IN SITU MAPPING OF FAULT-CONTROL AND REGOLITH DIVERSITY AT THE HEAD OF PERSEVERANCE VALLEY, ENDEAVOUR CRATER, MARS. Crumpler, L.S.[1] and MER Athena Science Team. [1]New Mexico Museum of Natural History & Science, 1801 Mountain Rd NW, Albuquerque, NM, 87104, USA, larry.crumpler@state.nm.us.

Introduction. The rim of Endeavour crater, like many complex impact craters, is discontinuous, varies in relief [*1*] and consists of right and left-stepping topographic segments. Outcrop exposures of a linear, rim-cutting fractures, interpreted as faults, at the head of Perseverance Valley support the inference that transitions between segments are significant structural offsets that controlled both subsurface aqueous transport [*2*], observed intense bedrock alteration [*3,10*] and the location, shape, and boundaries of valleys in the inner crater wall.

In Situ Study of Crater Rim. As of sol 4959, near the end of its 13th year of surface operations, Opportunity had traversed 11.6 kilometers along the rim of Endeavour crater**,** a Noachian-age [*4,5*] impact crater 22 km in diameter. A period of intense erosion of the crater rim occurred prior to onlap by later deposits (*Grasberg fm*) and filling [*6,7*] by sulfate-rich basaltic sandstone (*Burns fm*) [*8,9*]. The rim now consists of topographic segments between 200 m and 300 m wide varying in relief from a few tens of meters to 150 m. From Opportunity the transitions between segments are apparent as differences in petrologic character, differences in attitudes of foliations in outcrops, and cross-cutting disparities in structural grain across segments boundaries [*2*].

Stratigraphy & Lithology of the Crater Rim. Outcrops studied along the rim crest and upper slopes consist of coarse, unbedded but foliated outcrops of impact breccias ("*Shoemaker fm*") containing cm-sized angular to sub-rounded dark clasts enclosed in a lighter-toned fine-grained matrix material [*6,11*]. Differences in clast abundance in a few exposures define a crude layering [2]. At the boundary between segments are several instances of notable bedrock alteration [*10*]. Post-impact surficial deposits developed during erosion of the crater rim and much later, including autocthonous regolith and colluvial deposits on the crater inner walls [*2*].

Traverse across the transition between two major rim segments. During the past year Opportunity completed traverse of the large rim segment "*Cape Tribulation*" and entered the next lower segment to the south, "*Cape Byron*" (**Fig. 1**). Results of in situ mapping at the boundary between these two rim segments now characterize this type of transition. Opportunity descended the south tip of *Cape Tribulation* beginning around sol 4680 crossing a series east-west striking scarps and down-to-the-south topographic steps terminating in an abrupt east-west scarp in contact with stratigraphically higher, unconformably onlapping *Grasberg* and *Shoemaker fms*.

Diversity of Regolith. Within the transition area between rim segments, and within the trough-like region at the low pass and entrance to *Perseverance Valley* [*12*] bedrock is covered by unusually clast-rich regolith and dark float rocks not seen elsewhere along the rim (**Fig. 2**). These consist of unusual regolith material containing trains of dark rocks (**a_1d)**; mixed with cobble-size fragments of Shoemaker fm matrix and dark clasts (**a_1c**); containing only dark clast the size and shape of those in Shoemaker fm (**a_1b**); and a more common regolith unit consisting of dust and sand sized material generally accumulated in local low relief areas (**a_1a**) (**Fig. 3**).

Fault Control at Upper End of Perseverance Valley. Evidence for faulting has been elusive until now. Linear division between bedrock outcrops of different lithology (S_u & S_L) at the upper end of *Perseverance Valley* aligned with linear zones of alteration and fragmented bedrock are in situ evidence that such faults are present and influenced fluid movements within the crust [*10*]. Small variations in resistance to erosion in the bedrock exposed on either side of the fracture/fault zones may have controlled patterns of erosion (**Fig. 4**).

Summary. Regolith characteristics at the entrance to and within the floor of *Perseverance Valley* are distinctively clast-rich and appear unique to the entrance to *Perseverance Valley*. The origin of the greater weathering and sorting necessary for the development of clast-rich regolith here, and its relationship, if any, to *Perseverance Valley* remains unclear and is a focus of current investigation. These materials are a major component of the inter-outcrop regolith occurrences within the valley.

The fractures or faults in the upper valley floor and discontinuities between segments in the rim are consistent with development of transverse faults as deformation in the upper crust is accommodated by uplift along separate blocks during crater formation. The motion between blocks requires accommodation by vertical dip, scissor faults or lateral ramp structures. Coincidence strike of linear margins and troughs of *Perseverance Valley* with these features also supports an inference that they have been influential in development of valley morphology and possibly the processes from which the valley originated. Study of the process that created the valley and its system of troughs is on-going [12].

References. [1] Kenkman et al., 2014, J. Strc. Geol, 62, 156; [2] Crumpler et al., 2017, LPSC 48; [3] Arvidson , R.E., et al. (2017), LPSC 48; [4] Hynek et al., 2009, [5]Arvidson et al., 2014, [6] Crumpler et al., 2015, [7] Grant, J.A., et al. 2016, *Icarus*, Icarus 280 22; [8] Grotzinger et al., 2006, [9] Squyres and Knoll, 2005,[10] Arvidson et al,2016, Am. Mineral., 101,1389, [11] Squyres et al. 2012, Sci ence 336, 570; [12] Squyres et al., 2018, this abstract vol.

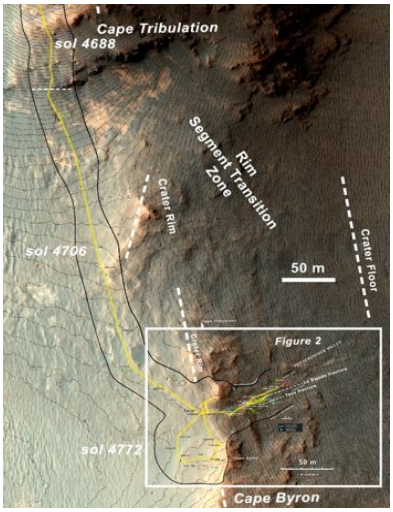

Figure 1. Opportunity's traverse across the transition from the *Cape Tribulation* rim segment to the *Cape Byron* rim segment and the entrance to *Perseverance Valley*. MRO/HiRISE base & DEM.

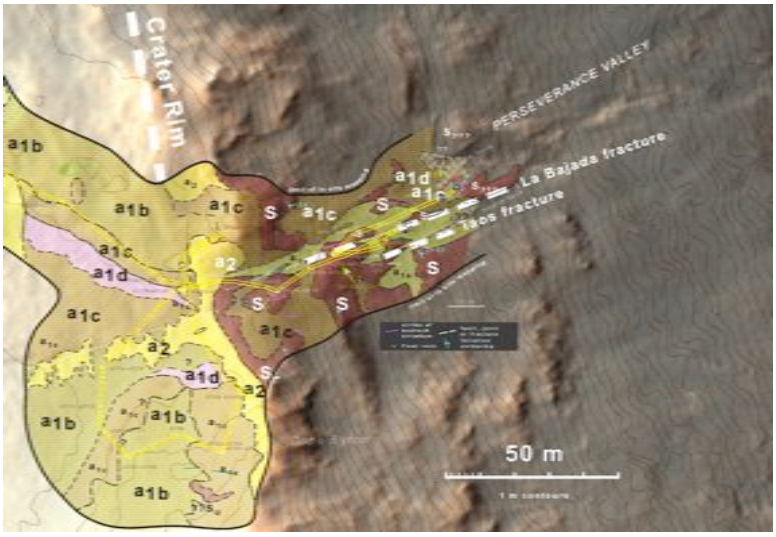

Figure 2. In situ geologic map of the entrance and upper *Perseverance Valley*. Note variety of regotlith units (a1b-a1d) and linear fractures/faults identified from outcrop mapping. MRO/HiRISE DEM & image base.

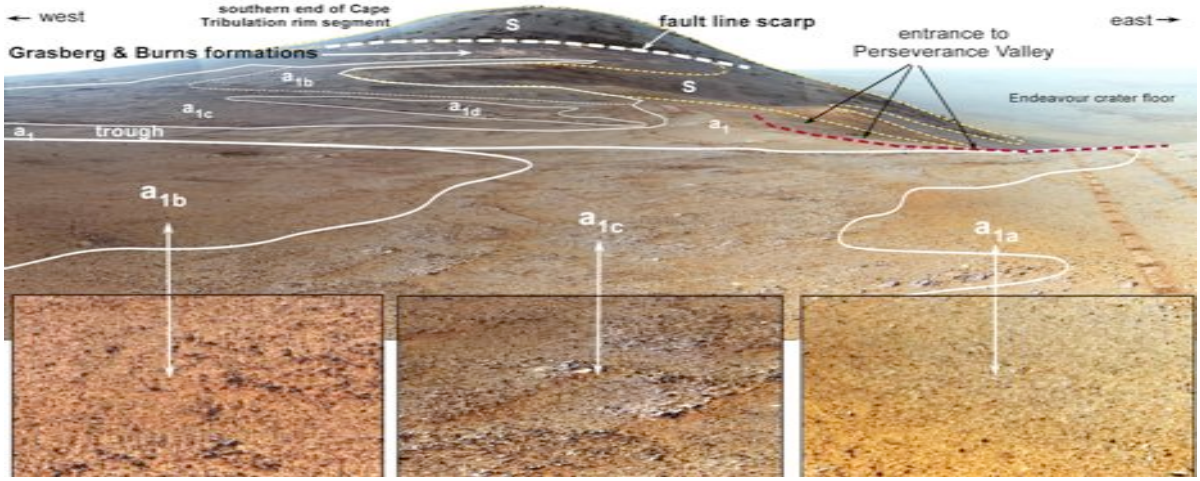

Figure 3. Example of three types of regolith at entrance to *Perseverance Valley*. Note fault-bounded southern end of *Cape Tribulation* in the distance.

Figure 4. Linear alteration fracture (*Taos*) and linear fracture (*La Bajada*) controlling margins of *Perseverance Valley*.