ADDITIONAL EVIDENCE OF EARLY FLUVIAL DISSECTION OF ENDEAVOUR CRATER'S RIM. M. N. Hughes[1] and R. E. Arvidson[1, 2], J. A. Grant[3], and S. A. Wilson[3], [1]Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, MO (mnhughes@wustl.edu), [2]McDonnell Center for the Space Sciences, [3]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC

Introduction: The Noachian-aged Endeavour Crater has been the focus of both ground observations by the Opportunity rover [1] and consideration of its age and nature of degradation using orbital observations [2]. In particular it has been concluded that the majority of rim degradation occurred early and was mainly due to fluvial activity [2]. In this abstract we focus on additional evidence for early fluvial processes affecting the rim using comparisons with the younger Bopolu Crater and imaging acquired by the Opportunity rover.

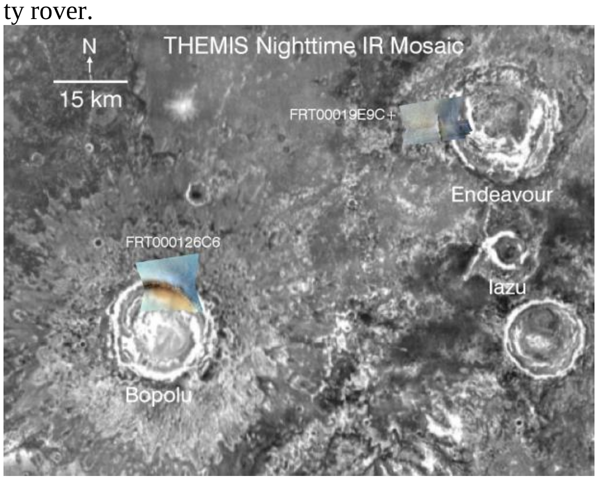

Figure 1: THEMIS night time IR mosaic showing Endeavour and Bopolu Craters. Bopolu ejecta is visible overlying the Meridiani plains and the Burns formation sulfate-rich sandstones. CRISM FRT false color images covering the northern rim and walls of Bopolu and Cape Tribulation on Endeavour are shown. The red to brown colors for the CRISM data indicate the presence of hydrated sulfates on Bopolu's walls, confirmed by examination of spectra for this scene.

Bopolu and Endeavour Craters Compared: Bopolu Crater is located to the SW of Endeavour Crater and was emplaced after the deposition of the Burns formation [2] (Fig. 1). This is in contrast to Endeavour, which is largely embayed by Burns formation strata, and thus is much older, likely forming during the Noachian [1]. Crater counts on the ejecta of Bopolu imply a likely age of late Hesperian (with a range in modeled ages of Early Hesperian to Early Amazonian), i.e., perhaps 0.5 Ga or more years younger that Endeavour Crater [3]. Both craters are similar in diameter (19 km for Bopolu and 22 km for Endeavour) and we use Bopolu and the style of rim and wall degradation to compare to what is found on the Cape Tribulation rim segment of Endeavour, terrain that has been thoroughly explored by Opportunity (Fig. 2). The northern wall of

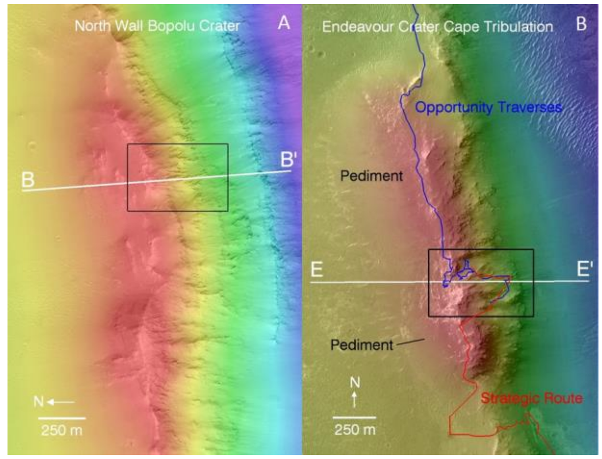

Figure 2: A. HiRISE image of the north wall of Bopolu Crater overlain with color-code elevations from HiRISE DTM, with red higher than blue (elevations can be seen in Fig. 3). **B.** Equivalent product covering Cape Tribulation. The profiles from both cross sections are shown in Fig. 3. Boxed regions are shown as perspective views in Figs. 4-5. Pediments on the western side of Cape Tribulation are labeled, along with Opportunity's traverses through 1/6/17.

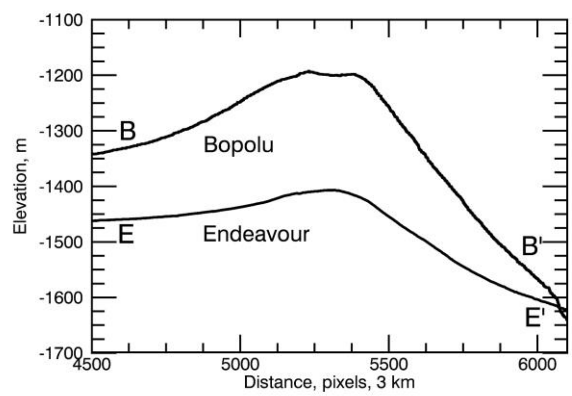

Figure 3: Topographic profiles of Cape Tribulation (Endeavour) and the northern wall of Bopolu Crater are shown.

Bopolu is used in this study because of coverage by a CRISM scene that has allowed mapping of hydrated sulfates and rocks of basaltic composition, both demonstrating that Bopolu is younger than the Burns formation and characterizing the types of rocks exposed (Fig. 1). Bopolu has more relief and steeper walls as compared to Endeavour (Fig. 3). The northern wall of Bopolu is tilted 25-27° toward the interior and the spurs and valleys present on the wall (Fig. 4) have a relief of 40 meters. This contrasts with Cape Tribulation, which is tilted 20-22° toward the interior, and the spurs have a relief of 5-8 meters to the adjacent valleys

(Fig. 5). The spurs on Bopolu are also steeper and less rounded as compared to those on Cape Tribulation. Thus, Cape Tribulation has been highly degraded relative to the much younger Bopolu rim segment under consideration.

Both the western and eastern slopes of Cape Tribulation exhibit concave upward surfaces with a thin regolith cover over bedrock (Figs. 2B, 6). These surfaces are downhill from steeper outcrops and together are similar of piedmont morphologies found on Earth, with upland hills and pediment surfaces extending downhill [2]. In fact the slopes and widths fit into terrestrial examples found in the Mojave Sonoran Deserts (Fig. 7). Of course the terrestrial examples formed by the interaction of fluvial erosion and transport.

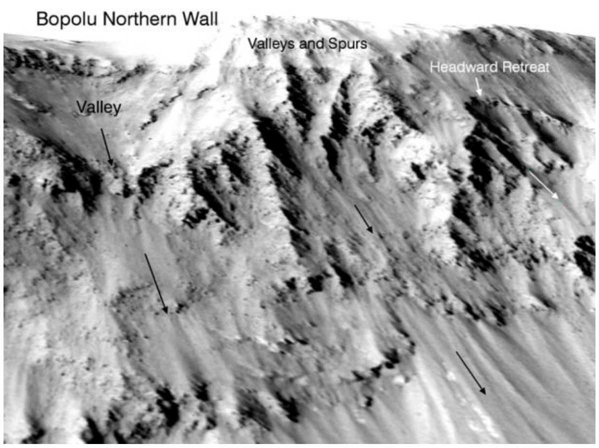

Figure 4: Perspective view of Bopolu Crater's northern wall. CRISM data indicate that the upper wall exposes basaltic materials similar to what is found on Cape Tribulation. These rocks overlie hydrated sulfates of the Burns formation evident in the lower portion of this view. Thus the Bopolu and Endeavour morphologic comparisons focus on similar rock types, i.e., above the sulfate exposures. 2x vertical exaggeration is used and the image width is covering 500 meters.

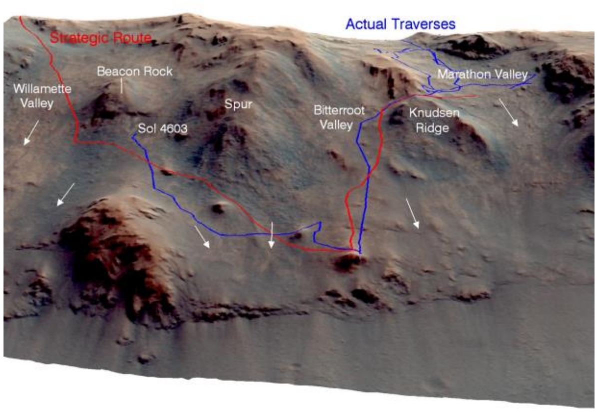

Figure 5: Perspective view of Cape Tribulation on the western rim of Endeavour Crater. 2x vertical exaggeration is used and the image width is covering 500 meters.

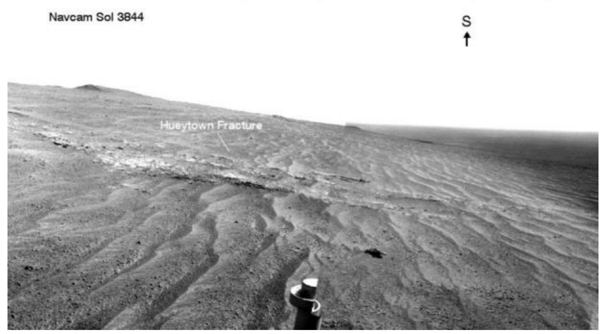

Figure 6: Navcam mosaic looking south at the Hueytown fracture and pediment of bedrock thinly covered with ripples and regolith. Data acquired midway along Opportunity's traverses on the large pediment shown in Fig. 2B.

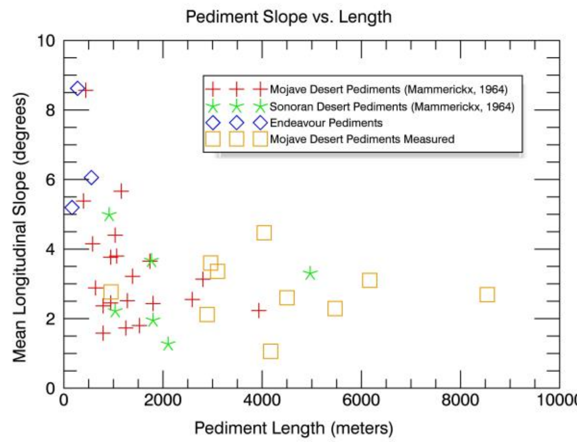

Figure 7: Plot comparing the mean longitudinal slope vs. the total length of pediments on the western rim of Endeavour Crater and terrestrial pediments [4].

Discussion: It seems likely that weathering and mass movements have been the primary mechanisms eroding the rim of Bopolu, as well as redistribution of the sediment of the ejecta deposits through aeolian stripping and infilling. It also seems highly unlikely that letting these processes operate at the same rate for another half billion years or more would produce the extent of degradation and range in local relief seen on Cape Tribulation. We thus conclude that a higher rate of degradation dominated the early modification of Endeavour Crater. The presence of a piedmont morphology and the extent of degradation are entirely consistent with the action of early fluvial activity combined with more intense weathering [2]. Additional work is planned simulating the development of these two disparate rim morphologies.

References: [1] Crumpler, L. S., et al. (2015) *JGR: Planets*, *120*, 538-569. [2] Grant, J. A., at al. (2015) *Icarus*, *280*, 22-36. [3] Hartmann, W. K., and Neukum, G., (2001) *Space Science Reviews*, *96*, 165-194. [4] Mammerickx, J. (1964) *American Journal of Science*, *262*, 417-435.