MERIDIANI PLANUM VUGS AS A CONSEQUENCE OF ICE CRYSTAL FORMATION FOLLOWED BY THAW AND DESICCATION. T. J. Wdowiak. Department of Physics, University of Alabama at Birmingham, Birmingham AL 35294-1170 (wdowiak@uab.edu)

Introduction: Early in the mission of the rover Opportunity after landing in Eagle crater, centimeter size vugs were observed over about 5% of the outcrop, most notably at rock named El Capitan and was interpreted as crystal-mold porosity formed by dissolution of a relatively soluble sulfate mineral phase [1]. The vugs exhibit prismatic to discoidal geometry with a maximum width of 1 to 2 mm near the midpoints and taper toward the ends [2]. It is of interest to note that to date there is no other suggestion of crystallinity on the scale of the vugs to be observed at Meridiani Planum and this includes for the interiors of the abundantly present hematite spherules.

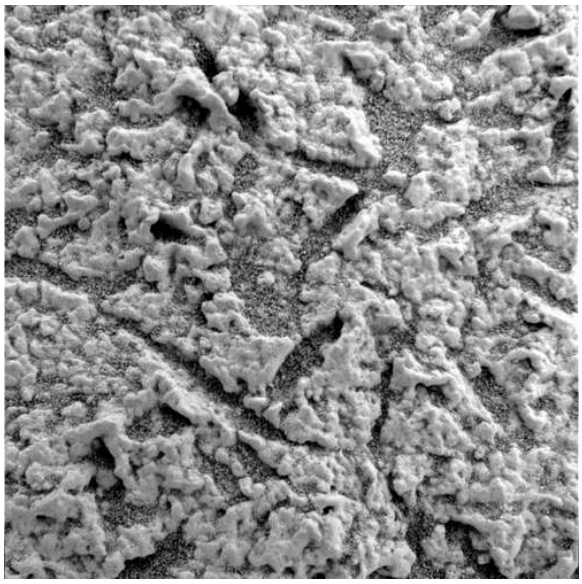

Fig. 1 Representative vugs from MER B MI Sol 28 illustrating their geometry and distribution that is characteristic (MER Archives).

The assemblages of vugs can be described as having a "chicken track" appearance to the eye. This morphology is very similar to features photographed at Racetrack Playa at Death Valley and attributed to ice crystal formed in wet playa mud that subsequently developed new mud cracks over old cracks [3] where it apparently is a occurrence when there is coincidence of initial wetness with suitable diurnal temperature variation [4}.

Fig. 2 Ice crystal induced patterns within polygonal cracking at Racetrack Playa, Death Valley CA [2].

Experiments: A simple series of experiments was done to examine the potential of ice crystal formation playing a role in the formation of the vugs found at Meridiani Planum. Natural jarosite $KFe_3(SO_4)_2(OH)_6$ powder (obtained from Iconofile sold as a pigment) was prepared as a slurry with distilled water and poured to a depth of ~0.5 cm into a small ceramic bowl which was the placed into the freezer (~-20C) of a refrigerator. Care was take to insure the pigment to water proportion resulted in a mud without surface liquid.

The sequence of photos shows: (A) the mixture immediate from the freezer with needle frozen -like ice crystals on the surface, (B) after thaw to room temperature, and (C) after overnight desiccation. The outer diameter of the vessel is 6.5 cm for scale.

Interpretation: The experiments show that a process of freeze followed by thaw followed by desiccation for a slurry/mud does not yield a simple crystal mold of the originating ice crystal but rather is best described as the ice crystal first deforming the surface of the slurry/mud through an indentation that subsequently develops into a more pronounced structure upon thaw and desiccation. The "latent image" of the ice crystal becomes exaggerated through a surface tension-like effect as shrinkage derived force vectors pull inward normal to the

surface geometry profile. This yields a deepened fracture that is wider at midpoint and tapers toward the ends similar to the geometry of the Meridiani Planum vugs.

Fig. 3(A) Jarosite-water frozen mixture immediate from the freezer with needle-like ice crystals on the surface (vessel is 6.5 cm in diameter).

Fig. 3(B) Jarosite-water mixture after thaw to room temperature. Note the more pronounced surface pattern relative to that exhibited in Fig. 3(A) as contraction of the volume occurs (vessel is 6.5 cm in diameter)..

Fig. 3(C) Jarosite -water mixture after overnight desiccation at room temperature and humidity conditions. The product exhibits vugs similar in size and geometry to that observed at Eagle crater, Meridiani Planum (vessel is 6.5 cm in diameter).

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Conclusions: While the sulfate or other mineral crystal dissolution hypothesis for formation of the Meridiani Planum vugs has merits particularly in general geochemistry as we now know it for the region, it does not have the advantage of simplicity that the ice crystal induced mechanism posses. Also there is no evidence to date of other kinds of crystallinity at the site which could be expected if conditions were proper for the hypothesized vug yielding minerals to be crystallized'. Liquid water on Mars would undoubtedly freeze seasonally and diurnally. and there is ample geochemical and geomorphic evidence for it having been present. Further more the vugs being derived from the ice crystal process described here still remain as a signature of water

References: [1] Squyres et al. (2004) *Science 306*, 1709-1714. [2] Herkenhoff et al. (2004) *Science 306*, 1727-1730. [3] Sharp and Glazner (1997) *Geology Underfoot in Death Valley and Owens Valley*, pp.163, Mountain Press. [4} Personal communication from Mel Essington, DVNP.