

MER FIRST IN SITU RESULTS FROM THE RIM OF A COMPLEX IMPACT CRATER ON MARS. L. S. Crumpler¹ and the Athena Science Team. ¹New Mexico Museum of Natural History & Science, 1801 Mountain Rd NW Albuquerque, NM, 87104, USA, larry.crumpler@state.nm.us.

Introduction. Mars Exploration Rover *Opportunity* has traversed 5.2 km along the rim of 22 km-diameter “Endeavour” impact crater since arrival, crossing the regional geologic contact between Meridiani Planum and the much older terrain of the crater rim on sol 2681. In situ observations of the outcrops on the crater rim are establishing (1) lithologies associated with the previously inferred general changes in environment of Mars over geologic time [1,2], and (2) *for the first time on Mars, the lithologies [3,4,5] and geologic characteristics associated with a complex impact crater.*

In Situ Observations of Crater Rim. Opportunity has examined the elemental, spectral, and petrographic character of geologically mappable units along its traverse on the crater rim. This includes both impact and pre-impact lithologies.

Impact Lithologies. Based on in situ mapping along the crest and upper slopes of Cape York and south at Murray Ridge (**Fig.1**), outcrops consist of breccias (“Shoemaker Formation”) from 3 to 5 m thick (**Fig. 2**), many bearing agglomeratic textures. Some suevite-like outcrops consist of slab-like exposures and mixed dark clast-rich breccia supported in an indurated (welded? altered glassy?) matrix displaying lineations or trains of clasts. A lower contact zone with the underlying unit at Matijevec Hill is transitional in texture and consists of coarse breccia as well as 1 to 2 mm round clasts [1]. Recent analyses at the base of Murray Ridge [3] suggest that impact melts may be present high on Murray Ridge.

Pre-impact Lithologies. Stratigraphically below the impactites is a light-toned, fine-grained (<30 μ) and orthogonally jointed unit that occurs as tabular-surfaced outcrops (“Matijevec Formation”) restricted to the interior of Cape York on the east face [2]. The exposures range from light toned, planar outcrops with discontinuous, erosionally resistant darker veneers to erosionally resistant ridges with high concentrations of small spherules (described below). It is within this unit that intense aqueous solutions moving along joint planes have resulted in alteration of the host rock to clays [1,2,3,4].

The basal contact between the lower Shoemaker formation and the underlying unit (Matijevec formation) is planar. The transition from the light-toned, fine-grained, orthogonally jointed Matijevec formation upward into darker, coarsely textured, and poorly jointed Shoemaker formation is an abrupt disconformity.

Structure. Geologic mapping along a looping traverse at Matijevec Hill established the contact between the Matijevec and Shoemaker formations. Using Navcam ranging and HiRISE DTM data, together measurements of the

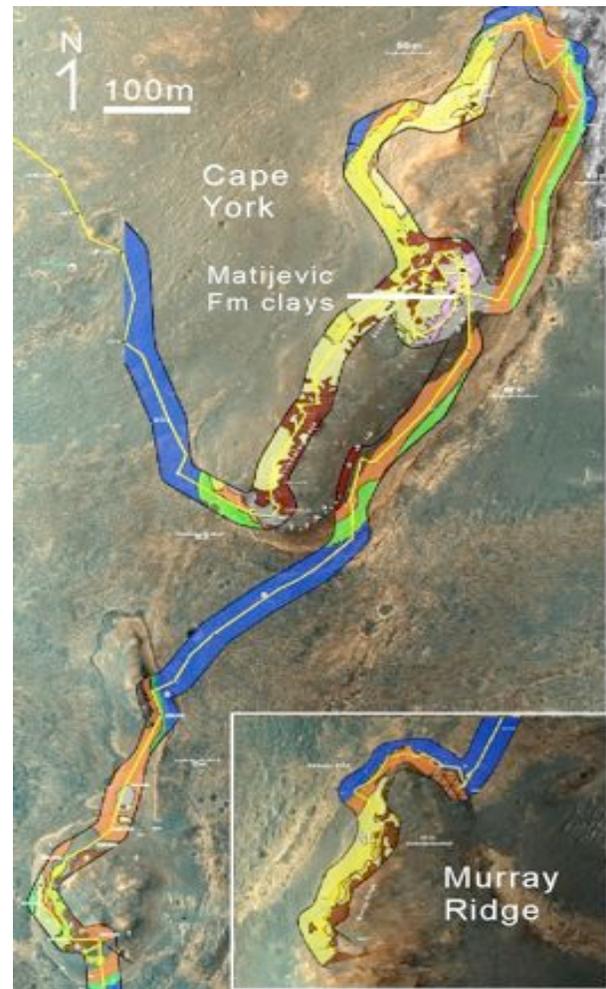


Figure 1. Status of in situ geologic mapping along Opportunity's traverse. Inset: mapping at Murray Ridge. Base image: MRO/HiRISE ESP_032573_1775. Unit colors as in Fig. 2.

strike and dip of contacts, we were able to construct a basic structural section (**Fig. 3**) across the central area of Matijevec Hill. The results indicate that the dip of the Shoemaker Fm impactite section, and the unconformity with the pre-impact surface, dip approximately 11 ± 2 degrees east, towards the crater center.

Crater Structure. Craters similar to Endeavour crater and between about 3-8 km and larger on Mars [6,7,8] are characterized by slumping or terracing around the inner slopes, relatively flat floors, and central peaks. The outcrop scale details of ejecta facies variations, thicknesses, and structural characteristics of the rims of impact craters of this size on Mars are not known.

Endeavour and Santa Fe Crater: Twins separated by birth date. A comparison with a youthful complex

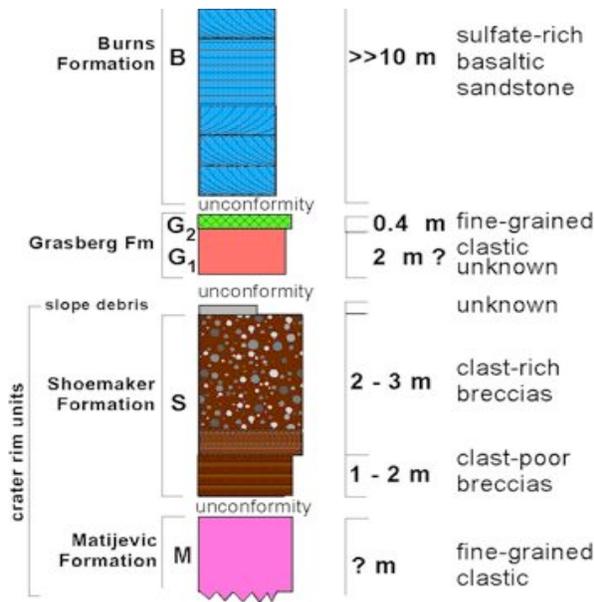


Figure 2. Stratigraphy based on in situ measurements at Cape York and Murray Ridge. Impactites (Shoemaker Fm) account for 3 to 5 m of the observed section.

crater highlights some points about complex craters that can now be clarified with in situ observations. Santa Fe crater, in Chryse Planitia (19.5°N 48.0°W), south of the Viking Lander 1 site, is similar in size (21 km) but much younger (Amazonian), preserving some of the structural complexities and ejecta characteristics eroded or buried at Endeavour (**Fig 4**). Inspection of HiRISE image data along the rim shows that the ejecta is no more than a few tens of meters thick, and that pre-impact lithologies may be sectioned along the outer rim. This is consistent with predictions of only a few meters of ejecta on the rim of a terraced 20 km or greater diameter crater. Ejecta thickness at the very youthful, 29-km diameter Tooting crater [9], estimated to be less than 8 meters. Because ejecta is

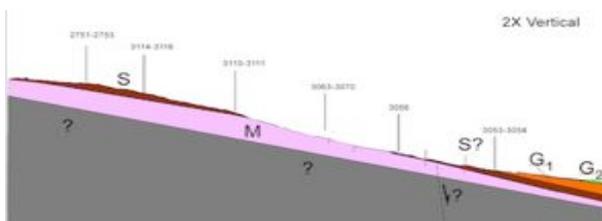


Figure 3. East-west geologic section at Matijevic Hill, east flank of Cape York, based on profiles from Navcam ranging, observed section thicknesses, and strike and dip of visited outcrops.

relatively thin, isolated fault blocks within the rim may expose the pre-impact substrate within their flanks. Also, the rims represent areas that are minimally deformed during the impact, so the stratigraphic and structural setting is relatively simple.

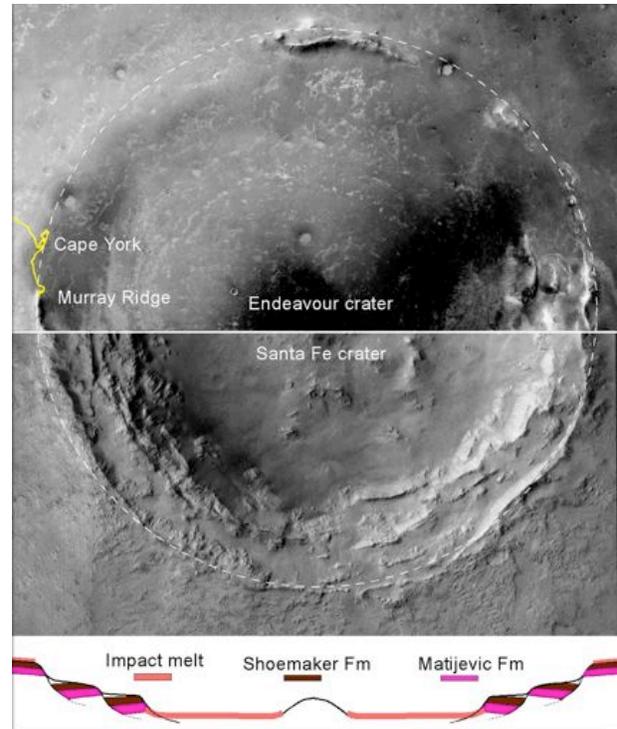


Figure 4. A. Comparison of Endeavour crater and Santa Fe crater. Traverse on western rim shown by yellow line. **B.** Generalized relief across a fresh complex crater.

Conclusions. While the apparent rim of the crater is raised, the geologic section dips craterward.; (2) the ejecta thickness at the apparent rim of the crater is only a few meters thick; and (3) the comparison with youthful craters similar to Santa Fe crater shows that pre-impact materials may be relatively well exposed along the rim. This is consistent with the hypothesis that the lowest stratigraphic, and phyllosilicate-bearing, Matijevic Fm is an exposure of the pre-impact Noachian surface. The unconformity observed at the base of the Shoemaker Fm, in which coarse clastic materials overlay the jointed, fracture-altered, and likely clay-bearing outcrops [1,4], could represent the contact between the ejecta and underlying pre-impact surface of Mars. This would mean that the surface of that unconformity represents a paleo-surface dating from the Noachian, exposed to the environment of that time, and that it has been preserved by burial beneath impact ejecta.

The Mars Exploration Rover mission is operated by the Jet Propulsion Laboratory on behalf of NASA.

References Cited. [1] Squyres et al, 2012. *Science* 336, 570; [2] Arvidson et al., 2013. *Science*; [3] Mittlefehldt et al., 2014, this volume; [4] Clark et al. 2014. this volume; [5] Crumpler et al., 2013, GSA Fall Mtg abstracts; [6] Pike, 1980, *Icarus*, 43, 1-19; [7] French, 1998. *LPI Contrib.* 954; [8] Melosh, 1989. *Impact Cratering*, Oxford; [9] Mouginiis-Mark and Garbeil, 2007, *MAPS*, v. 42, p. 1615 – 1625.