DEGRADATION OF ENDEAVOUR CRATER, MARS. J. A. Grant[1], L. S. Crumpler[2], T. J. Parker[3], M. P. Golombek[3], S. A. Wilson[1], and D. W. Mittlefehldt[4], Smithsonian Institution, NASM CEPS, 6th at Independence SW, Washington, DC, 20560 (grantj@si.edu), [2]New Mexico Museum of Natural History & Science, 1801 Mountain Rd NW, Albuquerque, NM, 87104, [3]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, [4]NASA JSC, 2101 NASA Parkway, Houston, TX 77058.

Introduction: The Opportunity rover has traversed portions of two western rim segments of Endeavour, a 22 km-diameter crater in Meridiani Planum (Fig. 1), for the past three years (e.g., [1]). The resultant data enables the evaluation of the geologic expression [2] and degradation state of the crater. Endeavour is Noachian-aged, complex in morphology [3], and originally may have appeared broadly similar to the more pristine 20.5 km-diameter Santa Fe complex crater in Lunae Palus (19.5°N, 312.0°E). By contrast, Endeavour is considerably subdued and largely buried by younger sulfate-rich plains (Fig. 1). Exposed rim segments dubbed Cape York (CY) and Solander Point/Murray Ridge/Pillinger Point (MR) located ~1500 m to the south reveal breccias interpreted as remnants of the ejecta deposit, dubbed the Shoemaker Formation [1]. At CY, the Shoemaker Formation overlies the pre-impact rocks, dubbed the Matijevic Formation [1, 2].

Erosional Form of the Rim: At CY, present relief along the exposed rim segment is ~10 m and consists of 6-7 m of Shoemaker Formation over at least several m of Matijevic Formation. By contrast, relief along the MR segment is considerably higher and the Shoemaker Formation/Matijevic Formation contact is not visible despite exposures extending about 20 m below and 60 m above the elevation of the contact at CY. This implies structural offset between the rim segments and suggests a thicker section of Shoemaker Formation (up to 70 m) is preserved at MR. Poor information about the strike and dip of the Shoemaker Formation at MR makes it difficult to measure true section thickness, but it appears to be 10s of meters more than at CY.

Offset between rim segments could relate to faulting during late stage crater formation, though any faults remain buried in areas explored to date. Fractures are observed at MR and may be similar to those seen around smaller terrestrial impacts [4].

Comparison to similar sized, fresh, complex craters on Mars (29 km-diameter Tooting crater [5]) and the Moon (craters with diameters of 17-30 km [6]) suggests at least 100-200 m of ejecta was originally present at the rim of Endeavour crater. For example, if 200 m of ejecta were present, then CY and MR experienced close to 190 m and >100 m erosional lowering, respectively. If 100 m ejecta were present, rim lowering was closer to 90 m and 10s of m, respectively. In either case, at least portions of Endeavour experienced significant degradation. A paucity of debris from the Shoemaker and Matijevic Formations relegates most erosion to before the surrounding plains were emplaced, implying more efficient erosion in the past [7].

Moreover, ejecta comprise ~50-60% of the relief around selected Mars complex craters [8] and only 20-25% around selected lunar complex craters [6]. Hence, original rim relief at Endeavour may have been only ~200-500 m or as much as ~400-800 m based on comparison with complex Martian and lunar craters of broadly similar size [4, 5, 8]. Almost complete removal of ejecta at CY indicates ~100-200 m or more erosion, with perhaps lesser amounts at MR. Hence, plains ~100-300 m to 400-800 m thick are needed to bury the uplifted rim: the higher end of this range is close to the 800-900 m plains section to the east and north [9-11].

The Crater Interior: Plains materials extend into Endeavour crater and partially fill the impact depression. Endeavour currently averages about 200-300 m deep around much of the northern portion of the interior, ranging up to 500 m depth in the south-central portion. By contrast, recent studies of pristine complex craters on Mars [12-16] suggests the original depth was probably between ~1.6 and 3.2 km, thereby indicating on order of 1.1 to more than 2 km of fill remains within the crater. While the surface expression of the fill indicates sulfate-rich rocks are present, it is impossible to discern how much older fill may also occur. However, if the thickness of plains in the crater is comparable to that outside of the rim, then much of the fill may relate to pre-plains materials shed from the crater walls.

Wdowiak Ridge and Erosional Processes: Wdowiak ridge is located immediately west of Endeavour's rim and oriented NE-SW (Fig. 1). The ridge is capped by more resistant dark rocks that are not breccia and are chemically and texturally distinct from the overlying Shoemaker Formation [17]. Origin of the ridge is uncertain, but possibilities include relief associated with an isolated rim segment, exhumed ejecta megablock, or erosional exposure of a local topographic high on the pre-impact surface [17]. Or the ridge could represent local, more resistant, impact melt left in relief after lowering of surrounding surfaces.

Wdowiak ridge relief is small relative to the vertical lowering inferred for the near rim region, thereby making it less likely to be the expression of material emplaced at the surface when the crater was more pris-

tine (e.g., inverted valley fill). The local occurrence and absence of a volcanic source, however, argues against a volcanic origin at some intermediate stage in the crater's modification.

It is clear that the original form of Endeavour crater has been considerably degraded, with the bulk of the modification occurring relatively early in the Noachian-aged crater's history. However, identifying signatures associated with the processes responsible for the bulk of the degradation remain elusive. This is due to later burial of much of the crater by younger plains materials and more recent eolian stripping of the exposed rim segments. The range of inferred degradation, however, implies sufficient modification to account for differences in relief along and between exposed rim segments (Fig. 1) that could relate to action of past processes including fluvial, mass wasting, or other. For example, the MR rim segment stands in higher relief than CY, yet has presumably experienced lesser erosion. Such differences in degradation along the rim must reflect changing resistance of the rocks to erosion and/or locally varying intensity of erosional processes. Finally, the contact between the younger plains and rim covers 10's of m total relief along MR. This suggests either the plains materials were not emplaced horizontally or that there has been subsequent tilting of the regional terrain.

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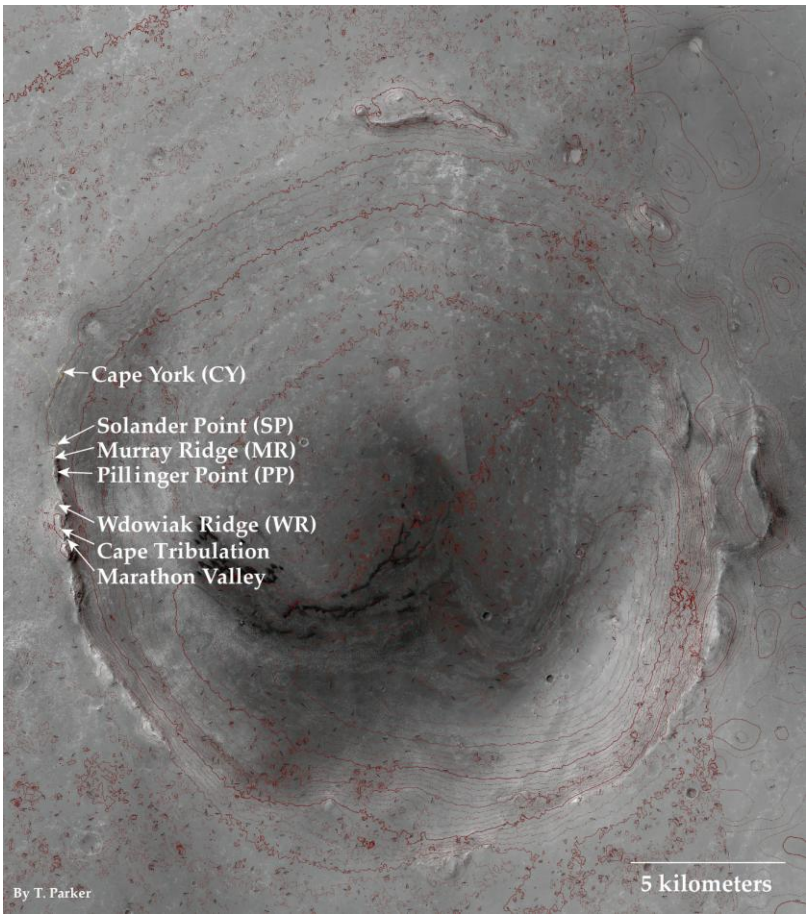

Figure 1. The 22 km-diameter, complex morphology, Noachian-aged, Endeavour crater in Meridiani Planum (2.3°S, 354.8°E). The Opportunity rover has been exploring the two western rim segments between Cape York (CY) and extending southward to Solander Point (SP), Murray Ridge (MR), Pillinger Point, and Wdowiak Ridge (WR). The rover is currently nearing Cape Tribulation and is driving towards Marathon Valley. 20 m contours indicated (produced by T. Parker). Rim segments are embayed by younger plains materials that partially fill the crater. 6 m pixel scale. CTX images G02_018912_1779_XN_02S005W and G04_019980_1779_XN_02S005W processed with Ames Stereo Pipeline to make ORR/DEM. North towards top.