RHENIUM AND OSMIUM ISOTOPE SYSTEMATICS IN CARBONACEOUS CHONDRITES;

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We report Re and Os abundances and $^{187}Os/^{186}Os$ measured by resonance ionization mass spectrometry (RIMS) [1,2] in nine samples of five carbonaceous chondrites (Table 1). Samples of chondrite (or iron meteorite) were equilibrated with ^{190}Os and ^{185}Re spikes by $NaOH-Na_2O_2$ fusion in Zr crucibles. From a solution made 5N in H_2SO_4, Os was distilled as OsO_4 by adding H_2O_2. The product was again distilled and Os finally converted to hexachlorosmate. Residual liquid from the first distillation was passed through an anion exchange column, Re was retained and other elements were easily removed by washing. Rhenium was eluted in 4N HNO_3. Because of the selectivity of RIMS, Re and Os were loaded together on the same filament. The RIMS instrument, which was developed at the National Bureau of Standards [3], consists of a 6" radius 60 degree sector mass spectrometer coupled to a pulsed Nd-YAG laser driving a tunable dye laser system that has frequency multiplication and a transient digitizer quantitation system. The laser is tuned to wavelengths that selectively photoionize Os (297.16 nm) and Re (297.69 nm) from a gas-phase reservoir produced from a hot Ta filament synchronously pulsed to 2000 to 3000 °C. Isotopic ratios can be measured with a precision and accuracy of better than 1% on less than 1 ng of each element. The blank is 70 pg Re and 10 to 20 pg Os. Duplicate analyses of two iron meteorites [Canyon Diablo (IA), Tocopilla (IIA)] plot within analytical uncertainty on the Luck-Allegre isochron[4] (Figure 1). Absolute Re and Os values agree less well, which apparently reflects the inhomogeneity at 0.1 to 0.4g sample size (Table 2) [4,5].

Existing RNAA abundance data for Re and Os in C chondrites show scatter due either to analytical error or to sample inhomogeneity [6-12]. For analyses of the U.S. National Museum standard Allende powder (Table 3), the isotope dilution (ID) values fall well within the range of previous RNAA results, and means values agree well: 68.6±3.5 ppb Re and 851±58 ppb Os (ID) versus 68.4±5.2 ppb Re and 841±71 ppb Os (RNAA). Analyses of pieces of other C chondrites show larger sampling variation (Table 3). As a group, the carbonaceous chondrites have lower $^{187}Re/^{186}Os$ than the metal phase of ordinary chondrites[13]. The chondrites, regardless of class, plot very close to, or within analytical uncertainty of, the iron meteorite isochron [4] (Figure 2) but lie systematically above the line by 1 or 2%. Assuming a 4.55 Ga closure age, we find initial $^{187}Os/^{186}Os$ of 0.813 and 0.821 for chondrite metal and C chondrites respectively; but these may not differ significantly from the iron meteorite intercept of 0.807 [4]. From osmiridium data, the isotopic composition of the Earth's mantle is estimated to be $^{187}Os/^{186}Os = 1.040\pm0.101$ and $^{187}Re/^{186}Os = 3.34\pm0.14$ [14]. This point falls close to the middle of the carbonaceous chondrite range and tends to confirm the late influx model for highly siderophile element abundances of the upper mantle [15]. Endogenous models may be able to accommodate the new data but lack specific predictive power [16]. The terrestrial point also lies directly on the iron meteorite isochron and, when viewed in isolation, may be open to other interpretations.

The C2M chondrite Murray plots significantly above the iron meteorite line and the chondritic field. For an assumed 4.55 Ga age, the Murray

initial $^{187}Os/^{186}Os$ (0.86) is significantly higher than the iron meteorite intercept. Data for Murchison, another C2M, appear to be concordant with other C chondrites. At least some samples of Murray have been leached severely [17], and Re loss at a late stage could account for excess ^{187}Os; Re does not seem particularly depleted compared to other chondrites, however. Very preliminary data suggest Semarkona (LL3) also may have unusually radiogenic Os ($^{187}Os/^{186}Os$ = 1.17±0.02: $^{187}Re/^{186}Os$ = 3.75±0.19) but require confirmation.

References: [1] R.J. Walker and J.D. Fassett (1986) Anal. Chem., **58**, 2923. [2] R.J. Walker, et al. (1988) EPSL, in press. [3] J.D. Fassett, et al. (1985) Science, **230**, 262. [4] J.-M. Luck and C.J. Allegre (1983) Nature, **302**, 130. [5] W. Herr, et al. (1961) Z. Naturforschg., **16a**, 1053. [6] J.W. Morgan and J.F. Lovering (1967) GCA, **31**, 1893. [7] U. Krähenbuhl et al. (1973) GCA, **37**, 1353. [8] E. Anders, et al. (1976) GCA, **40**, 1131. [9] H. Takahashi, et al. (1978a) GCA, **42**, 97. [10] H. Takahashi, et al. (1978b) GCA, **42**, 1859. [11] R. Wolf, et al. (1980) GCA, **44**, 711. [12] M. Ebihara, et al. (1981) GCA, **46**, 1849. [13] J.W. Morgan (1985) Nature, **317**, 703. [14] C.J. Allegre and J.-M. Luck (1980) EPSL **48**, 148. [15] J.W. Morgan (1986) JGR, **91**, 12, 375. [16] J.H. Jones and M.J. Drake (1986) Nature, **322**, 221. [17] G.W. Kallemeyn and J.T. Wasson (1981) GCA, **45**, 1217.

Table 1: Abundances of Re and Os and Os isotopic composition in carbonaceous chondrites

Meteorite	Re ppb	2σ	Os ppb	2σ	$^{187}Os/^{186}Os$	2σ	$^{186}Os/^{187}Os$	2σ
CI Orgueil	43.3	1.2	518	3.6	1.072	.020	3.358	.1
C2M Murchison	56.3	0.56	759	8	1.026	.015	2.979	.05
C2M Murray	53.2	1.0	713	3.5	1.063	.012	2.996	.075
C2M Murray	67.0	0.70	810	8	1.095	.010	3.329	.05
C3V Allende	65.8	1.3	819	8	1.046	.010	3.228	.065
C3V Allende	68.1	0.7	911	9	1.038	.015	3.002	.06
C3V Allende	71.8	2.0	824	8	1.075	.010	3.501	.10
C3V Vigarano	66.3	0.8	795	5	1.065	.010	3.350	.043
C3O Ornans	67.5	0.8	822	6.8	1.050	.015	3.298	.08

Table 2: Comparison of Re and Os analyses in two iron meteorites

Meteorite	Re ppb	Os ppb	$^{187}Os/^{186}Os$	$^{187}Os/^{186}Os$	Refs.
Canyon Diablo	273	2926	1.084	3.743	This
	247	2620	1.070	3.783	work
	247	2300	1.115	4.330	(5)
	222	2030	1.113	4.400	(4)
	252	2070	1.122	4.882	(4)
Tocopilla	230	1085	1.390	8.550	This
	247	1090	1.452	9.160	work
	252	1290	1.409	7.868	(4)
			1.430	7.871	(5)
	222	1060	1.404	8.420	(5)

Table 3: Comparison of rhenium and osmium abundances in carbonaceous chondrites

Meteorite	Rhenium, ppb: This Work	Rhenium, ppb: Literature Values	Osmium, ppb: This Work	Osmium, ppb: Literature Values	Refs.
Orgueil	43.3	31.9 39.9, 40.2	518	484, 530, 595	(12)
		40.6, 35.3		520, 480	(12,9)
		37.0, 35.8		435, 466	(6)
Murchison	56.3	43.0	759		(7)
Murray	53.2	49.7, 51.2	713	683, 686	(6)
	67.0	48.8	810		(7)
Allende	65.8	69.2, 75.4, 64.6	819	925, 868, 759	(9)
	68.1	64.2	911	812	(12)
	71.8		824		
Vigarano	66.3	56.7	795		(8)
Ornans	67.5	63.3	822	751	(9)

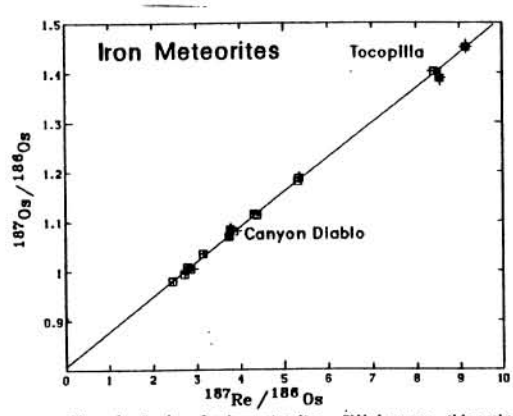

Figure 1. Isochron for iron meteorites. Filled squares, this work; open squares, ref 4. Error bars are two standard deviations.

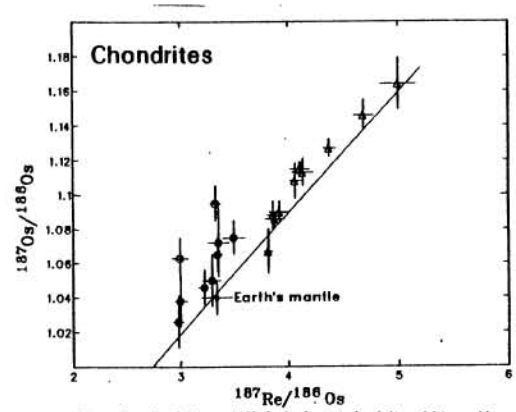

Figure 2. Chondrites. Filled circles, C chondrites (this work); open circles, Murray (this work); open triangles, ordinary chondrite metal (ref 4). The straight line is the iron meteorite isochron from Fig. 4. Error bars are two standard deviations.