

SYSTEMATIC CHEMICAL VARIATIONS IN LARGE IIIAB IRON METEORITES: CLUES TO CORE CRYSTALLIZATION;

H. Haack, E.R.D. Scott; Planetary Geosciences, University of Hawaii, USA; G. S. Rubio, D.F. Gutierrez, Institute of Geology and Institute of Astronomy, Universidad Nacional Autonoma de Mexico, Mexico, D.F., Mexico; C.F. Lewis, Center for Meteorite Studies, Arizona State University, Tempe, USA; J.T. Wasson, Institute for Geophysics and Planetary Physics, UCLA, USA; R.R. Brooks, X. Guo, Dept. of Chemistry and Biochemistry, Massey University, Palmerston North, New Zealand; D.E. Ryan, and J. Holzbecher, Dept. of Chemistry, Dalhousie University, Halifax, N.S., Canada

Abstract. Analysis of numerous individual iron meteorites have shown that fractional crystallization of iron cores results in variations in chemical concentration of the solid core which span several orders of magnitude. The magnitude and direction of the resulting spatial gradients in the core can provide clues to the physical nature of the core crystallization process [1,2]. We have analyzed suites of samples from three large IIIAB irons (Cape York, 58t; Chupaderos, 24t; Morito, 10t) in order to estimate local chemical gradients. Initial results for the concentrations of Ge, Pd, Pt (Massey group), Ir, Au, As, Co, Os, and Rh (Dalhousie group), and P (Arizona group) show significant ranges among the Cape York and Chupaderos samples and marginally significant ranges among the Morito samples. Measurements of Au, Ir, Co, Ni, Cu, Ga, As, W, Re (from UCLA) and Ni and Co (Arizona group) are in progress. We find a spatial Ir gradient in Chupaderos with a magnitude similar to the one reported for Agpalilik (Cape York iron) by Esbensen et al.[1].

Introduction. Prior to the remarkable discoveries of chemical variations in Cape York by Esbensen et al. [1] it was generally believed that core crystallization process did not result in chemical gradients which could be detected in even large iron meteorites. Previous workers have either argued that the iron cores crystallized by dominantly outwards concentric growth [1,3] or inward dendritic growth [2,4]. Pure concentric growth would result in spatial chemical gradients within a single meteorite below the detection limit, whereas dendritic crystallization would produce gradients which are generally above the detection limit. One possible way to discriminate between the two scenarios is therefore to measure typical spatial gradients in large iron meteorites.

Purpose of study. In the current study we have sampled two more large IIIAB iron meteorites (the 24-ton Chupaderos and the 10-ton Morito) and expanded the study of Cape York in order to provide more constraints on the crystallization of the IIIAB core. We have tried to answer 3 important questions about chemical variations in iron cores: a) Are the observations from the Cape York shower a normal or a rare feature of iron cores. b) What is the average magnitude of chemical gradients? c) Do the compositional variations within large iron meteorites differ from the trends defined by individual analyses of small iron meteorites?

Method. We hacksawed 10 samples from Chupaderos and 4 from Morito, each sample weighing 10-20 g. The spatial coordinates of each sample was measured and the relative orientation of the two main Chupaderos masses prior to break-up was determined. Au, As, Pd, Rh, Os, Ir, and Pt were determined using the methods described in Hoashi et al. [5].

Results: *Cape York*, Esbensen et al. [1] found a chemical gradient in Ir within the 20-ton Cape York Iron, Agpalilik. They also found a variation in chemical composition among the Cape York irons with Thule (2.68 ppm Ir) and Savik II (5.13 ppm Ir) as end-members. Haack and Scott [2] suggested a correlation between scatter in IIIAB and the deviation between the Cape York trend and the main IIIAB trend. This could indicate that the scatter in the IIIAB compositional trends are in part due to deviating local trends like the Cape York trend. In order to further test this idea we have expanded the data set to include the elements P, Pt, Ge, Rh, and Os for the meteorites Savik I, Agpalilik, and Thule. These data are consistent with the idea that part of the scatter is due to deviating local trends. We find a correlation between Au and Pd, an inverse correlation between Au and Pt, Rh, Ir, and Os, and a correlation between our new Ge data and the previously reported Ga data [1]. The Ir concentrations span the largest range (a factor 2.1).

Of particular interest is the distribution of P, since it has a much higher diffusion rate (2 orders of magnitude higher than Ni) than the other elements. Our data shows that the P variation among the Cape York iron meteorites follows the variation defined by data on other IIIAB iron

SYSTEMATIC COMPOSITIONAL VARIATIONS: Haack H. et al.

meteorites (e.g. there is no evidence for solid state equilibration of P). This observation suggests that the compositional gradients through the Cape York meteorites extended over tens of meters.

Chupaderos. This meteorite is the second largest IIIAB iron meteorite and therefore a prime candidate for a study of chemical gradients in the IIIAB core. With a Ni concentration of 9.7 wt % [6], Chupaderos crystallized much later than Cape York (≈ 8 wt% Ni) and may possibly provide clues to the state of the core at a time were it was largely solid. The three Chupaderos fragments can be reassembled to form a mass with dimensions of 4.0 x 2.65 x 0.9 m [7]. Abundant troilite nodules can be seen on the surface of these fragments with the larger nodules being aligned within and among the three masses.

9 out of the 10 analyzed samples from Chupaderos seem to define a spatial gradient. One sample had a very unusual composition, possibly due to the proximity of a troilite nodule [1]. In the remaining 9 samples Au showed a correlation with Ge, Pd, Rh, and Ir, an inverse correlation with Pt, and no correlation with Co. Discarding the anomalous sample we obtained the following ratios between the highest and lowest measured concentrations: Co: 1.1, Ge: 1.1, As: 1.2, Au: 1.4, Pd: 1.7, Ir: 1.8, Rh: 2.2. Compositional variations show relatively well defined trends along a direction which coincides with the direction defined by the troilite nodules in the XY-plane. The limited vertical dimensions of the meteorites does, however, make it difficult to constrain the Z-component of the compositional gradient vector.

We found that the P concentrations of the Chupaderos samples varied by a factor of 2 consistent with previous measurements of P in the Chupaderos fragment Adargas (0.47 wt% P) [8] and 0.16 wt% P in Chupaderos [9]. These numbers are lower by approximately a factor of 2 compared to other IIIAB irons with similar Ni concentrations. The lack of correlation of the P data with our other analyses does, however, suggest that sample heterogeneity is partially responsible for the variation.

Morito. Morito has the same average composition as Cape York and did therefore crystallize around the same time. Due to the beautifully sculptured shape of this large meteorite we were only allowed to take 4 samples spaced approximately 1 m from each other. We found significant compositional variations for the following elements: Co: 1.1, Ge: 1.2, As: 1.4, Au: 1.1, Pd: 1.1, Ir: 1.1, Rh: 1.4. The small number of samples made it impossible to estimate a spatial gradient, although the compositions of the samples seem to correlate with position. Positive correlations between Au and As and Os, Pt, and Ir suggest that the variations are real, although we cannot draw any conclusions before the full data set is available.

Conclusions: Our new compositional data from three large IIIAB iron meteorites suggest that at least the IIIAB core had large spatial gradients in chemical composition. Comparison of our data with literature data on IIIAB iron meteorite compositions suggests that local compositional trends in the parent core may deviate from the general IIIAB trends. The magnitude of the Ir gradient inferred for Chupaderos is close to the previously reported Ir gradient in the Cape York mass Agpalilik.

Acknowledgements: Ignacio Casanova's help to initiate this project is greatly appreciated. V.F. Buchwald, F. Ulff-Møller, and K.L. Rasmussen are thanked for providing the Cape York samples. This work was partially supported by NASA grant NAG 9-454 and NAGW - 3281 (K. Keil).

References: [1] Esbensen K.H., V.F. Buchwald, D.J. Malvin, and J.T. Wasson (1982) *Geochim. Cosmochim. Acta*, **46**, 1913-1920. [2] Haack H. and Scott E.R.D. (1993) *Geochim. Cosmochim. Acta*, submitted. [3] Pernicka, E, and J.T. Wasson, (1987) *Geochim. Cosmochim. Acta*, **51**, 1717-1726. [4] Haack H. and Scott E.R.D. (1992) *J. Geophys. Res.*, **97**, 14727-14734. [5] Hoashi, M., H. Varela-Alvarez, R.R. Brooks, R.D. Reeves, D.E. Ryan, and J. Holzbecher (1992) *Chem. Geol.*, **98**, 1-10. [6] Scott, E.R.D., J.T. Wasson, and V.F. Buchwald (1973) *Geochim. Cosmochim. Acta*, **37**, 1957-1983. [7] Buchwald, V.F. (1975) *Handbook of Iron Meteorites*, University of California Press. [8] Moore, C.B., C.F. Lewis, and D., Nava (1969) In *Meteorite Research* (ed. P.M. Millman) 738-748. [9] Lewis, C.F. and C.B. Moore (1971) *Meteoritics*, **6**, 195-205.