THE IIG IRON METEORITES: PROBABLE FORMATION IN THE IIAB CORE.

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Introduction: The addition of two meteorites to the iron meteorite grouplet originally known as the Bellsbank trio brought the population to five, the minimum number for group status. The new group has been designated IIG. The members of this group have low Ni contents in the metal and large amounts of coarse schreibersite; their bulk P contents are 17 to 21 mg/g, the highest known in iron meteorites. These are lower limits of the true values; IIG irons fall as showers, with breakage occurring in schreibersite-rich regions. The IIG S contents are exceptionally low, ranging from 0.2 to 2 mg/g.

Compositional links between the IIG and IIAB irons have long been recognized. However, because on element-Au or element-Ni diagrams (Fig. 1) the IIG fields of the important taxonomic elements Ni, Ga, Ge and As are offset by tens of percent from those of the IIAB irons, past researchers have concluded that the IIG irons could not have formed from the same magma, i.e., that the two groups originated on separate parent bodies. In contrast, on the remaining element-Au diagrams (Fig. 2) the IIG fields tend to form extensions of IIAB trends to higher Au concentrations. We argue that this close compositional relationship cannot be coincidence but is best understood in terms of both sets of irons forming in the same core. We suggest that the offsets are the result of IIG formation in a highly evolved, P-rich part of the IIAB core.

Compositional trends: We use neutron-activation to obtain data for ~ 15 elements in iron meteorites; compositions of 78 IIAB irons were published by [1]. Our IIG data show smooth trends on element-Au diagrams; low Ir and high Au contents suggest formation during the late crystallization of a magma.

There is general agreement that, after some crystallization, the IIAB core experienced liquid immiscibility and thus the formation of an upper S-rich and a lower P-rich magma. Most metal crystallization occurred in the P-rich lower core. As continuing crystallization enhanced the P and S contents of the melt, the P content of the lower core increased and that of S decreased, as discussed by [2,3,1]. We suggest that the IIG irons formed from the P-rich magma and that schreibersite was a liquidus phase during the final stages of crystallization.

The Fe-P system forms a eutectic at 1320 K and 106 mg/g P [4]. The addition of Ni seems to have little effect on the P content of the eutectic; the eutectic temperature may [5] or may not [6] be several tens of degrees lower. Depending on the Ni/(Ni+Fe) ratio in the system, the Ni content of the eutectic schreibersite is low, ~65 mg/g.

We propose that the IIG-IIAB offsets in Ni, As and other elements are partly the result of major changes in melt/solid distribution ratios in the late P-rich magma and partly the result of solid-state elemental redistribution between metal and schreibersite during slow cooling. For example, in the IIG irons, Ni content is more than 2× higher in late-formed rhabditic schreibersite relative to early-formed, massive schreibersite. As noted above, the Ni content at the time of schreibersite crystallization was still smaller, 60-65 mg/g. Most, perhaps all of the difference between IIAB kamacite with 57 mg/g Ni and IIG metal with 45 mg/g Ni can be explained by diffusion of Ni from metal into schreibersite at subsolidus temperatures.

It is likely that As substitutes almost ideally for P at eutectic temperatures and that it exsolves from the schreibersite at low temperatures. This could account for part or all of the As enhancement visible in Fig 1d.

Our scenario is that, at the bottom of the evolved IIAB magma, dendrite-like growth led to the formation of cavities containing liquids unable to participate in the convective motions of the main magma body. The metallic walls of these cavities were normal IIAB irons, but the enclosed liquids gradually became more enriched in P; the immiscible S-rich melt escaped because of buoyancy. Metal crystallization eventually led to the formation of smaller and smaller subcavities and eventually eutectic compositions. The IIG irons consist of these eutectic-filled subcavities together with their thin metallic walls. The absence of S indicates that the S-rich melt continued to escape until most of the eutectic had crystallized.

One possible explanation of the low Ga and Ge contents of the IIG irons is that these elements partition into the S-rich liquid in preference to the P-rich liquid, and that they are gradually extracted into the S-rich magma. We suspect that Au also prefers the S-rich magma and As the P-rich magma.

Summary: Because on most element-Au diagrams the IIG elements plot as approximate extensions of IIAB trends, we argue that the best interpretation is that these formed under exceptional circumstances in the evolved IIAB core. We suggest that, late in the crystallization history of IIAB, cavities in the floor of the P-rich lower core became isolated by dendrite-like barriers. After moderate metal crystallization, the composition of the melt in subcavities reached the Fe-Ni-P eutectic. The IIG irons consist of these subcavities and their pre-eutectic walls. The compositional offsets in Ni and As can be roughly modeled by this scenario. The offsets in Ga and Ge may reflect partitioning of these elements into the S-rich immiscible liquid that escaped from the local system.

References: [1] Wasson J et al. (2007) *GCA* 71, 760; [2] Ulff-Møller F. (1998) *MPS* 33, 207 ; [3] Chabot N., Drake M. (2000) *MPS* 35, 807; [4] Brandes E., Brook G. (1992) Metal Reference Handbook; [5] Doan A., Goldstein J. (1969) Meteorite Research p.763; [6] Buchwald V. (1966) Acta Polytechn. Scand. Chem. Met. Ser. 51.

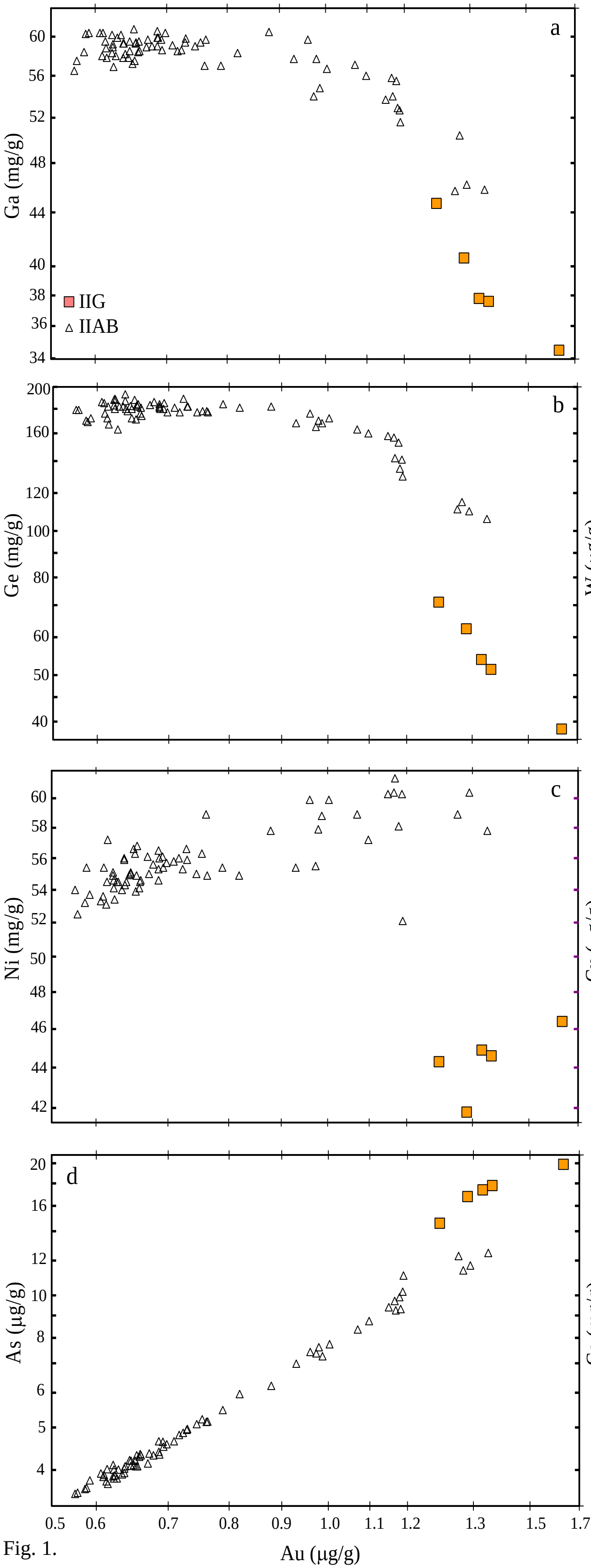

Fig. 1.
Taxonomic elements in IIG irons are offset from IIAB trends.

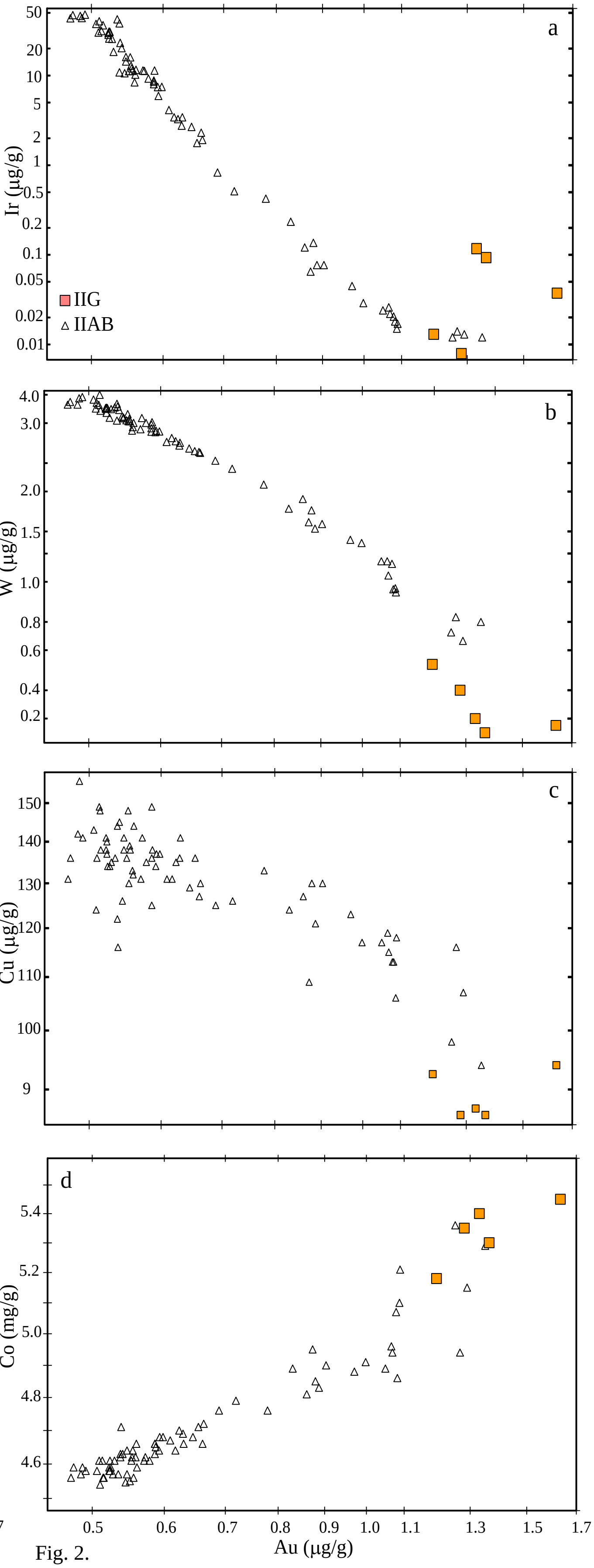

Fig. 2.
Most IIG elements plot on or near IIAB trends.