VEINS IN MATIJEVIC HILL LITHOLOGIC UNITS OBSERVED BY OPPORTUNITY. W. H. Farrand[1] , S. W. Ruff[2], M. S. Rice[3], J. W. Rice, Jr.[4], R. E. Arvidson[5], B. L. Jolliff[5], S. W. Squyres[6], A. H. Knoll[7], J. F.Bell III[2] , J. R. Johnson[8], [1]Space Science Institute, 4750 Walnut St., #205, Boulder, CO 80301, farrand@spacescience.org, [2]Arizona State University, Tempe, AZ, [3]California Institute of Technology, Pasadena, CA, [4]Goddard Space Center, Greenbelt, MD, [5]Washington University, St. Louis, MO, [6]Cornell University, Ithaca, NY, [7]Harvard University, Cambridge, MA, [8]Applied Physics Laboratory, Laurel, MD.

Introduction: In its exploration of the section of the rim of Endeavour crater known as Cape York, Opportunity has observed numerous veins on a bench unit that surrounds the central ridge (Shoemaker Ridge) and has examined one of these veins in situ, determining that it is composed largely, or in whole, of gypsum [1]. At the time of writing, Opportunity is in the midst of exploring the upper eastern flank of Shoemaker Ridge in a region named Matijevic Hill (in honor of the late JPL engineer, Jake Matijevic) (**Fig. 1**). A number of distinct lithologic units have been observed on Matijevic Hill [2], a common feature of which are veins, albeit smaller in scale and in some cases, with more complex patterns of exposure than those observed on the bench unit of Cape York. Here we describe a number of the distinct textural and visible to near infrared (VNIR) spectral characteristics of these veins. Given the distinct occurrences of these veins, it is not clear whether they are the same composition as those in the bench unit or even if there might not be more than one composition. Elemental analysis via Opportunity's alpha particle X-ray spectrometer (APXS) is forthcoming and is expected to provide compositional information to complement Pancam multispectral observations that suggest the veins consist of a hydrated material.

Occurrence and Texture: The Matijevic Hill veins have been observed to occur in the spherule-rich [2] Kirkwood (**Fig. 2**), the adjacent fine-grained Whitewater Lake (**Fig. 3**), and in the coarsely clastic Onaping units (**Fig. 4**). In all of these occurrences the veins are on the order of millimeters up to approximately a centimeter in width and they generally occur in a stockwork, in some instances within a sub-rectangular fracture pattern. In Whitewater Lake, they exhibit positive relief relative to the very soft rock in which they occur. At the Copper Cliff location, veins are observed in the Microscopic Imager (MI) view of the Onaping target (**Fig. 4**). The Onaping target provides a good example of the veins cutting across both the matrix of the outcrop and clasts within it.

Multispectral VNIR Character: The veins observed running through the outcrop on Matijevic Hill display a multispectral VNIR character similar to some bright drift material, but with a steeper downturn in the R6 to R7 (934 to 1009 nm) Pancam bands (**Fig. 5**). This down-turn can be, but is not always, associated with certain minerals and materials that have an H_2O overtone absorption centered near 995 nm. The ability to detect this absorption in Pancam data has been previously demonstrated with high-Si deposits near the Home Plate feature examined by Spirit [3] and has also been observed in the gypsum veins on the bench unit of Cape York [1].

Possible interpretations: The larger veins investigated by Opportunity on the bench unit with their dominant or exclusive gypsum composition have been interpreted as the result of precipitation from low-temperature aqueous fluids flowing upward from the ancient materials of the rim [1]. The rocks on Matijevic Hill that host the smaller veins may be ancient crater rim materials, and the veins might share a common origin with those in the bench unit. Alternatively, the Matijevic Hill rock units could potentially be pre-impact substrate exposed by the crater-forming event. The veins could then represent fractures formed by the impact event which were then filled during a contemporaneous or later episode of fluid flow. The timing of vein emplacement is not known. The to-be-determined chemical composition of the veins will potentially allow us to distinguish among alternative hypotheses for the origin of the Matiejevic Hill veins.

Conclusions: While the composition of the veins is yet to be determined, their presence in the Matijevic Hill area provides evidence of fluid flow within its constituent rock units. Also, the stockwork pattern of many of the veins, which contrasts with generally more linear trends among the gypsum veins observed in the Cape York bench unit, provides evidence of greater and, likely, a different mechanism of, fracture development in the Matijevic Hill units. Finally, while it is not conclusive evidence, the 934 to 1009 nm drop in reflectance is consistent with the presence of some hydrated material [3].

References: [1] Squyres S.W. et al. (2012) *Science*, *336*, 570–576. [2] Squyres S.W. et al. (2013) this meeting. [3] Rice, M.S. et al. (2010) *Icarus,* 375–395.

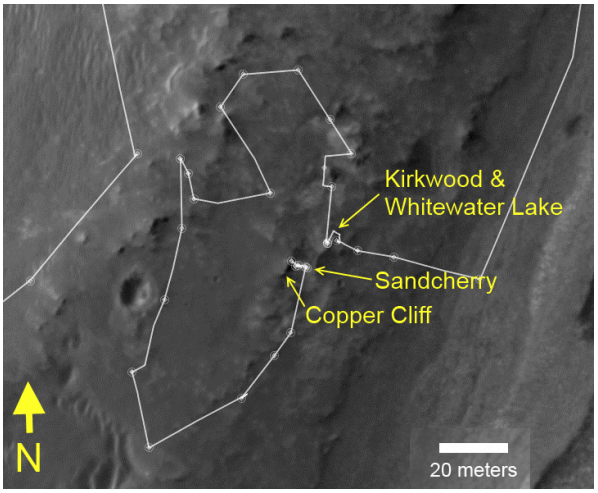

Fig. 1. HiRISE overview of Opportunity's traverse in the Matijevic Hill area. Targets noted in the text are shown.

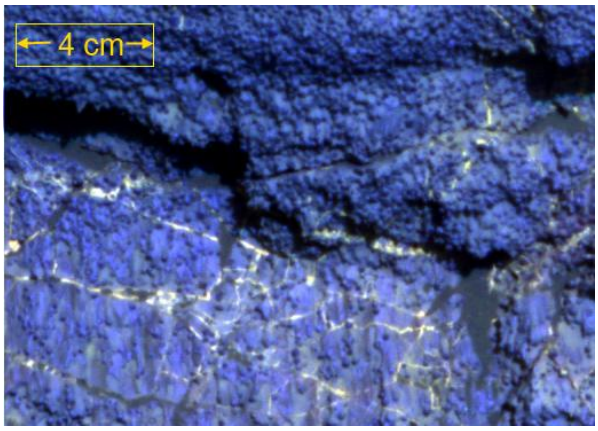

Fig. 2. Sol 3067 P2277 R721 observation of veins displaying a stockwork pattern in the Kirkwood unit.

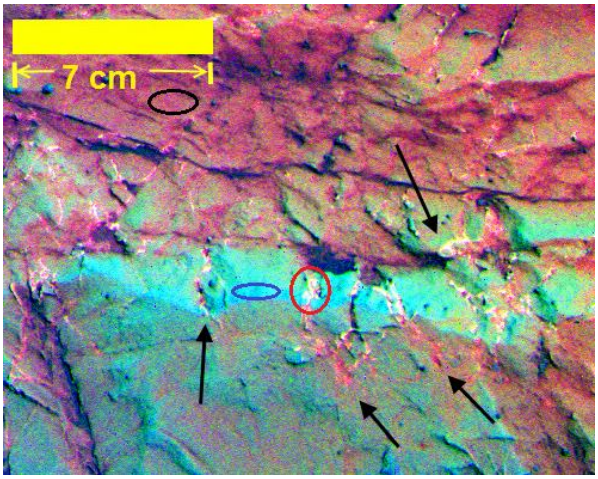

Fig. 3. Veins in Whitewater Lake in a decorrelation stretch of bands L357 in the sol 3082 P2567 scene. Arrows indicate veins; red, black, and blue ellipses correspond to spectra extracted and shown in **Fig. 5**.

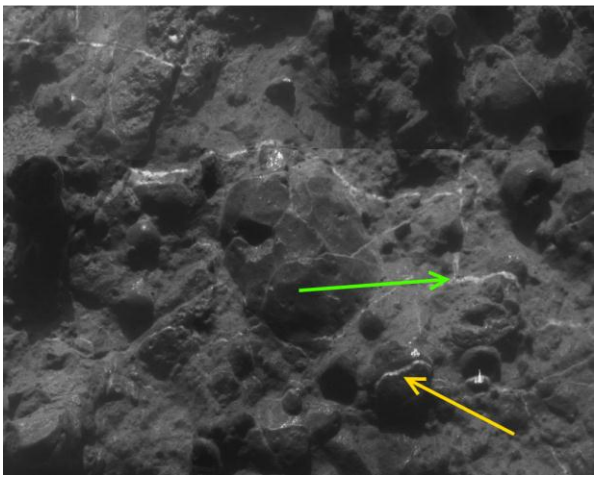

Fig. 4. Sol 3158 portion of MI mosaic of the Onaping target with veins. Green arrow indicates vein through matrix and yellow arrow points to vein through clast. Subsection is approximately 4.5 cm across.

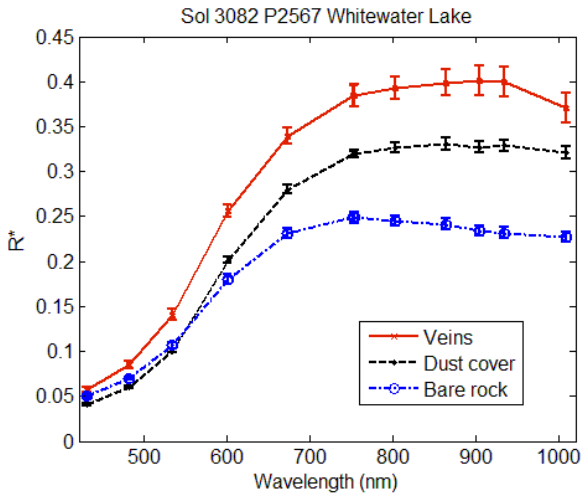

Fig. 5. Pancam spectra of veins (red), dust covered surface (black), and "bare" (bluer colored) rock (blue) on Whitewater Lake from the sol 3082 P2567 observation. Spectra extracted from regions indicated in **Fig. 3**.