

Pancam Visible/Near-Infrared Spectra of Fe-Ni Meteorite Oileán Ruaidh at Meridiani Planum, Mars. J.R. Johnson¹, K.E. Herkenhoff², J.F. Bell III³, W.H. Farrand⁴, R. Gellert⁵, J. Ashley³, C. Schröder⁶, S.W. Squyres⁷, ¹Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, Jeffrey.R.Johnson@jhuapl.edu, ²USGS, Flagstaff, AZ, ³Arizona State University, Tempe, AZ, ⁴Space Science Institute, Boulder, CO, ⁵Univ. of Guelph, Ontario, Canada, ⁶University of Bayreuth and University of Tübingen, ⁷Cornell University, Ithaca, NY.

Introduction: The Panoramic Camera (Pancam) on the Mars Exploration Rover (MER) Opportunity [1] imaged the cobble-sized Fe-Ni meteorite Oileán Ruaidh in the visible/near-infrared (432-1009 nm) on Sols 2367-2371 (Sept. 20-24, 2011) at Meridiani Planum. This is the fifth such meteorite imaged in detail by Opportunity, joining “Heat Shield Rock” [2] (Sol 352; Jan. 19, 2005), “Block Island”, “Shelter Island”, and “Mackinac Island” (observed between Sols 1961 and 2038; July 30, 2009 to Oct. 17, 2009) [3]. The surface of Oileán Ruaidh is similar to those other meteorites, exhibiting variable degrees of dust contamination along with discontinuous coatings that exhibit Pancam reflectance spectra consistent with ferric oxides, suggestive of chemical weathering on portions of the meteorite surfaces.

Observations. Oileán Ruaidh was observed by Opportunity from four locations around the rock between Sols 2367 and 2369. Each of these image sequences used a partial set of Pancam filters. However, all 13 filters (432-1009 nm) were acquired on Sol 2369 (Figure 1) and Sol 2371 (Figure 3) from the rover location where the Alpha Particle X-ray Spectrometer (APXS) measured a target on the rock named “Mulroy.” Microscopic Imager (MI) images were acquired of both Mulroy and an apparent metal-rich region below Mulroy (Figure 4). Preliminary analysis of the APXS measurements confirmed the high Ni content of the meteorite.

Results. Pancam images and spectra of Oileán Ruaidh suggest that coatings of ferric-rich nanophase dust with variable thickness occur on the meteorite. However, intermittent patches of relatively dust-free, smooth materials are also observed with “purple” hues in Pancam false-color representations and decorrelation stretches using 432 nm, 535 nm, 753 nm filters (Figure 1). In MI images these materials exhibit lobate margins and appear to coat the underlying meteorite surface (Figure 4). On all meteorites observed by Opportunity, these surfaces consistently exhibit greater 535 nm band depths (Table 1) and more negative near-infrared slopes (753 nm to 934 nm) than the typical meteorite surface over the ~40-90° phase angle range observed [3].

Figure 2 shows Pancam spectra of representative surfaces on Oileán Ruaidh compared to those from the Opportunity meteorites studied by [2,3,6]. Also shown is a laboratory spectrum of the Fe-Ni meteorite Canyon Diablo, which exhibits a featureless, positive slope. The “purple” patches on

Oileán Ruaidh are brighter at all wavelengths than its typical meteorite surface. This is unlike all other Fe-Ni meteorites imaged by Pancam except portions of Heat Shield Rock [2,3]. However, Oileán Ruaidh exhibits average 535 nm band depths similar to those observed for Shelter and Mackinac Island meteorites (Table 1).

Table 1. Average 535 nm band depths

Meteorite	“Purple” patch	Typical surface
Heat Shield Rock	0.03	-0.18
Block Island	0.19	0.12
Shelter Island	0.11	-0.01
Mackinac Island	0.09	0.00
Oileán Ruaidh	0.10	-0.01

Analysis and Conclusions. The “purple” coatings on Fe-Ni meteorites exhibit Pancam spectra consistent with a more oxidized surface than typical meteorite surfaces. As was inferred by [3], this is likely a mixture of ferric materials, dominated by nanophase (np-) hematite (particles diameters <10 nm), as evidenced by strong 535 nm absorptions combined with lack of the 860 nm band (usually observed in crystalline hematite [4]). Mössbauer data of the other Fe-Ni meteorites suggest minor phases of ferric oxide such as np-hematite in addition to kamacite [5]. The “purple” coatings on Oileán Ruaidh are sufficiently spectrally similar to the Fe-Ni meteorites studied with the IDD to infer that they also represent an altered or secondary weathering coating. As suggested by [2,3,6] these materials are possibly partially eroded by aeolian abrasion, rather than representative of an unaltered, remnant fusion crust on the meteorite. Similar to the other meteorites, sand and spherules fill small pockets on the surface of Oileán Ruaidh, suggesting episodes of burial and exhumation of the rock among the ripples and dunes of Meridiani Planum. Such burial might provide the necessary conditions to cause the observed surface alterations [e.g., 7].

References: [1] Bell, J.F. III et al., *Science*, 1703-1709, 306, 2004; Squyres, S.W. et al., *Science*, 1698-1703, 306, 2004; [2] Schröder, C., et al., *JGR* 113, E06S22, doi:10.1029/2007JE002990, 2008; Squyres, S., et al., *JGR* 111, E12S12, doi:10.1029/2006JE002771, 2006; [3] Arvidson, R. E., et al. (2010), *JGR*, doi:10.1029/2010JE003746; Johnson, J.R. et al., *Lunar Plan. Sci. Conf. 41*, abstract #1974, 2010; [4] Morris, R.V. and Lauer, H.V., Jr, *JGR*, vol 95, No. B4, 5101-5109, 1990; [5] Fleischer, I., et al., In Situ Investigation of Iron Meteorites at Meridiani Planum, Mars, *LPSC 41*, #1791, 2010; [6] Ashley, J.W. et al., (2010), *JGR*, doi:10.1029/2010JE003672; [7] Yen et al., *LPSC 36*, #1571, 2005.

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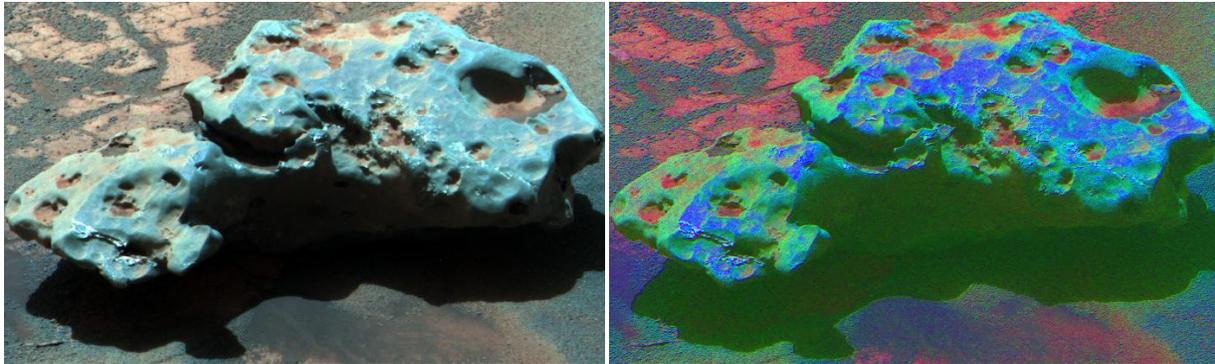


Figure 1. Pancam false-color (753 nm (L2), 535 nm (L5), and 432 nm filters (L7) (left) and L257 decorrelation stretch (right) of Oileán Ruaidh meteorite (P2537, Sol 2369, image ~45 cm across), viewed from southwest side.

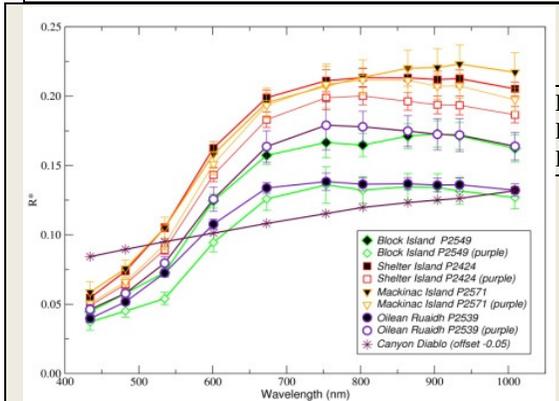


Figure 2. Spectra of typical meteorite and “purple” patches for Oileán Ruaidh, Block Island, Shelter Island, and Mackinac Island. (Canyon Diablo spectrum is RELAB MI-CMP-008, spectrum 001, offset by -0.05).

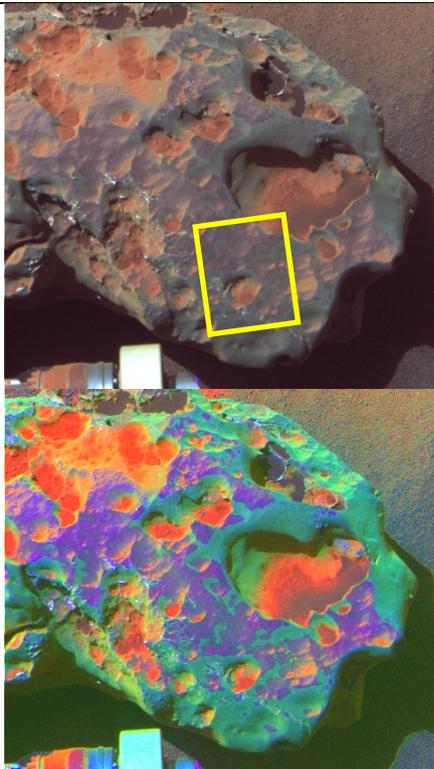


Figure 3. Pancam L257 false-color (top) decorrelation stretch (bottom) of Oileán Ruaidh meteorite (P2539, Sol 2371, image ~30 cm across).

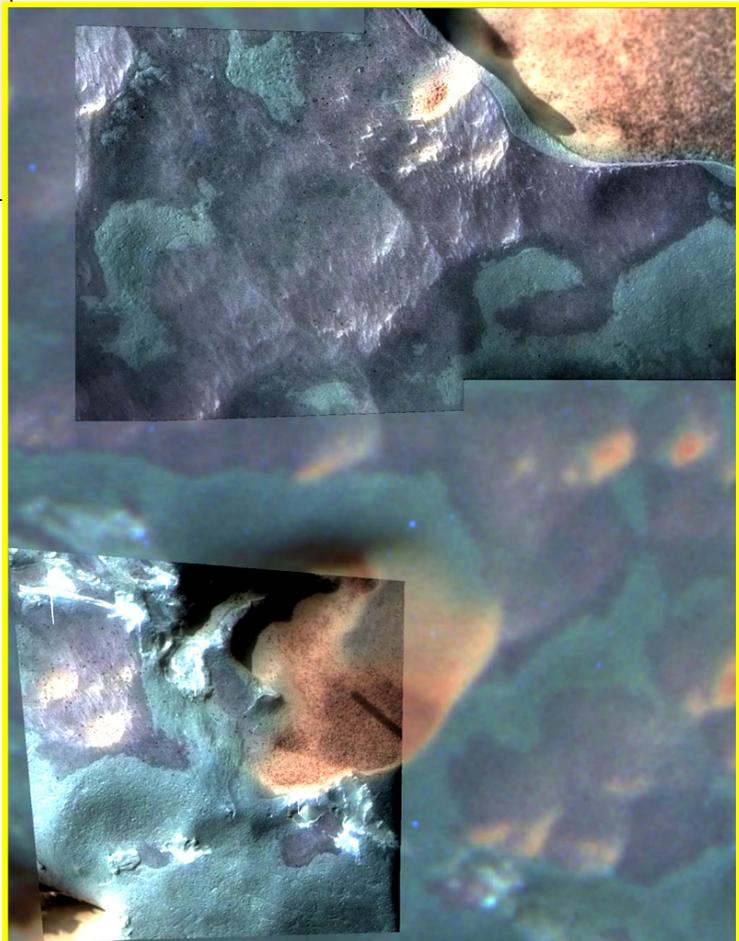


Figure 4. Three Microscopic Imager frames colorized using Pancam 753nm, 535nm, and 432nm filters of Oileán Ruaidh (background image from Sol 2371, sequence P2539) including Mulroy IDD target (image is ~7.5 cm across). Location shown as yellow box in the top of Figure 3.