METAL-SULFIDE SHOCK FEATURES IN THE WILLAMETTE IIIAB IRON.
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Introduction: Willamette is the sixth largest known meteorite (15.5 t). It is a medium octahedrite and a member of group IIIAB. Willamette's structural features, including recrystallized, equiaxed kamacite and shock-melted troilite, indicate that the meteorite has been significantly shocked and recrystallized [1]. The presence of Neumann bands within the recrystallized kamacite indicates that a mild shock event followed a more severe one [1].

Unusual Metal-Sulfide Structures: We have observed a previously unreported metal-sulfide structure in Willamette in which metallic Fe-Ni-rich protrusions form embayments extending 1-10 mm into large troilite nodules (Fig. 1).

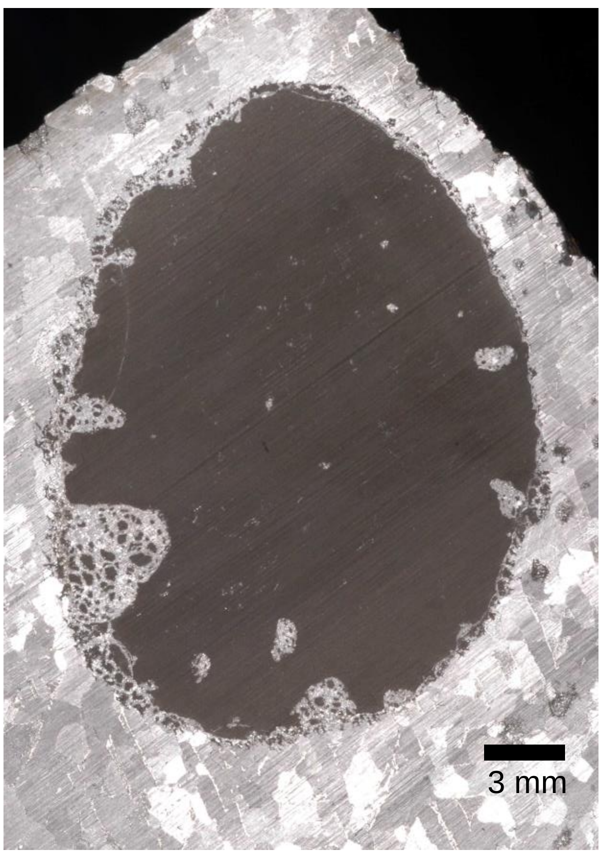

Fig. 1. A troilite nodule (dark gray) with several protrusions of metallic Fe-Ni (light and medium gray) forming embayments in the troilite. The dark grains in the embayments are troilite. The brightness of the surrounding recrystallized metal varies from grain to grain due to their different orientations. Reflected light.

The metallic-Fe-Ni-rich embayments contain 15-35 vol.% small angular to irregularly shaped troilite patches, typically 300 - 1000 µm in size (Fig. 2). These troilite patches have ragged edges and are themselves embayed by metallic Fe-Ni (Fig. 3). Some patches are mostly coherent; others appear to enclose small rounded grains of kamacite. Also present are 2-15-µm wide filaments of troilite that surround fragmented and recrystallized kamacite grains (Fig. 3). Some troilite filaments extend for ≥500 µm; many filaments emenate from the troilite patches (Fig. 3).

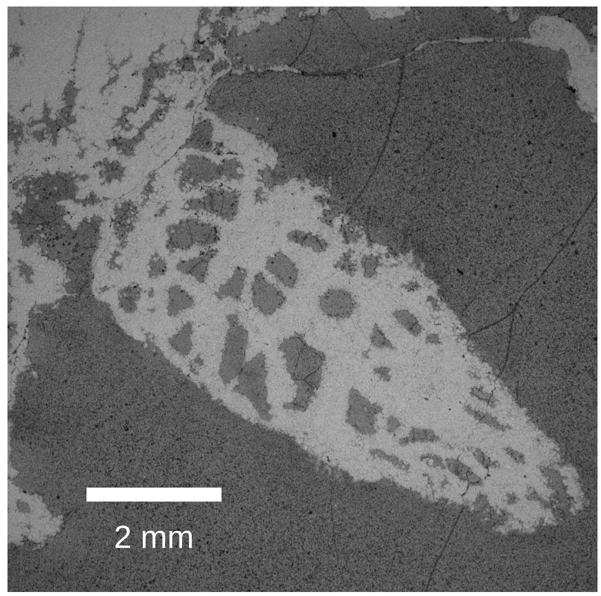

Fig. 2. An embayment of metallic Fe-Ni (light gray) into a troilite nodule (dark gray); about 30 vol.% of the embayment consists of small, irregularly shaped troilite grains. BSE image.

Formation: The metallic Fe-Ni-rich embayments formed during a severe shock-heating event. At metal-sulfide interfaces (where shock effects were particularly strong due to the impedance mismatch arising from the differing densities of these phases), a localized melt was produced that extended into the sulfide nodules. The interiors of the nodules remained unmelted. Along the sides of the embayment, portions of the troilite wall rock became detached from the nodule. Some of these fragments may have experienced minor melting, particularly at their margins (where small-scale embayments were formed; Fig. 3). Some of the metal in the embayments may have been crushed during this event. This is supported by the small size of the recrystallized kamacite grains within the embayments (20-80 µm; Fig. 3) relative to those distant from the troilite nodules (typically 1.5-3 mm; bottom of Fig. 1)

The shock event responsible for forming the embayments and the troilite filaments is likely to be the same one that caused widespread recrystallization of kamacite thoughout Willamette. It seems likely that the troilite filaments in the embayments formed during initial shock heating and that that the crushed kamacite recrystallized between the filaments during slow cooling [1]; this would have been at the same time that the equiaxed kamacite formed throughout Willamette.

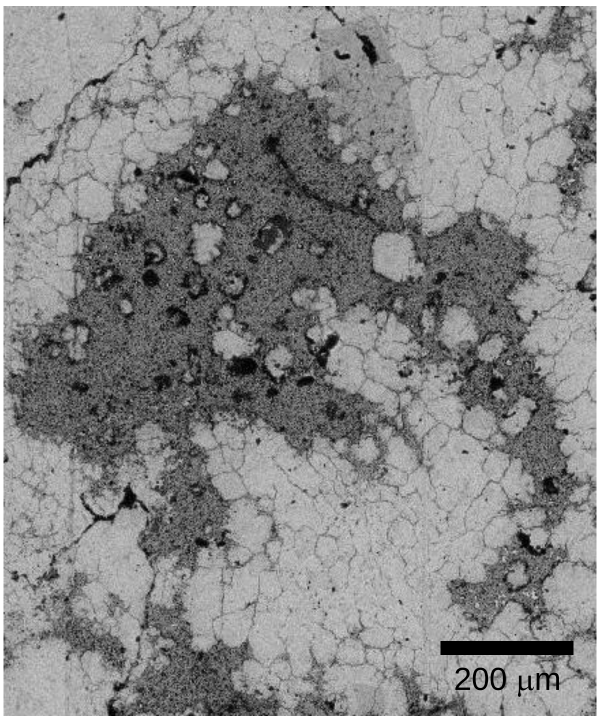

Fig. 3. A troilite patch (dark gray) surrounded by metallic Fe-Ni (light gray) within an embayment in a large troilite nodule. The troilite patch has ragged edges and is itself embayed. Filaments of troilite mark the boundaries of recrystallized kamacite grains. BSE image.

Reference: [1] Buchwald V. F. (1975) *Handbook of Iron Meteorites*, Univ. Calif. Press, 1418 pp.