

Re-Os SYSTEMATICS AND HSE DISTRIBUTION IN METAL FROM OCHANSK (H4) CHONDRITE.

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Introduction: Previous studies of the Re-Os systematics of chondrites have documented considerable variation in the Re/Os ratios of whole rock samples [1,2]. For some whole rock chondrites, Re-Os systematics display large deviations from the primitive isochron that are considerably larger than deviations in other isotope systems [1]. Possible interpretation of these facts is that the Re-Os system in chondrites is particularly sensitive to post-formation alteration processes, thus providing a useful tool to examine such processes. Significant variations that have been detected in highly siderophile element (HSE) patterns for ordinary chondrites [3] support this conclusion.

We report Re-Os isotope data for metal separates from the Ochansk H4 chondrite coupled with abundance data for Ru, Pd, Ir, and Pt, determined in the same samples by isotope dilution. We chose this meteorite mainly because it is an observed fall with minimal signs of weathering, and its low metamorphic grade (H4) and shock stage (S3).

Experimental methods and samples: A single fragment of Ochansk (~ 2 g, free of fusion crust) was gently crushed in agate mortar to preserve chondrules. Chondrules and chondrule fragments were handpicked and removed at all stages of sample processing, so that the samples reported here represent mostly matrix metal. The sample was divided into three fractions by size and magnetic separation (labeled as FM, MM, and CM, fine, medium and coarse metal, respectively). In addition, a handpicked aliquant of coarse metal (mm-size, labeled as "CM hpk") was processed again via mortar, to remove a non-metal "coating". We also subdivided an aliquant of fine metal with a hand magnet. The resulting fractions are labeled FM1, FM3, and FM5, where FM5 represents the finest and purest metal (~ 95%, judging from the amount of residue after acid digestion).

Samples were digested with aqua regia using quartz Carius tubes [3,4]. For isotope dilution we used a mixed ¹⁸⁷Re-¹⁹⁰Os spike and a mixed HSE spike (¹⁰⁴Ru, ¹¹⁰Pd, ¹⁹¹Ir, and ¹⁹⁸Pt).

Osmium was separated by solvent extraction, followed by microdistillation using a H₂SO₄ - dichromate mixture as oxidant [1]. Anion exchange resin was used to separate Re, Ir, Pt, Ru and Pd. Rhenium and Os were measured in negative mode on the Sector 54 mass spectrometer at the University of Maryland. Platinum, Ir, Ru and Pd were measured on the Plasma-

54 ICP-MS at DTM using faraday cups and static multicollection. Total analytical blanks were 5 pg Re, 5 pg Os, 14 pg Ir, 25 pg Pt, 14 pg Ru, and 150 pg Pd.

Results and Discussion - Re-Os systematics in Ochansk metal: Figure 1 shows Re-Os results for Ochansk metal. Our data display a good agreement with the group IIA iron meteorite isochron [5], as well as with whole rock data for Ochansk [1]. Our isochron is also in good agreement with Re-Os isochron for St. Séverin [2]. The isochron precision for Ochansk (±150 Ma) is limited by the small range in ¹⁸⁷Re/¹⁸⁸Os ratios of this set, only from 0.43 to 0.47. However, if we assume a Solar System initial Os ratio for these samples, then the uncertainties in the calculated model ages range from 10 to 30 Ma, illustrating the resolution potential of the Re-Os system to constrain the timing of alteration in chondrites.

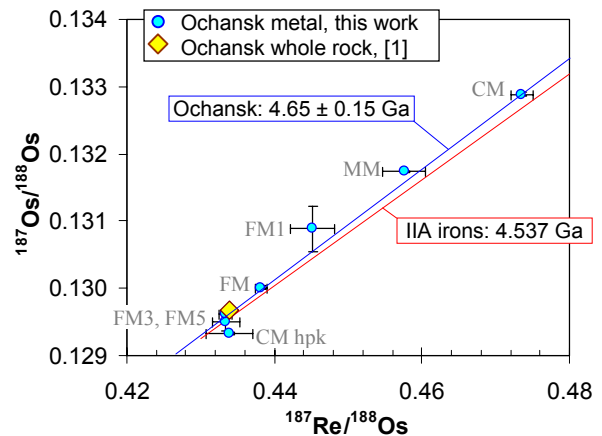


Fig. 1. Re-Os isochron for matrix metal from Ochansk H4 chondrite, compared with total rock data [1] and with IIA reference isochron is from [5].

HSE distribution in Ochansk metal: Iridium has a condensation temperature similar to that of Re and Os, and its distribution in the samples analyzed is very similar to Re and Os. Hence, the Re/Ir and Os/Ir ratios vary by only 8% and 4%, respectively. Ruthenium, Pt, and Pd, which have significantly lower and different condensation temperatures, show much wider variations in our samples than Re, Os and Ir. Fig. 2A illustrates this for Pt/Ir vs Pd/Ir ratios. This figure also shows whole rock data from [3] for a set of H chondrites which covers almost the entire range of metamorphic grades (3.4 - 5) and shock stages (S1 - S6).

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Unlike whole rock samples, our data plot fairly close to a single curve, allowing application of chemical modeling to this set. Fractional crystallization modeling yields unreasonably high distribution coefficients for Pt and Pd, far exceeding (5–8 times) the values observed for magmatic irons. Such discrepancy excludes fractional crystallization from consideration for our samples. Alternatively, a fractional condensation model fits the data quite well using condensation temperatures similar to [6] and Orgueil whole rock data [3] for initial gas ratios. However, it is necessary to note that the elements modeled in Figure 2A are retained in metal during metamorphism, so that metamorphic digestion of iron only alters the concentrations of Ir, Pt, and Pd, but not their ratios. On the other hand, both Re and Os can exit metal during metamorphism (e.g., Os can form volatile OsO_4), and if we switch Pd/Ir for Re/Os ratio we get a completely different picture - Figure 2B.

First, our data in Fig. 2B do not form an array which can be fitted with a simple curve. Second, all experimental points in Fig. 2B plot far to the right of the Orgueil point. Therefore, to apply a fractional condensation model we have either to assume *very* different condensation temperatures for Re and Os, or to suggest that the initial gas composition was *very* different from CI chondrites. It seems more reasonable here to suggest Re and Os redistribution during metamorphism, where Os loss via volatilization dominated.

Summary: Our new data demonstrate that the Re-Os system can be applied to dating multiple events in individual chondrites. The determination of corresponding HSE distribution patterns is critical for interpretation of Re-Os systematics. In the case of Ochansk, the HSE data provide evidence that the Re-Os isochron reflects the metamorphic alteration of the distribution record, which was originally set during nebular condensation.

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References: [1] Walker R. J. et al. (2002) *Geochim. Cosmochim. Acta* 66, 4187–4201. [2] Chen J. H. et al. (1998) *Geochim. Cosmochim. Acta* 62, 3379–3392. [3] Horan M. F. et al. (2003) *Chem. Geology*, in press. [4] Shirey S. B. and Walker R. J. (1995) *Anal. Chem.* 67, 2136–2141. [5] Smoliar M. I. et al. (1996)

Science 271, 1099–1102. [6] Kelly W. R. and Larimer J. W. (1977) *Geochim. Cosmochim. Acta* 41, 93–111.

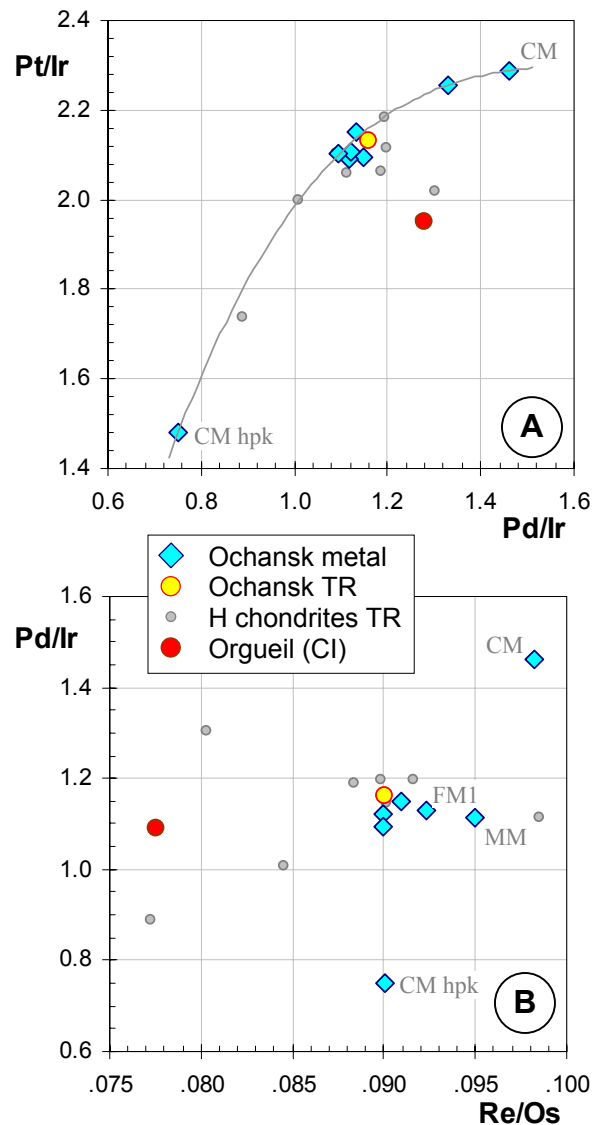


Fig. 2. HSE ratios in Ochansk metal fractions (diamonds, this work) and in total rocks of H chondrites and Orgueil (circles, [3]).