

Re-Os DATING OF IIIAB IRON METEORITES Tezer M. Esat and Victoria Bennett.
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Recently, Creaser et al., [1] and Völkening and Heumann, [2] have demonstrated the efficient production of large ($\approx 10^{-11}$ A) ion beams by negative thermal ionisation mass spectrometry (NTIMS) using standard laboratory solutions of Os compounds. Horan et al., [3] have applied NTIMS to a group of 7 IIA iron meteorites and obtained a Re-Os closure age of 4596 ± 152 million years. The initial $^{187}\text{Os}/^{186}\text{Os}$ ratio was 0.8007 ± 0.0029 . In addition they analysed 3 IIIA meteorite samples which indicated an age of 4554 ± 180 million years and Os initial of 0.8120 ± 0.0075 which does not overlap with the initial for the IIA irons. We have been independently pursuing a similar program with the direct aim of determining possible variations in the initial $^{187}\text{Os}/^{186}\text{Os}$ ratio or Re-Os closure age of different classes of iron meteorite. We have applied NTIMS to Os extracted from the most common group of iron meteorites the IIIAB. These meteorites are believed to be of magmatic origin, formed by fractional crystallisation of molten cores of asteroidal bodies. The present results point to a significantly lower initial $^{187}\text{Os}/^{186}\text{Os}$ ratio of 0.7731 ± 0.0050 than previously determined.

Samples of iron meteorite were obtained from the ANU meteorite collection. Small (50 to 100 mg) pieces were hand sawn using clean hack-saw blades lubricated with ethanol. Samples were cut from interior portions away from ablated surfaces. Each sample was de-greased in acetone in an ultrasonic bath and rinsed with ethanol followed with high-purity water. Samples were dissolved in a mixture of HCl and ethanol, including mixed Re and Os spikes, in glass bottles at 60°C . Following dissolution the sample was dried and was redissolved in H_2SO_4 in a sealed glass bottle at 90°C . An oxidant was included to ensure complete equilibration between the Os from the sample and the Os spike. This step is essential as complete sample/spike equilibration has been the single most difficult problem impeding precise Os concentration measurements. The sample in H_2SO_4 solution was transferred to the distillation apparatus and gradually heated to 120°C using a hot air gun while small amounts of H_2O_2 was added to help oxidise Os. The residue from distillation was passed through a 3 cm anion exchange column and Re eluted with HNO_3 . A mixture of BaOH and KOH solutions were loaded into a V-shaped pocket in a single Pt filament followed by the addition of the sample in chloride form. All were then dried in air. We find that the presence of KOH enhances negative ion formation. Corrections for mass dependent isotope fractionation and for interference from minor oxygen isotopes were computed in a single step by first order expansion in terms of the fractionation factor. The contribution of minor tracer isotopes were handled in a similar fashion in a single step together with fractionation and $^{17,18}\text{O}$ interferences. Statistical precision for individual runs, where ^{192}Os beam intensity was larger than 4×10^{-12} A, is $\pm 0.2\%$ 2σ .

The data for the 6 iron meteorites Costilla Peak, Henbury, Cape York, Duketon, Kyancutta and Carthage form a collinear array on the $^{187}\text{Os}/^{186}\text{Os}$ vs. $^{187}\text{Re}/^{186}\text{Os}$ diagram (Fig.1). The best linear fit to the data defines an isochron with a slope of 0.0830 ± 0.0012 and an intercept of 0.7731 ± 0.0050 . The slope corresponds to an age of 4865 ± 50 million years. Including the uncertainties resulting from the decay constant, $(1.639 \pm 0.050) \times 10^{-11} \text{yr}^{-1}$ ($\pm 3\%$) of Lindner et al., [4] uncertainty in the Re-Os spike calibrations ($\pm 2\%$) and the slope ($\pm 1.5\%$) results in an age estimate of 4865 ± 190 million years.

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This age is incompatible with the maximum age of 4560 Ma for chondrites as the iron meteorites are expected to have evolved from chondritic precursors. It is possible that there is a larger uncertainty in the determination of the Re decay constant or that our calibration of the Re and Os spikes are in error by more than 2% (an increase of 7% in the Re/Os ratio is required to obtain an age of 4558 million years). In either of these two cases, however, the intercept corresponding to the initial $^{187}\text{Os}/^{186}\text{Os}$ ratio should not be affected. Both us and Horan et al., [3] have analysed the IIIA iron meteorite Costilla Peak. For the Re concentration we obtain 1.420 ppm vs. 1.426 ppm; in good agreement and similarly for the $^{187}\text{Os}/^{186}\text{Os}$ ratio of 1.0331 vs. 1.0393. For the Os concentration we have 17.98 ppm vs. 19.58 ppm indicating a difference of about 9%. This translates to a difference of about 8.5% in the Re/Os ratio. However, a decrease in our Re/Os ratios by this magnitude would lead to an even older (>5000 Ma) apparent age for the IIIAB irons.

Horan et al., [3] have determined an initial ratio of 0.8007 ± 0.0029 for IIA and 0.8120 ± 0.0075 for IIIA meteorites; the latter based on three analyses. As we have not as yet analysed any IIA iron meteorite samples we are unable to independently confirm any differences between IIA and IIIA initial Os ratios. Our data can only be reconciled with that of Horan et al., [3] if we assume a random error in Re/Os concentration determinations which resulted in the rotation of the isochron to produce an older age and a lower initial. This is a possibility given the difficulties of achieving complete equilibration between Os spike and sample and would require approximately a 3% increase in Re/Os ratio for the 3 high Re/Os points and a 3% decrease for the 3 low Re/Os data points to preserve the linearity of the array. In the absence of such a contrived arrangement, we are unable to offer a reasonable explanation for the differences in the initial $^{187}\text{Os}/^{186}\text{Os}$ ratio.

If we accept the present data at face value then we can draw the following conclusions: i) The older apparent age is due to either an error in the Re decay constant or analytical problems in the calibration of our Os spike by about 7%. ii) The low initial $^{187}\text{Os}/^{186}\text{Os}$ ratio of 0.7731 is unaffected by either of these problems. iii) The difference in the initial Os between IIA iron meteorites as determined by Horan et al., [3] and the present result for IIIAB irons may be due to the heterogeneous accretion of Os in the parent bodies of these two groups of iron meteorite.

References: [1] Creaser, R.A., Papanastassiou, D.A. & Wasserburg, G.J. (1991), *Geochim. Cosmochim. Acta* **55**, 397. [2] Völkening J., Walczyk T. & Heumann, K.G. (1991), *Int. J. Mass. Spectrom. Ion Proc.* **105**, 147. [3] Horan, M.F., Morgan, J.W., Walker, R.J. & Grossman, J.N. (1992), *Science* **255**, 1118. [4] Lindner, M., Leich, D.A., Russ, G.P., Bazan, J.M., and Borg, R.J. (1989), *Geochim. Cosmochim. Acta* **53**, 1597.

Fig 1. Re-Os evolution diagram for IIIAB iron meteorites. The 6 samples in order of increasing $^{187}\text{Re}/^{186}\text{Os}$ ratio are: Costilla Peak (17.975, 1.420), Henbury (15.083, 1.325), Cape York (2.343, 0.237), Duketon (2.886, 0.313), Kyancutta (0.827, 0.116), and Carthage (0.234, 0.0362). Where the entries in brackets are the Os and Re concentrations in parts per million respectively. Error bars are smaller than the size of the points plotted.

