**MULTISPECTRAL VNIR EVIDENCE OF ALTERATION PROCESSES ON SOLANDER POINT, ENDEAVOUR CRATER, MARS .** W. H. Farrand[1], J. F. Bell III[2], J.R. Johnson[3], D.W. Mittlefehldt[4], [1]Space Science Institute, 4750 Walnut St., #205, Boulder, CO 80301, farrand@spacescience.org, [2]Arizona State University, Tempe, AZ. [3]Applied Physics Lab, Johns Hopkins University, Laurel, MD, [4]NASA Johnson Space Center, Houston, TX.

**Introduction:** The exploration of the segment of the rim of Endeavour crater known as Cape York by the Mars Exploration Rover Opportunity revealed evidence of aqueous alteration in the form of calcium sulfate veins, outcrops bearing Fe smectites, and fracture filling boxwork veins with Al smectites and hydrated silica [1-3]. Recent exploration of the next major rim segment to the south, Solander Point, has revealed additional signs of alteration and aqueous activity. To date, the primary indications of aqueous alteration observed on Solander Point are the light-toned materials and a spectrally red coating associated with the overturned rocks Pinnacle Island and Stuart Island (**Fig. 1**) and clast-bearing outcrop otherwise similar to Shoemaker Fm. outcrops observed at Cape York [1,2], but chemically distinct as measured by the APXS [4] and spectrally distinct in visible and near-infrared (VNIR) spectra measured by Pancam.

**Spectrally Distinct Materials:** Opportunity observed clast-bearing outcrop (**Fig. 2**), that was grouped with the Shoemaker Fm. impact breccias on Cape York and along the Murray Ridge portion of Solander Point. At Murray Ridge, a change in the spectral and chemical character of that outcrop was observed. **Fig. 3** shows Pancam spectra of Shoemaker Fm. and Murray Ridge outcrops. Starting with the Trinity Island outcrop, imaged on sol 3522 and with a number of successive observations of Murray Ridge outcrops, spectra more closely resembled the brushed Green Island observation of sol 3571 in **Fig. 3** than the earlier Shoemaker Fm. spectra shown in that figure. As shown in **Fig. 4**, these spectral differences include a deeper 535 nm band depth and a steeper 934 to 1009 nm slope in the Murray Ridge outcrops than in the earlier Shoemaker Fm. observations. Farrand et al. [5,6] observed a direct correlation between increases in 535 nm band depth and increases in $Fe^{3+}/Fe_{Total}$ as measured by the Spirit rover's Mössbauer spectrometer. Thus, these factors are indicative of increased oxidation of the Murray Ridge outcrops.

Even more distinctive materials were observed with the fortuitous overturning of the rocks Pinnacle Island and Stuart Island. Imaging of these rocks, including after Stuart Island was broken by driving over it, indicated three primary spectral classes associated with them: the broken surface, a light-toned coating, and a spectrally red coating. Spectra of these units are shown in **Fig. 5**.

The spectrum of the broken surface is a match for the RAT-brushed Green Island spectrum of **Fig. 3** indicating that the body of Stuart Island is composed of the same type of outcrop material observed elsewhere on Murray Ridge.

The spectrum of the spectrally red material is very uncommon, although similar spectra were observed on a few small rocks at the soil-air interface near the north end of Cape York. The steep red slope and lack of spectral absorption features is consistent with several types of materials including some metals and, intriguingly, with manganese oxide-rich terrestrial desert varnishes. Assigning the major spectral contributor to a Mn oxide is consistent with APXS results that showed an enrichment of Mn associated with the red coating.

Finally, the light-toned material around the fringe of Pinnacle Island and on the sides of Stuart Island shows a downturn in reflectance from the 934 to 1009 nm bands, and, in some portions a shallow absorption with a minimum in the 864 to 904 nm region. The drop in reflectance from 934 to 1009 nm is potentially associated with a hydrated phase [7] and the cause of the 864 to 904 nm band is currently unknown

**Discussion:** Orbital observations of Solander Point and Murray Ridge by CRISM indicate occurrences of a 2.2 μm band attributed to an Al-OH absorption [8]. Lacking mineralogy-sensitive instruments, Opportunity now relies on chemistry from APXS and VNIR multispectral observations from Pancam to assess mineralogical changes associated with alteration. Evidence of more oxidized materials in some Murray Ridge outcrops and of a possible Mn oxide coating and a hydrated phase associated with Stuart and Pinnacle Island are evidence of aqueous alteration at Solander Point.

**References:** [1] Squyres, S.W. (2012) *Science*, 336, 570-576. [2] Arvidson, R.E. et al. (2014) *Science*, **343**, 10.1126/science.1248097. [3] Farrand, W.H. et al. (2013) *Icarus*, **225**, 709-725. [4] Mittlefehldt, D.W. et al. (2014) *LPSC 45*, Abstract #1640. [5] Farrand, W.H. et al. (2006) *JGR*, **111**, 10.1029/2005JE002495. [6] Farrand, W.H. et al. (2006) *JGR*, **113**, 10.1029/2008JE003237. [7] Rice, M.S. et al. (2010) *Icarus*, **205**, 375-395. [8] Arvidson, R.E. et al. (2014) LPSC 45, Abstract #1400

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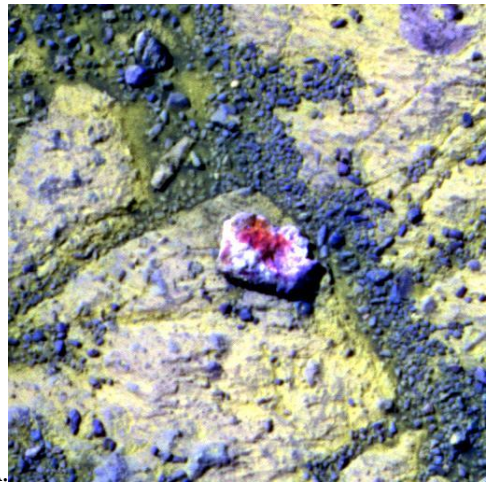
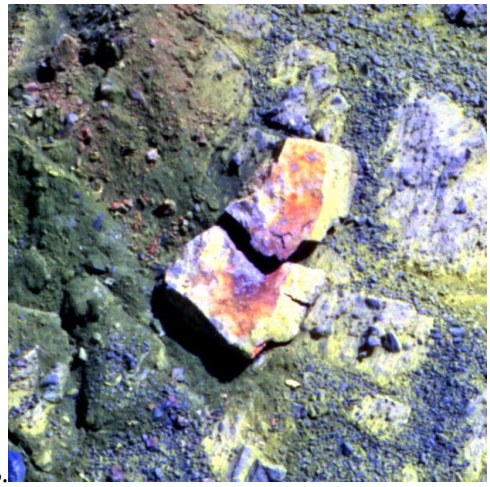


**A.**



**B.**

**Fig. 1. A**. Sol 3555 P2531 R731 view of Pinnacle Island. **B**. Sol 3589 P2545 R731 view of broken Stuart Island.

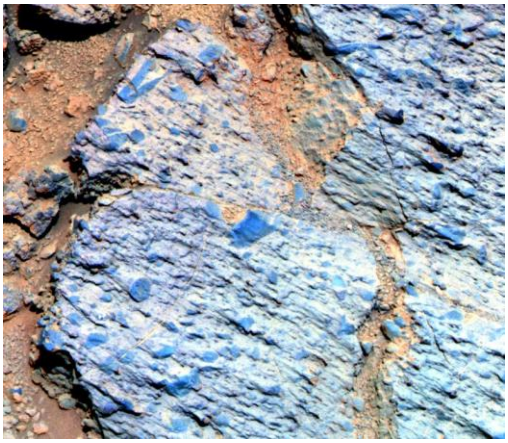


**Fig. 2**. Sol 3494 P2368 L357 view of Moreton Island outcrop.

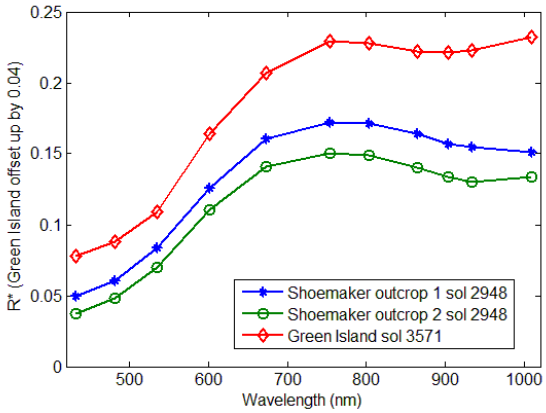



**Fig. 3**. Blue and green spectra are of pre-Murray Ridge Shoemaker Fm. outcrop. Red spectrum is representative of altered Murray Ridge outcrop.

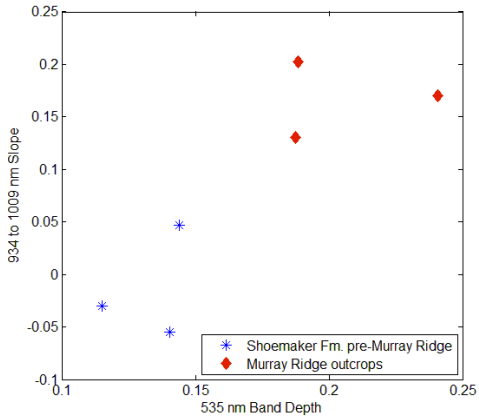



**Fig. 4**. Plot of 934 to 1009 nm slope vs. 535 nm band depth for Murray Ridge outcrop vs. previous outcrop.

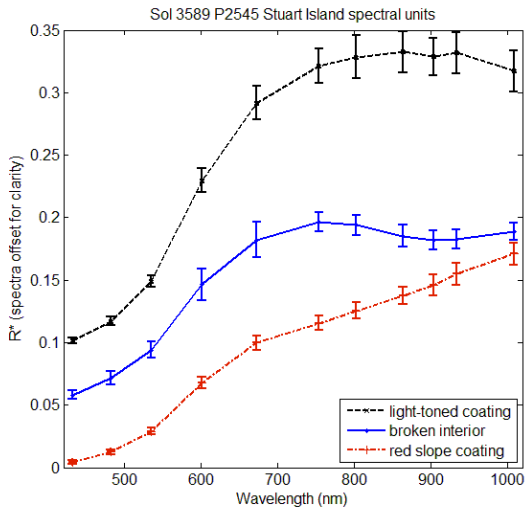



**Fig. 5**. Spectra of Stuart Island spectral units.