Rhenium and Osmium Isotope Systematics in Carbonaceous Chondrites;

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We report Re and Os abundances and $^{187}\text{Os}/^{186}\text{Os}$ 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 $^{185}\text{Os}$ and $^{185}\text{Re}$ spikes by NaOH-Na$_2$O$_2$ fusion in Zr crucibles. From a solution made 5N in H$_2$SO$_4$, Os was distilled as OsO$_4$ by adding H$_2$O$_2$. 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 0.4 g 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 $^{187}\text{Re}/^{186}\text{Os}$ 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 $^{187}\text{Os}/^{186}\text{Os}$ 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 $^{187}\text{Os}/^{186}\text{Os} = 1.040±0.101$ and $^{187}\text{Re}/^{186}\text{Os} = 3.34±0.14$ [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 $^{187}\text{Os}/^{188}\text{Os}$ (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 $^{187}\text{Os}$; Re does not seem particularly depleted compared to other chondrites, however. Very preliminary data suggest Semarkona (LL3) also may have unusually radiogenic Os ($^{187}\text{Os}/^{188}\text{Os} = 1.17\pm0.02$; $^{187}\text{Re}/^{188}\text{Os} = 3.75\pm0.19$) but require confirmation.