FORMATION OF THE BELLSBANK TRIO IRON METEORITES AS IMMISCIBLE, P-RICH LIQUID POCKETS ON THE CRYSTALLIZING FLOOR OF THE IIAB CORE.

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Three genetically related iron meteorites called the Bellsbank trio (Bellsbank, La Primitiva, Tombigbee River) are mainly comprised of low-Ni ($\sim$40 mg/g) kamacite and massive skeletal or hieroglyphic low-Ni ((Ni/(Fe+Ni)$\sim$0.14) schreibersite. Their metal-phase trace-element compositions are similar to those of low-Ir IIAB irons, though significant differences are observed (Bellsbank Ge 0.5X; Cu, Ga 0.7X; As 1.2X; Au 1.05X those in low-Ir IIAB). Clarke and Goldstein (1) noted a general metallographic similarity between the Bellsbank irons and P-rich nodules in the low-Ir Santa Luzia IIAB iron. The high P contents of these materials (17-20 mg/g) cannot be explained by solid-state exsolution because the low P solid-liquid distribution coefficient requires implausibly high P contents in the liquid. It is more likely that these regions containing massive schreibersite formed by the closed-system crystallization of liquid pockets. In a recent paper Jones and Drake (2) drew attention to the existence of immiscible liquids if P contents exceed 30 mg/g in the system Fe-S-P.

Such high P contents would be expected in magmas that had experienced high degrees of fractional crystallization. The IIAB core had high volatile abundances roughly comparable to those in CI chondrites. Its initial Ni concentration is estimated to be about 60 mg/g, thus multiplication by the cosmic P/Ni mass ratio of 0.10 yields an initial P content of $\sim$6 mg/g. If the P solid/-liquid distribution ratio was 0.10 throughout crystallization, application of the Rayleigh equation indicates that the magma P content reaches 30 mg/g only after a fraction 0.83 of the core crystallized.

Thus liquid immiscibility would be possible late in the crystallization of the IIAB core. For mass balance reasons the P-rich second liquid should be volumetrically much smaller than the primary liquid, which we will call the S-rich liquid because of its high S/P ratio (2,3). The P-rich liquid has a higher Fe and Ni content than the S-rich liquid, and is thus more dense by $\sim$1 g cm^{-3} and should therefore settle into topographic lows on the floor of the IIAB core. If the puddles crystallized in equilibrium with the S-rich liquid the metal would be identical to that crystallizing from the S-rich liquid. However, in those cases when crystal growth or settling isolated the P-rich liquid from contact with the S-rich liquid, the composition of the trapped liquid would be preserved in the solid phases.

The similarity of the Bellsbank irons to the 3-6 cm Santa Luzia nodules suggests that both formed by the crystallization of a P-rich second liquid under approximately closed-system conditions.

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Although solid-state diffusion must have led to some elemental exchange between the Santa Luzia nodules and the surrounding coarsest-octahedrite metal, we investigated a transsect (provided by R.S. Clarke) across the center a Santa Luzia nodule (that figured on p. 22 of Clarke and Goldstein (1) in the hope that we could find some compositional evidence of a link to the Bellsbank irons.

Samples 3-mm thick were taken perpendicular to the long axis of the bar; One sample consisted of troilite, one of schreibersite, and the remainder were metal, some with minor schreibersite contamination. These were analyzed for Cr, Fe, Co, Ni, Cu, Ga, As, W and Au by instrumental neutron-activation analysis; Re and Ir were below our detection limits. The most interesting metal samples were those near the center of the nodule adjacent to schreibersite and troilite. Preliminary data after correction for schreibersite contamination show that nodule metal Cu is $\sim$0.8X, Ga $\sim$1.0X, As $\sim$1.1X, Au $\sim$1.0X mean values measured in the surrounding coarsest octahedrite metal. These are generally consistent with the hypothesis that the nodule originally had a composition very similar to that of the Bellsbank irons, but that subsequent diffusion has reduced compositional gradients.

If the Bellsbank irons did form as P-rich melt pockets, laboratory partitioning studies should confirm that the differences in elemental concentration mentioned in the first paragraph are those obtained from coexisting S-rich and P-rich melts having appropriate IIAB compositions.

We speculate that other meteorites containing massive schreibersite surrounded by swathing kamacite formed by the same mechanism. Such meteorites should be reexamined to determine whether their compositional shifts relative to well-established groups are those that could be explained by the existence of P-rich melt pockets. As an example, we note that Ballinger, which contains such nodules, was assigned to group IIICD rather than IAB largely on the basis of its lower Ga and Ge and higher As contents relative to expected IAB values.

References.

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3. Schürmann E. and Neubert V. (1980) Schmelzgleichgewichte in den eisenreichen Ecken der Dreistoffsysteme Eisen-Schwefel-Kohlenstoff, Eisen-Schwefel-Phosphor und Eisen-Schwefel-Silicium. Giessereiforschung 32, 1-5.