VAPOR-PHASE CRYSTALLIZATION OF SULFIDES? U. S. Clanton, NASA Johnson Space Center, Houston, TX; J. L. Carter, Univ. of Texas at Dallas, Richardson, TX and D. S. McKay, NASA Johnson Space Center, Houston, TX

Sample 76015, a fragment collected from boulder 5 at station 6 along the base of the North Massif, is a green-gray breccia similar to other Apollo 16 and 17 KREEP-like poikilitic impact melt rocks (1, 2). Foliated vesicles and vugs comprise up to 20% of this rock by volume and have maximum dimensions of up to 5 cm (3); larger vesicles were noted in the unit from which this sample was collected (1).

Optical, scanning electron microscope (SEM) and energy dispersive x-ray analysis (EDAX) observations reveal that some of the vugs are lined with euhedral crystals of plagioclase, pyroxene and ilmenite. Micron sized euhedral nickel-iron crystals (Fig. 1) and millimeter sized euhedral troilite crystals (Fig. 2) are present on the dominantly silicate substrate. The euhedral troilite crystals, some almost 2 mm in maximum dimension, are characterized by hexagonal prism, bipyramid and basal pinacoid faces. The prism and bipyramid faces are heavily modified by "growth steps" (bunched growth lines).

Near the base of the troilite crystals, Cr-Fe rich crystals up to 50 microns in maximum dimension surround and protrude from the troilite (Fig. 3 and 4). Angular faces typically outline the larger Cr-Fe crystals but attempts to determine crystal morphology have been unsuccessful. Electron microprobe x-ray mapping of surface features combined with SEM and EDAX observations reveal smaller Cr-Fe rich crystals protruding from the contact of the pinacoid and bipyramid faces. In addition, small crystals of pentlandite occur on the troilite "growth steps". A Cu and P rich phase is observed also on the surface of the troilite crystals.

Studies of successive polished surfaces of the troilite crystals reveal a complex crystallization sequence; troilite, chalcopyrite, pentlandite and the Cr-Fe rich phase. All of these phases protrude from the surface and have not been observed in the interior of the troilite crystals. Electron microprobe analysis of these minerals is given in Table 1. These data suggest that these minerals are remarkably close to the stoichiometric composition and that the Cr-Fe rich phase may be chromite.

A large fragment broke from the center of one troilite crystal during preparation for electron microprobe studies. SEM and EDAX studies of the exposed silicate surface revealed a surface similar to the rest of the vug walls. Optical studies of the polished surfaces perpendicular to the vug wall confirm this observation and suggest further that the troilite crystallized after the silicate substrate minerals ceased crystallizing.

Studies of the surface morphology of 76015 reveal that the vug which sample 76015:84 came from had been exposed to micrometeorite bombardment for some period of time. This observation is supported by the brown glassy patina in the vug near the exterior surface of the fragment (2) and by the presence of impact craters up to 1 micron in diameter and Si-C rich splashes similar to those reported by Carter and McGregor (4).

From the above data the crystallization sequence in the vugs appears to be silicate, ilmenite, Ni-Fe, troilite, chalcopyrite, pentlandite, and a Cr-
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Fe, (chromite?). Abundant "growth steps" on the pyroxene and troilite crystal faces and the open network of crystals lining the vug walls appear to support the concept of vapor-phase crystallization (4, 5). A sulfur species appears to be a significant component of the vapor phase in the formation of the vugs in sample 76015.

References:

<table>
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<th>Troilite</th>
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<td>99.70</td>
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Table 1

Figure Captions:
Fig. 1: SEM micrograph of a Ni-Fe crystal on a substrate of plagioclase, pyroxene and ilmenite. The dominant form present on the crystal is the tetrahexahedron {hko} modified by smaller cube {100} faces.

Fig. 2: SEM micrograph of a troilite crystal; the forms present are: first and second order pyramids {h01, h-h-h0}, first order prism {1010} and basal pinacoid {0001}. The pyramid faces are characterized by numerous "growth steps" (bunched growth lines).

Fig. 3: SEM micrograph; enlargement of the lower left edge of the troilite crystal shown in Fig. 2. The Cr-Fe (chromite?) crystal partially spalls from the troilite to reveal "growth steps" at the contact interface.

Fig. 4: SEM micrograph of the base of a troilite crystal shows an elongate Cr-Fe (chromite?) crystal growing on the stepped surface of the troilite. The irregular shaped mounds in the lower right of the photograph are a mixture of pentlandite and chalcopyrite.

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U. S. Clanton

University of Texas at Dallas,
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