**RECONSTRUCTION OF EOLIAN BEDFORMS AND PALEOCURRENTS AT MERIDIANI PLANUM, MARS.** L. A. Edgar[1], [1]California Institute of Technology, Pasadena, CA (ledgar@caltech.edu).

**Introduction:** Over the past eight years, the Mars Exploration Rover *Opportunity* has investigated several impact craters at Meridiani Planum, studying the exposed sedimentary rocks in an effort to better understand the role of aqueous and atmospheric activity in its geologic history. Bedrock exposures at Eagle, Endurance, and Erebus craters reveal a complex sedimentary history, involving eolian sediment transport and deposition, followed by episodic inundation by shallow surface water, evaporation, exposure, and desiccation [1-4]. Bedrock outcrops exposed at Eagle and Endurance craters make up the Burns formation, represented by eolian dune, sand sheet, and interdune facies. The strata exposed at Eagle and Endurace craters is interpreted to represent a progressive increase in the influence of groundwater and surface water during deposition [2]. This wetting-upward trend contrasts with the overall drying-upward trend as seen at Erebus crater, at a slightly higher stratigraphic level [4]. This series of outcrops may comprise a full climatic cycle, from dry to wet to dry conditions, as one moves stratigraphically upward from the strata at Eagle crater through the strata at Erebus crater [4].

After completing its exploration at Erebus crater, *Opportunity* explored much larger bedrock outcrops at Victoria crater. It became clear that both depositional and diagenetic processes acted regionally in extent [5] and that most primary sedimentary bedforms are also of very large magnitude. This is important because it facilitates a greater understanding of the processes controlling deposition as well as the scale of the depositional environment. The work described here focuses on the reconstruction of eolian bedforms and paleocurrents from large-scale outcrops at Victoria crater, and an extended understanding of the climatic history at Meridiani Planum.

**Geologic Setting:** Victoria crater lies 6 km southeast from the original *Opportunity* landing site in Eagle crater. The plains surrounding Victoria crater are ~10 m higher in elevation than those surrounding previously explored Endurance crater, suggesting that Victoria crater exposes a stratigraphically higher section (assuming flat dip of strata). The outcrop exposed at Victoria crater may lie at the same elevation as the uppermost unit in Erebus crater, allowing for possible stratigraphic correlation between these two locations. Victoria crater has a scalloped rim produced by erosion and downhill movement of crater wall material, which results in a series of alcoves and promontories exposing more than 10 m of well-bedded sedimentary rocks.

Prior to ingress, *Opportunity* spent several months traversing the rim of the crater. Observations of outcrops at several promontories reveal large-scale cross-stratification with bedsets of at least several meters in thickness [5]. Analysis of cross-bedding geometries indicates reversing paleowind directions oriented in a dominantly north–south direction [6]. Detailed measurements of the stratigraphy were taken by the Panoramic Camera (Pancam) and Microscopic Imager (MI) as *Opportunity* descended into the crater at Duck Bay.

**Stratigraphy at Duck Bay and Cape Verde:** *Opportunity's* ingress path in Duck Bay intersects three stratigraphic units, named Lyell, Smith and Steno, in ascending stratigraphic order. The units consist of sulfate-rich cross-bedded sandstone, interpreted as fossil eolian dunes. Smith is a light-toned band that lines much of the upper rim of the crater. Smith is interpreted as a diagenetic band, exhibiting a lighter tone and poor expression of lamination consistent with recrystallization. Evidence of the diagenetic unit reworked in the impact breccia indicates that Smith formed prior to the crater impact. The contact between Smith and Lyell is gradational, and the darker tone and well-defined stratification of Lyell gradually fade upward. A clear erosional contact distinguishes Smith from the overlying Steno unit. Strike and dip measurements suggest that this truncation surface between Steno and Smith has a dip of ~10$^o$ to the southeast [7]. Bedding measured within Lyell dips to the southwest, while bedding measured within Steno dips to the southeast. These units define the "Reference Section" for Victoria crater. They can be traced visibly around much of Duck Bay, but cannot be directly correlated with the nearest promontory, Cape Verde, which is separated by a large area of breccia.

After completing observations of the Duck Bay strata, *Opportunity* made a close approach to the outcrop at Cape Verde. Cape Verde exposes a light-toned band overprinting well-laminated sandstone with low-angle cross-bedding. In some places, small climbing ripples are super-imposed on the larger dune cross-stratification. The base of the Cape Verde cliff face contains a truncation surface dipping ~10$^o$ to the southeast. It is inferred that the erosional contact at the base of Steno correlates with the erosional surface at the base of Cape Verde. Although these surfaces lie at different elevations, they have a similar 10$^o$ dip into the crater and projection of this dip shows the potential continuity of the surface between elevations. This surface indicates deposition at the same time between locations, but on pre-existing topography, and represents an architectural element larger than the scale of the cross-bedding [7].

**Reconstruction of Eolian Bedforms:** The erosional surface exposed in the ingress path and at Cape Verde may be interpreted as a bounding surface produced by migration of dunes on a larger bedform (cf., [8]). The compound bedform (smaller dunes migrating over a larger dune) may be termed a draa. Consideration of cross-bedding geometry produces additional insight. Strata below the erosional surface, both at Duck Bay and at Cape Verde, dip to the southwest, while the strata above the surface dip to the southeast. This leads to two possible interpretations. The different dip directions may be interpreted as remnants of three-dimensional sinuous crested dunes migrating southward. Trough cross-bedding produced by three-dimensional sinuous crested dunes is observed at nearby promontory Cape St. Mary, although the scale of the bedsets is much smaller [6].

Alternatively, the different dip directions could be indicative of different dune-migration directions, from which paleo-wind directions may be inferred. This interpretation is consistent with observations of terrestrial draas, which may contain reactivation surfaces representing the migration of dunes across a draa in different directions [9]. Detailed paleocurrent analysis indicates that a pattern of reversing transport direction is observed at other locations around Victoria crater, and also with juxtaposition of cross-bedsets across larger-scale surfaces [6]. Furthermore, bedform modeling [10] of these inferred conditions produces results that match the stratal geometries observed at Duck Bay and Cape Verde.

Given the available data, we are unable to distinguish between these two hypotheses, but both scenarios suggest paleowind directions from north to south. In the case of a large bedform with superimposed bedforms that reverse migration direction, the orientation of the erosional surface (rather than the cross-strata above the surface) may serve as a better indicator of the local orientation of the bedform surface when it was formed. The erosional surface at Duck Bay and Cape Verde is important in that it exposes a larger-scale bedform than had previously been seen at Meridiani Planum. If it represents the migration of dunes across a draa, then three orders of bedforms are observed: ripples, dunes, and draas. Draas are typical of modern ergs (sand seas), often occurring in the centers of well-developed ergs, where sand cover is thickest [11-12].

**Conclusions:** The strata exposed at Duck Bay and Cape Verde indicate deposition in an eolian dune environment, with further modifications though diagenesis. Correlation between Duck Bay and Cape Verde reveals an erosional surface that is interpreted to represent the migration of dunes across a draa, and its orientation indicates that the draa was migrating from northwest to southeast at the time that the surface was formed. The stratal geometry above and below the erosional surface indicates dune migration in opposing directions or by southward migrating three-dimensional bedforms. Additionally, the presence of three orders of bedforms and a complex wind regime indicates that the strata may have been part of a large sand sea, with no evidence for aqueous deposition, as observed at Eagle and Endurance craters. Victoria crater not only reveals the regional extent of processes seen elsewhere in Meridiani Planum, but the greater size of its outcrop exposures reveals the building of ever-larger eolian bedforms.

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