr after CAIs. This age might indicate that the parent material of the chondrites condensed later than CAIs, consistent with Al-Mg ages for chondrules. However, this ages is also identical to Hf-W ages obtained for type 6 ordinary chondrites [2], suggesting that some part of the variations in Hf/W ratios within the chondrite groups may also be related to mobility of W during thermal metamorphism (or other parent body processes). Alternatively the variation in Hf/W ratios might also be due to sample heterogeneities. For instance, given that metal in equilibrated chondrites is highly enriched in W [2], slight variations in the metal content of equilibrated ordinary chondrites can cause variations in Hf/W of the "bulk" sample. Late-stage open system behaviour of siderophile elements has also been reported for highly siderophile elements in chondrites [3, 4].

Given the variations in W content from samples of one group it is difficult to determine average Hf/W ratios and ε_W values for each of the groups. In spite of the within-group variations however there still are systematic differences among the chondrite groups. An important aspect of our new data is that H chondrites on average have lower Hf/W ratios than carbonaceous chondrites, whereas L chondrites have Hf/W ratios indistinguishable from carbonaceous chondrites. This is unexpected given the fact that H chondrites have solar Fe/Mg ratios whereas L chondrites have sub-solar Fe/Mg ratios. Taken at face value this would indicate that the variation in Hf/W ratios among the chondrites groups cannot be related to the metal-silicate separation in the solar nebula. This would imply that a significant part of the W did not condense as metal. More data however are needed to confirm these observations. First, the average Hf/W and ε_W of carbonaceous chondrites is largely based on CV and CM chondrites [1] and as such must not necessarily reflect the solar Hf/W ratio. For instance, there are slight variations in Fe/Mg ratios among different carbonaceous chondrites. It thus is possible that in Fig. 1 CI chondrites plot at slightly lower Hf/W and ε_W than "average carbonaceous chondrites". The origin of the Hf/W variations among the H chondrites (and other chondrite groups) also needs to be better constrained. However, our new Hf-W data for bulk rock chondrites indicate that Hf-W chronometry may ultimately be used to date early fractionation events in the solar nebula.

References: [1] Kleine T. et al. (2004), *GCA*, *68*, 2935-2946. [2] Kleine T. et al. (2006), *Meteoritics and Planetary Science*, *41*, A97. [3] Horan M.F. et al. (2003), *Chemical Geology*, *196*, 5-20. [4] Walker R.J. et al. (2002), *GCA*, *66*, 4187-4201.