RECENT SCIENTIFIC RESULTS FROM OPPORTUNITY'S TRAVERSE TOWARD ENDEAVOUR CRATER, MERIDIANI PLANUM, MARS. S.W. Squyres[1] and the Athena Science Team, [1]Cornell Universtiy, Ithaca, NY 14853.

The Mars Exploration Rover Opportunity spent nearly two years of its mission exploring Victoria crater. Victoria is an impact crater about 800 meters in diameter that lies roughly 5 km south of Opportunity's landing site. At Victoria, Opportunity traversed about 30% of the way around the crater, documenting eolian cross-stratification exposed in the crater walls, and then descended into the crater. Measurements inside the crater revealed chemical stratigraphy similar to that seen at Endurance crater, near Opportunity's landing site, demonstrating that the aqueous processes that produced these chemical trends operated on regional scales [Squyres et al., 2009].

Opportunity exited Victoria crater on sol 1634 of its mission, and began a long southward traverse toward Endeavour crater. Endeavour is an ancient crater, approximately 20 km in diameter, that predates and is partially buried by the Meridiani sediments. Recently, MRO CRISM data have demonstrated that phyllosilicate minerals are present in materials forming the rim of Endeavour crater [Wray et al., 2009], making it a target of high scientific interest.

Opportunity's route toward Endeavour has been circuitous, with substantial detours mandated by fields of large eolian ripples that would pose substantial hazards to the rover if traversed. As of this writing, Opportunity has driven ~7.1 km since leaving Victoria (Fig. 1).

A major objective of Opportunity's traverse has been investigation of the loose rocks that litter the plains at infrequent intervals. These rocks have been loosely grouped under the name "cobbles", although they actually span a much broader range in size than the formal geologic definition of a cobble. The cobbles examined prior to leaving Victoria revealed remarkable diversity. Some, like Russet, are clearly locally-derived impact ejecta similar to the outcrop rocks. Some, like Bounce Rock, have exotic compositions that suggest they are ejecta from distant impacts. Others, like Heat Shield Rock, Barberton, and Santa Catarina, clearly are meteoritic. Still others (examples include Arkansas and Perseverance) may be impact melt breccia, mixtures of meteoritic and martian material, or samples of deep units that lie beneath the ubiquitous sulfate sandstones.

Because of their diversity, and because some may come from significant distances or depths, these "cobbles" represent an important opportunity to study geologic diversity at Meridiani. In particular, they provide the chance to search for materials that may be related to but distinct from the sulfate-rich sandstones that form all the bedrock observed by Opportunity.

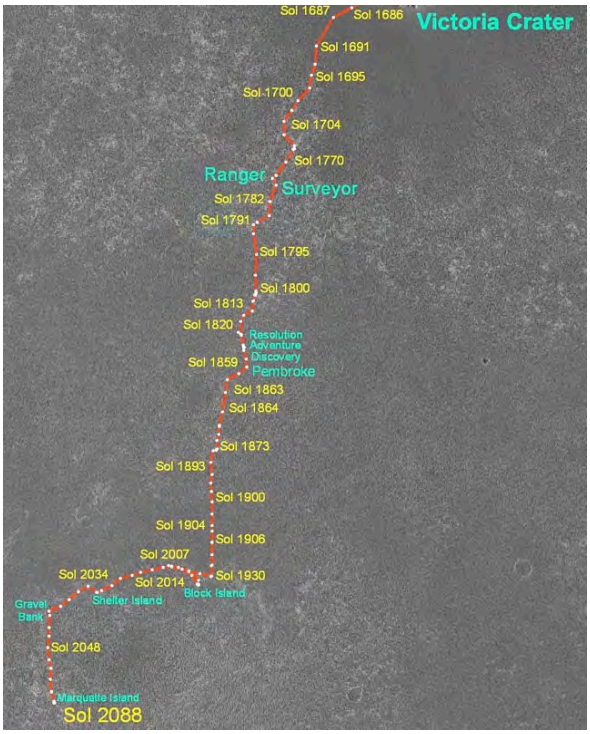

Figure 1: Opportunity's traverse southward from Victoria crater. Total distance traversed is ~7.1 km.

One of Opportunity's most significant findings along this traverse has been discovery of three "cobbles" found to be iron meteorites, named Block Island, Shelter Island and Mackinac Island. Block Island and Shelter Island were investigated in detail with the instruments on the rover's Instrument Deployment Device; Mackinac Island was only imaged.

The elemental chemistry of Block Island and Shelter Island indicates that both are type IAB iron meteorites, as was Heat Shield Rock, nearly 10 km to the north. The close proximity of Block Island, Shelter Island, and Mackinac Island to one another, as well as the compositional similarity of the first two, suggest that all three may be part of a strewn field resulting from a single impact. The relationship to Heat Shield Rock is less clear, given the substantial distance to that meteorite.

Block Island is the largest of the three, and is about 60 cm across. The long dimensions of Shelter Island and Mackinac Island are ~50 cm and ~30 cm, respectively. Microscopic Imager images of Block Island reveal clear Widmanstätten patterns.

A noteworthy aspect of all three of these meteorites is that they are extensively weathered, with large portions of the meteorite hollowed out. (Fig. 2).

Figure 2: Mackinac Island, showing extensive weathering of the left-hand portion of the meteorite.

Imaging and observations with in-situ instruments showed no evidence for compositional heterogeneity within any of these meteorites. In particular, no evidence for remnants of weathered inclusions was found in proximity to the hollowed-out portions of the meteorites. We are investigating the relative roles of physical and chemical weathering in the post-impact evolution of these meteorites, and the possible implications for paleoenvironmental conditions at Meridiani.

The most unusual rock found by Opportunity on its post-Victoria traverse is Marquette Island (Fig. 3), which is being investigated by the rover at the time of preparation of this abstract. Marquette Island is comparable in size to the aforementioned meteorites, but is made of a substantially different material. APXS data show that the rock is mafic in character, but the composition does not match any known martian meteorite or any rock observed to date by Opportunity. The nickel concentration is low, arguing against a meteoritic origin. Of all the rocks observed by both rovers, the closest match is to the Adirondack Class basalts examined by Spirit at Gusev crater early in the mission.

Mössbauer spectrometer data for Marquette Island reveal a substantial amount of olivine in the rock, as well as some pyroxene. Normative calculations using APXS data suggest that substantial plagioclase is present as well, although this has not been confirmed with the Mini-TES due to the obscuration of the Mini-TES scan mirror suffered during a prior global dust storm. Pancam and Microscopic Imager images of Mackinac Island show mm-size grains, and no layering or sedimentary textures. We tentatively interpret Mackinac Island as an ejecta block from some distant crater, and we are investigating the implications of it being a sample of previously unexamined martian crustal material.

Figure 3: Marquette Island.

Opportunity has also investigated local bedrock, eolian bedforms, and small impact craters along its southward route. APXS measurements on the RAT-abraded bedrock outcrop Penrhyn on sol 1843, about 2 km south of Victoria, showed fairly typical sulfate-rich Meridiani bedrock, with more than 18 wt% SO_3. Investigation of a cluster of small fresh craters including the craters Resolution, Adventure, and Discovery showed that the craters are more recent than the ubiquitous eolian ripples on the Meridiani plains. This crater cluster probably formed when a weak projectile fragmented in the atmosphere, and its existence places constraints on the timing of ripple migration at Meridani.

References:

[1] Squyres S.W et al. (2009) Science 324, 1058.

[2] Wray J.J. et al. (2009) Geophys. Res. Lett. 36, L21201.