ORIGIN OF METAL IN AUBRITES: SIDEROPHILE ELEMENT ABUNDANCES IN CM-SIZED METAL NODULES OF NORTON COUNTY;

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Introduction. Metallic Fe,Ni in aubrites occurs as fine-grained particles of several microns to a few mm in size (commonly referred to as matrix metal, [1]), and as large nodules of up to 2 cm in diameter. Such metal nodules have been reported in Norton County, Mayo Belwa, Khor Temiki and some Antarctic aubrites. Several possibilities exist for the origin of metal in aubrites: a) extraneous chondritic material, incorporated into the aubrite parent body (bodies) as clasts, b) in situ reduction of FeO under low oxygen fugacity conditions, as proposed for the origin of the kamacite in the Camel Donga metal-rich eucrite [2], c) fragments of a fractionally crystallized metallic core from the aubrite parent body or another asteroid, and d) disseminated globules segregated from the silicate magma (inefficient core formation). Previous work on aubritic metal has only focused on the fine-grained fraction [1,3,4]. We are applying petrographic and chemical techniques to address the origin of the metal in aubrites.

Results. We have studied seven cm-sized metal nodules from the Norton County aubrite. These nodules are generally polycrystalline, well-rounded masses of sizes ranging between 0.8 and 1.6 cm in diameter. Major minerals are kamacite, perryite and schreibersite; taenite was found in only two of the seven samples. Sulphides (troilite, alabandite and daubréelite) occur as accessory phases. We used INAA techniques to determine the concentrations of Fe, Ni, Co, Cr, Ir, Au, W, Ga, Ge, As, Sb, and Re, and the electron microprobe to analyze the bulk contents of Fe, Ni, P and Si. Fe and Ni concentrations obtained by both techniques agree within the precision of microprobe analysis. Our results for Ni, Ir, Au, Ga and As are plotted as element/Ni ratios in figs. A to D, together with available literature data for one metal inclusion from the Mayo Belwa aubrite [5] and the main iron meteorite groups.

Discussion. The Norton County metal nodules show well-defined igneous contacts with the silicate host: this strongly supports the idea that this metal is not xenolithic material incorporated into the parent body as a result of accretionary processes or collisions between different asteroids, even though aubrites are highly brecciated meteorites. In the Mayo Belwa and Norton County aubrites, the Ni contents of the metal nodules (5.8-7.6 wt.%) indicate that in situ reduction of FeO from a silicate magma is unlikely, since grains of considerably lower Ni concentrations would be formed, as in the Camel Donga eucrite [2]. The Ni contents of the fine-grained metal of aubrites [1, 3, 4] are roughly chondritic, ruling out a reduction origin as well. Siderophile-element/Ni ratios for the analyzed metal inclusions of Norton County and Mayo Belwa also yield approximately chondritic values (within a factor of 5; CI element/Ni ratios indicated with a dashed line in figs.). It is therefore unlikely that the Norton County metal represents fragments of a fractionally crystallized core, as in the "magmatic" iron meteorite groups where large variations from chondritic ratios are observed [6]. Furthermore, it seems improbable that a core can be broken up into such homogeneously-sized metal particles as observed in aubrites. At this stage of the study, the possibility that we consider more likely is that the metallic nodules represent original aubritic metal which has not completely segregated into a core. High degrees of partial melting are needed to efficiently settle out metal into a core: calculations show that melt fractions greater than 0.90 are required to sink metal particles of a few cm in diameter in a parent body of several tens of kilometers in diameter [7]. The data for the analyzed Mayo Belwa and Norton County metal nodules suggest a possible systematic variation of the abundances of Au, As and Ga, but not for Ir. Do these variations reflect an igneous trend or some kind of nebular process affecting the metal in the material from which the aubrite parent body accreted? Earlier studies [8] have suggested that significant liquid metal/solid metal fractionations may occur upon partial melting; that might explain the observed trends for Au, Ga and As but not the apparent scatter of data for Ir. It may also be possible that Au, Ga and As fractionate into another phase (sulphide?) to a larger extent than Ir, but this idea has not yet been quantitatively tested. Chemical variations due to nebular processes have been observed in chondritic metal and such variations in the material that accreted to form the aubrite parent body are certainly likely. We are currently analyzing other aubrites to test these ideas.

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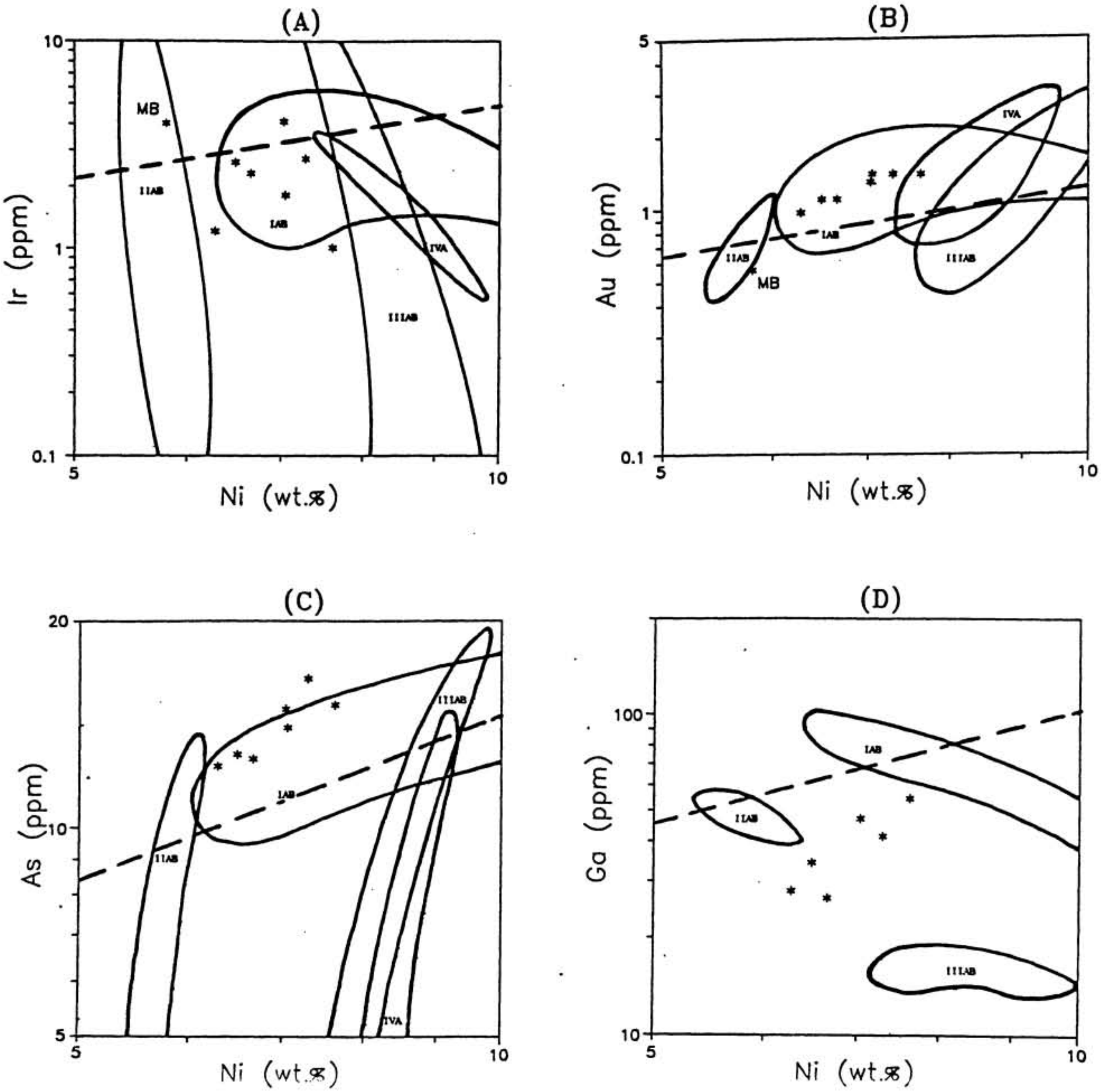

MB - Mayo Belwa metal inclusion
no label - Norton County metal nodules