Tungsten and molybdenum isotopic constraints on the origin and chronology of IIIF iron meteorites.

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Introduction: The genetic heritage and chronology of meteorites and their parent bodies are crucial in understanding fundamental early Solar system dynamics. Because iron meteorites derive from the cores of the earliest formed planetesimals from both the non-carbonaceous (NC) and carbonaceous (CC) meteorite reservoirs [1], their study allows to better constrain the early formation of the NC-CC isotopic dichotomy and thus fundamental astrophysical processes in the evolving protoplanetary disk. While Mo and W nucleosynthetic isotope anomalies allow to link meteorites to their parent bodies and the NC or CC reservoir, the W isotopic compositions can additionally be used to calculate Hf-W model ages, dating the time of core formation of the respective parent body. In this context, the relatively small IIIF iron meteorite group (CC) is of special interest: 1) The Hf-W chronology of the IIIF parent body is based on only two samples (Clark County and Klamath Falls), and this age records the earliest planetesimal core formation in the CC reservoir but is weakly determined due to its large uncertainty [1]. 2) A recent study of the trace element systematics in all IIIF iron meteorites shows large variations for different interelement trends that are difficult to explain by simple fractional-crystallization models, questioning a common single IIIF iron meteorite parent body [2]. 3) Molybdenum isotopic data, which could be used to track the genetic heritage of IIIF iron meteorite samples, are only available for three members of the group [1, 3].

We determined Mo, W and Pt isotopic data for most meteorites classified as IIIF irons to 1) better constrain whether or not the IIIF iron meteorites constitute a single group/parent body and 2) determine precise Hf-W model ages. We additionally investigated the pyroxene-rich pallasite Zinder and its potential genetic link to the IIIF iron meteorites.

Samples and Methods: We have analyzed 7 out of 9 meteorites classified as IIIF irons (Clark County, Nelson County, St. Genevieve County, Cerro del Inca, Oakley (iron), Moonbi, Fitzwater Pass), and, in addition, the metal fraction of pyroxene-bearing pallasite Zinder. Aliquots for Mo, W and Pt purification by ion exchange chromatography were taken from single sample digestions and high-precision isotope measurements were performed on a *Neptune Plus* multicollector ICP-MS. The isotope data were internally normalized using the exponential law and are reported as ε-unit (parts per 10^4) deviation from the terrestrial standard solutions.

Results: After correction for a small mass-independent effect, the ε^{183}W data for all samples but Zinder and Fitzwater Pass show positive nucleosynthetic isotope anomalies, indicative for iron meteorites from the CC reservoir. Fitzwater Pass and pallasite Zinder record ε^{183}W values that are not resolved from zero. The ε^{182}W data were corrected for nucleosynthetic variations using ^{183}W and subsequently corrected for CRE effects using the sample's ε^{196}Pt values. The iron meteorites (except Fitzwater Pass) define a good linear correlation in a ε^{182}W vs. ε^{196}Pt plot, yielding a slope of -1.33, which is in excellent agreement with the previously determined average slope for the main iron groups [1], allowing to precisely determine a group-intern pre-exposure ε^{182}W of -3.24. Fitzwater Pass records a significantly more radiogenic pre-exposure ε^{182}W of ~-2.7. The Mo isotopic data will be presented at the conference.

Discussion: With the exception of Fitzwater Pass, all analyzed IIIF irons could indeed derive from a single parent body in the CC reservoir. In contrast, Fitzwater Pass records no positive ε^{183}W anomaly but rather falls in the range of NC irons. A recent study suggests that this meteorite might belong to the non-magmatic IAB iron meteorites from the NC reservoir [2], which would also be in agreement with its relatively radiogenic ε^{182}W of ~-2.7. As the W isotope data alone do not allow to unequivocally determine whether the remaining samples constitute a single IIIF group or not, additional Mo isotopic measurements are needed. Assuming a mutual parent body, the precise pre-exposure ε^{182}W of -3.24 would translate into a Hf-W age for the IIIF parent body of ~2.2 Ma. This date reflects among the oldest formation age for any planetesimal core from the CC reservoir and would indicate a temporal overlap of planetesimal differentiation in the CC and NC reservoirs. Additionally, on a ε^{182}W vs. Fe/Ni plot the IIIF group plots together with the IVA iron group, marking the transition from NC to CC material and supporting a linear correlation between the redox environments and the timing of planetesimal core formation, which has been previously observed for the main iron meteorite groups [4]. If the Fe/Ni ratio of the parental melt reflects the activity of water(ice) and hence the oxidation state during core formation, the trend might further record a positive correlation between the heliocentric distance and timing of protoplanetesimal differentiation.

References: [1] Kruijer et al. (2017) Proc. Natl. Acad. Sci. 114, 6712-6716. [2] Zhang et al. (2022) Geochim. Cosmochim. Acta. [3] Worsham et al. (2019) Earth Planet. Sci. Lett. 521, 103-112. [4] Spitzer et al. (2021) Earth Planet. Sci. Lett. 576, 117211.