LAYERED SEDIMENTS, RAMPART CRATERS, AND POTENTIAL FLUVIO-LACUSTRINE ACTIVITY IN S.W. ARABIA TERRA, MARS: SUPPORT FOR A HISTORY OF AQUEOUS CONDITIONS.

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Introduction: Arabia Terra is a unique area on Mars in that it is the only major, equatorial region characterized by high abundances of near-surface water (as measured by gamma ray and neutron spectroscopy [1, 2]). Vernal Crater [3] is a 55 km-diameter structure in southwest Arabia Terra, centered at 6°N, 355.5°E (Figs. 1, 2). The crater includes layered sediments, potential remnants of fluvio-lacustrine activity, and indications of aeolian processes. Regional considerations, along with new THEMIS and MOC data [4, 5], are being assessed to gain insight into the significance of the geomorphic units within Vernal Crater and the geologic history of SW Arabia Terra.

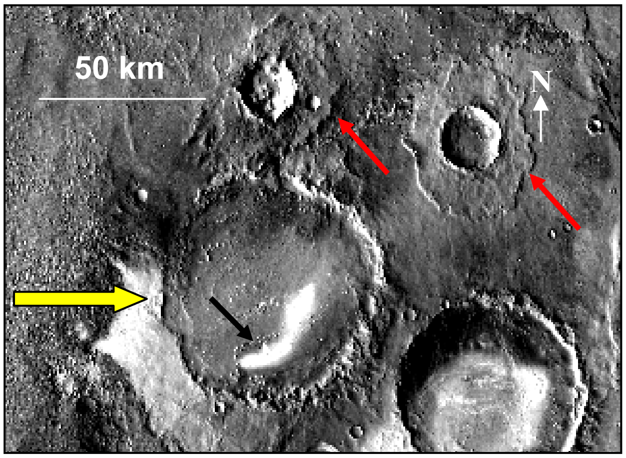

Fig. 1. Vernal Crater (yellow arrow) in daytime IR (msl_24-dayir) [4]. IR-bright area characterized by layered sediments (black arrow). Rampart craters (red arrows).

Regional Setting: Vernal Crater lies halfway between the massive circum-Chryse outflows to the west and a proposed giant Noachian basin (in Arabia Terra proper) to the east [6, 7]. SW Arabia Terra adjoins NW Meridiani Planum and both include extensive layered units that have been interpreted as sedimentary rocks [8, 9]. Rampart craters are common in the region; they impact various units and have ejecta blankets showing both rounded and angular morphologies (Fig. 1).

Geologic/Geomorphic Features: Within the crater (Fig. 2), elevation slopes from a high of about -1300 m in the northwest (yellows) to a low of about -2000 m in the southeast (dark blue area). The crater rim is strongly asymmetric; the highest part (red) reaches elevations of about -1000 m and lies just south of the deepest low within the crater (arrows, Fig. 1).

An area having very bright daytime IR response (black arrow, Fig. 1) also has a bright nighttime IR response (not shown); this area corresponds to a slight ridge in the topography (Fig. 2) and is comprised of light-toned layered sediments with a wavy fabric (Fig. 3). The correspondence of the layered sediments to a ridge suggests that they are indurated and somewhat resistant to erosion. Their wavy fabric might suggest fluid-rich deposition and/or soft sediment deformation. Analysis suggests that the nighttime IR response is due to the light-toned layers while the daytime response originates from dark sand resting in lows within the layered unit (Fig. 3).

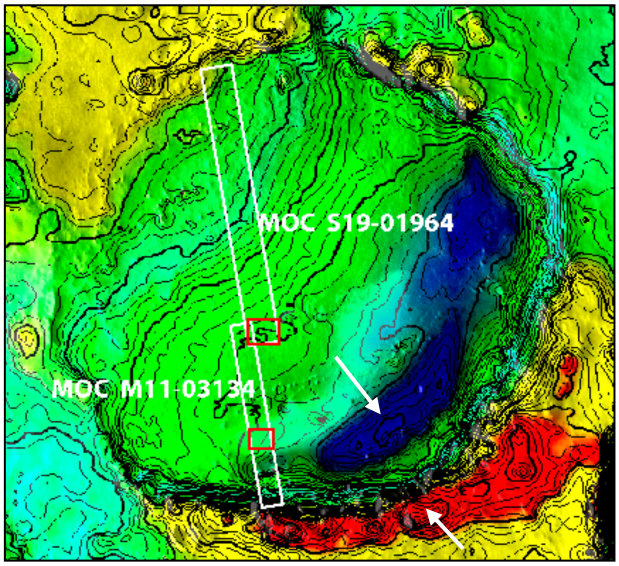

Fig. 2. Vernal Crater. MOLA topography on daytime IR [4]. MOC footprints [5] with red rectangles indicating areas of detail for Figs. 3 and 4. Contour interval, 20 m. Reds are highest elevations, dark blues are lowest. White arrows point to highest and lowest elevations.

Farther to the north is a distinctive, east-west trend of blocky outcrops (Fig. 4; location on Fig. 2, MOC S19-01964). These outcrops have flat tops and somewhat curved edges, and are individually separated by rounded, incised regions. The belt of outcrops is separated from features to the south by a relatively wide, curving path that is smooth except for the presence of occasional dunes.

In general, the northern half of the crater contains abundant evidence of aeolian processes (dunes and yardangs). The southern, deeper and older half seems different: Few dunes or clear-cut yardangs have been observed south of the blocky outcrops, and while there are some wind-eroded features in the south (outcrops with sharp, linear ridges), the derivation of the southern units is uncertain.

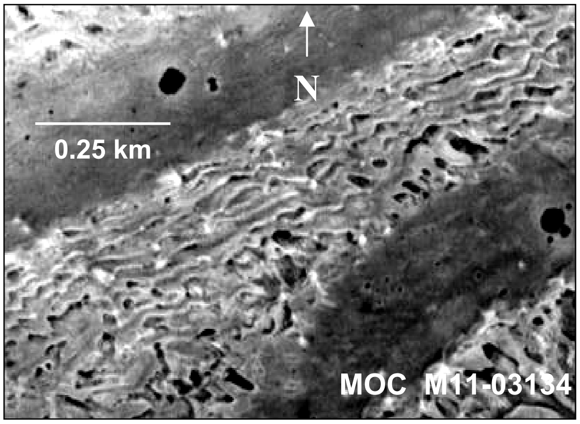

Fig. 3. Light-toned, wavy layered unit with dark sand in lows (location on Fig. 2).

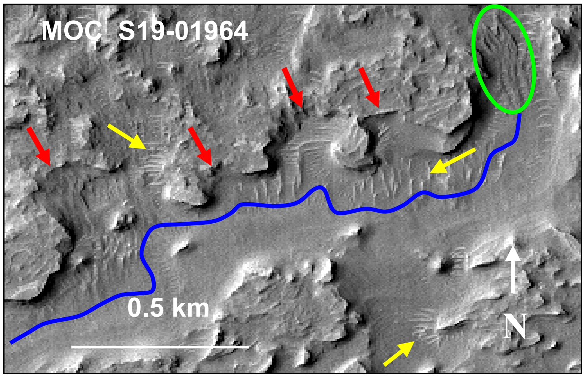

Fig. 4. Blocky outcrops (location on Fig. 2). Curved edges (red arrows) might suggest water erosion (incised meanders?); possible meander path (blue) and inverted, braided stream (green oval). Dunes (yellow arrows).

Discussion: While the northern half of Vernal Crater seems dominated by aeolian features, the exposed, deeper surfaces in the southern half are less obviously aeolian and could include remnants of fluvio-lacustrine sediments that date from the crater's early history. The wavy fabric of the layered deposits is suggestive of fluidized deposition; this fabric is unlikely to be attributable to lava, since few volcanic features or fissures are known from which lava could emanate [9] and the rampart craters argue against a primarily volcanic nature to the region. Thus, the layers seem likely to be of aqueous origin and their induration and resistance to erosion might be attributable to cementation by evaporation. A possibility that the blocky outcrops may reflect fluvial activity by meandering streams (Fig. 4) would be consistent with this view, though other interpretations are certainly possible.

While exhumation is likely to have been significant in producing the topography and exposing older units in the southern part of Vernal Crater, remnants of crater lake deposits conceivably could be located in the area of the major topographic low. It may not be coincidental that the lowest elevation in the crater is just north of the highest part of the rim (Fig. 2). While the rim may have focused wind currents, it also could have shadowed the region immediately to the north during periods of high obliquity, preserving ice in that portion of an ancient crater lake. Thus, Vernal Crater's asymmetric rim, with its highest part in the south, may have set the stage for a relatively long-lived lake in the southeastern part of this particular crater.

It is difficult to distinguish among different scenarios for the history of Vernal Crater based on available data: Was the crater filled with layered deposits, then simply exhumed by wind to give us the topography we see today? Or is it possible that some ancient features, such as a long-lived lake, are reflected in the current topography? Is all of the erosion that we see due to wind or are we seeing a combination of erosion due to wind and fluvial processes? New data from Mars Reconnaissance Orbiter and Mars Express will provide additional insight into these questions. Since Vernal Crater is a landing site candidate for Mars Science Laboratory [11], HiRISE and CRISM data will be acquired for this crater over the next year or so, and we anticipate using these new data to better assess the crater-filling deposits and their regional significance.

Conclusions: A variety of data suggests that SW Arabia Terra has had a considerable aqueous history. The varying morphologies of the rampart ejecta blankets suggest differing degrees of erosion and hence differing ages of impacts into fluid-rich targets (Fig. 1). This, coupled with the profusion of rampart craters, suggests that fluids have existed in the subsurface [10] for extended periods. In addition, prior regional analysis of layered sediments over all of Arabia Terra has suggested a history of wet conditions as well as an aqueous origin for at least some of the layered deposits [12, 13]. These observations, together with the spectroscopic evidence for shallow aqueous phases, imply that significant quantities of fluids have been in the subsurface.

It may be that the regional setting of SW Arabia Terra predisposed this area to receive abundant surface and sub-surface waters (surface waters from southern highlands runoff and extensions of circum-Chryse outflows; sub-surface waters from updip migration out of the proposed giant Arabia Basin to the east). If such processes did occur, they may have resulted in settings with relatively long-lived aqueous conditions, and that, coupled with subsequent uplift and erosion of the basin proper [6], may help to explain the vast sedimentary deposits in the region.

References: [1] Boynton W.V. *et al*. (2002) *Science*, *297*, 81-85. [2] Feldman W.C. *et al.* (2002) *Science*, *297*, 75-78. [3] The name, Vernal, has recently been approved by the IAU WGPSN. [4] Christensen, P.R. *et al*., *THEMIS Public Data Releases*, Az. State Univ., http://themis-data.asu.edu. [5] Mars Orbiter Camera images, Malin Space Science Systems., www.msss.com/moc_gallery/. [6] Dohm, J.M. *et al.* (2004) *LPS XXXV*, Abs. #1209. [7] Barlow, N.G. & Dohm, J.M. (2004) *LPS XXXV,* Abs. #1122. [8] Malin, M.C. & Edgett, K.S. (2000) *Science, 290*, 1927-1937. [9] Edgett, K.S. (2005) *Mars. Intl. J. Mars Science & Expl. 1*, 5-58. [10] Barlow, N.G. & Bradley, T.L. (1990) *Icarus, 87*, 156-179. [11] Paris, K.N. *et al.* (2007) *LPS XXXVIII.* [12] Venechuk, E.M. *et al.* (2006) *LPS XXXVII,* Abs. #1380. [13] Venechuk, E.M. (2006) Thesis, Scripps College, Claremont, CA.