PRELIMINARY OBSERVATIONS ON DRUSY VUGS IN THE ALBION* IRON METEORITE;
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A 22.28-kg mass of iron, found in Albion, Washington, in the winter of 1966-1967 remained unknown until 1991 when the finder brought it to Carleton B. Moore at Arizona State University. Moore identified it as a meteorite and sent a sample to John A. Wasson at UCLA who classified it as a IVA fine octahedrite. This iron is unique in having vugs, ranging in length from 4 to 9 mm, scattered throughout the otherwise orderly Widmanstätten structure. Drusy spheroids cover the walls and partially fill some of the vugs. We have analyzed the constituents of Vug-A (Fig. 1) and the metals surrounding it.

Textures and Mineralogy. Vug-A (7 x 5 mm) is more than half-filled with spheroidal masses consisting mainly of a fine-grained reticulated intergrowth of kamacite and troilite with a few rounded segregations of tetrataenite. Each of the spheroids is bordered by a rim, 35-65 μm wide, chiefly of interlocking kamacite grains. The rims occur not only where the spheroids project into the void but also where they abut other spheroids, and on both sides of a crack within the largest spheroid (Figs. 1a, b). The vug is bordered by a zone, 1 to 2.5 mm wide, of granular kamacite with minor troilite and taenite. Where the granular kamacite itself borders the vug (Fig, 1a, b at lower left) it, too, has a rim, up to 125 μm wide, of interlocked kamacite and a few clumps of Ni-rich metal. Away from the vug, the metal of the granulated zone gradually merges with the Widmanstätten pattern of the main mass.

Within the spheriodal masses, kamacite, with 2-3.5 wt.% Ni, occurs in irregular grains, <1 to 35 μm across. The bright rounded and lenticular masses within the spheroids consist of tetrataenite (55.6 wt.% Ni), which also occurs as individual grains scattered through the kamacite. Both metals are enmeshed in troilite which appears to have invaded and corroded the metals (Figs. 2, 3). Daubreelite ($FeCr_2S_4$) occurs in blocky, euhedral grains, 5-15 μm across, in the spheroids (Figs. 2, 3), in the zone of granulated metal, and, sparsely, in the main mass. Of the two sulfides, the daubreelite formed earlier than the troilite, which contains no chromium and shows no sign of reaction where the two are in contact. An apparently new phosphide mineral occurring in rounded euhedral to subhedral grains, 3-15 μm across, is limited to the spheroids. After several calibrations our analyses of sixteen grains yielded a consistent compositon of $[Ni_{0.54}Fe_{0.46})_{3.7}$ P].

Ni-Fe Fractionation in Metal. As indicated above, we measured a strong fractionation of nickel in the metals of the main mass, the granulated zone, and the spheroids. The kamacite of the Widmanstätten structures averages 7.1 wt.% Ni; that in the granulated zone averages 5.3 wt.% Ni; and that predominating in the spheroids ranges from 2.06 to 3.5 wt.% Ni. Kamacite forming the rims and in small masses enclosed within tetrataenite contains up to 4.25 wt.% Ni. The taenite of the Widmanstätten patterns contains normal values averaging 33.7 wt.% Ni; that within the spheriods is tetrataenite averaging 55.6 wt.% Ni. This fractionation takes place within distances of 2-4 mm between the Widnanstätten pattern and the spheroids. The coupling of very high-nickel with low-nickel metals indicates equilibration at low temperatures.

Early Speculations on Origin. At present, we regard the vugs in the Albion iron as primary features--inherited from bubbles in the cooling melt that remained open during the formation of Widmanstätten structures. Clearly the iron was not part of a core; it had cracks, voids, and, perhaps, imperfectly-sealed grain boundaries that allowed the passage of hot fluid or vapor that mobilized troilite, fractionated nickel, and deposited drusy spheroids on the walls of vugs. By analogy with vugs in terrestrial rocks, it seems clear that the spheroidal masses grew by stages, finally forming rims. This is the first time we have had to account for drusy vugs in iron meteorites. Previous investigators have attributed masses of troilite-kamacite intergrowths in IVA irons to shock-melting of troilite nodules. If such shock effects occured, we would expect to find evidence in metals of the main mass, but we find no trace of shock damage in the Widmanstätten patterns of the Albion iron. We find it difficult, in any case, to envision shock effects opening cavities, lining them with drusy minerals, and fractionating nickel in the associated metals. Thus, we are investigating further our hypothesis that the unique vugs in the Albion iron are of primary origin.

* The name is under consideration by the Nomenclature Committee of the Meteoritical Society.

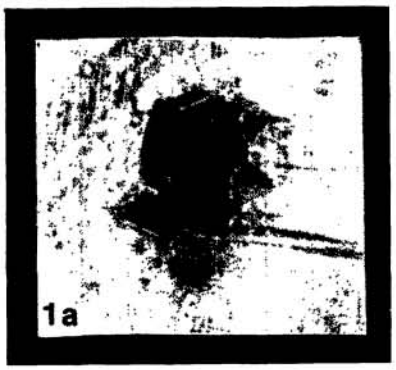
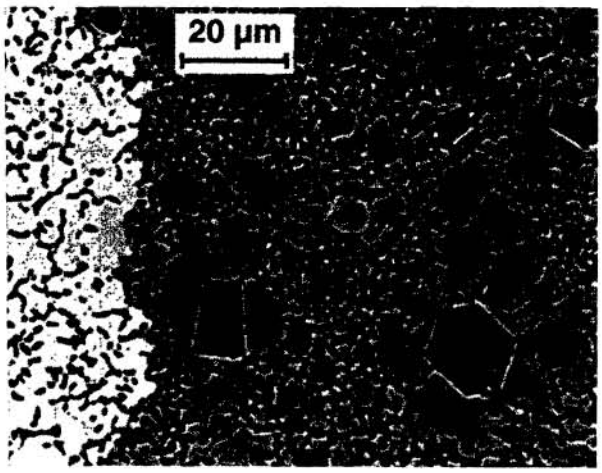


Figure 1. Vug-A. a. Photo of vug in unpolished slab. (Width of field 1 cm.) b. Tracing of granulated zone and backscattered electron images of the open cavity (black) with drusy spheroids consisting mainly of kamacite and troilite (mottled gray). The tip of the large spheroid (upper left) was broken off during polishing. Rounded features (white) in spheroids are clumps of tetrataenite. Note kamacite rims on spheroids, granulated metal, and both sides of the open crack in the spheroid at upper left. (Scale bar, 1 mm.)



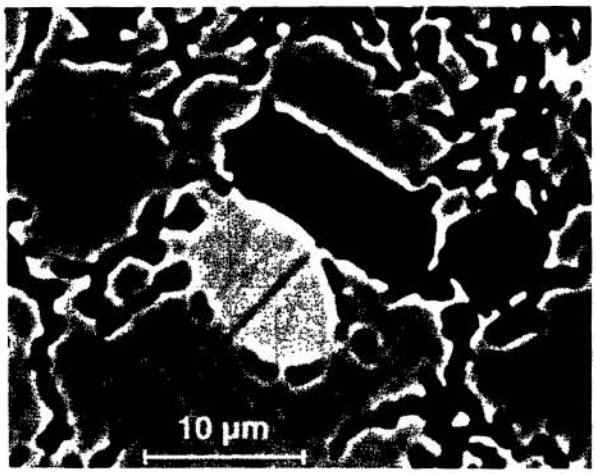


Figure 2, Left. A portion of the spheroid at lower right in Fig. 1b. The constituents are kamacite (gray), tetrataenite (white, in band at left and single grain near upper right corner), and troilite (black) in thin, irregular channels interlaced through both metals. The troilite appears to have invaded and corroded the kamacite and tetrataenite. Kamacite surrounding euhedral daubreelite crystals (black) appears to be coarser and to have undergone less invasion of troilite than elsewhere. The rounded light gray grain at center is a grain of phosphide $(Ni,Fe)_{3.7}$ P. (Backscattered electron image).

Figure 3, Right. High magnification of a phosphide crystal (light gray, oval) adjacent to two daubreelites (black) in kamacite (gray) invaded by troilite (black, wormy). The tiny troilite at the northwest end of the phosphide lies entirely outside that crystal. (Backscattered electron images.)