**Signatures of Hydrated Minerals from Lampland Crater in the Thaumasia region of Mars.** Pragya Singh[1], Ranjan Sarkar[1], Alok Porwal[1], [1]Geology and Mineral Resources Group, CSRE, Indian Institute of Technology, Bombay, (pragya.singh@iitb.ac.in).

**Introduction:** We report upon hydrated minerals, including sulfates and phyllosilicates, in Lampland Crater (35° 33' S; 79° 35' W). Lampland has a diameter of 75 km and is located in Thaumasia, Mars.

The Thaumasia region (Fig.1a) is mostly a plateau area consisting of high lava plains formed during the Noachian and Hesperian; it has a complex volcano-tectonic past [1]. Lampland (Fig.1b) is located on the Thaumasia highlands, an ancient mountain range [2, 3].

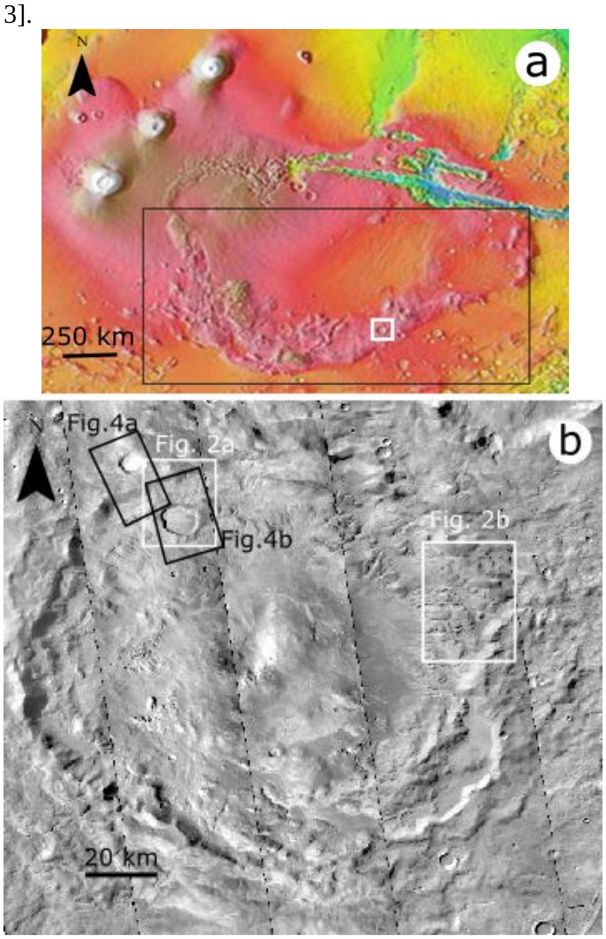


Fig. 1. (a) Thaumasia region (black box) on MOLA elevation map with white box showing the location of Lampland crater. (b) Context Camera mosaic of Lampland crater. Locations of subsequent figures are shown with boxes.

**Methodology:** Minerals are observed using the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), onboard the Mars Reconnaissance Orbiter (MRO), which is an imaging spectrometer covering visible to near-infrared regions of the electromagnetic spectrum with two modes of operation, targeted and survey [4]. The targeted mode collects data in 545 channels as Full Resolution Targeted (FRT) at 18m/pixel (FRT) and Half Resolution Long (HRL) at 36m/pixel. Survey mode collects data as Multispectral Reduced Data Record (MRDR) containing 72 bands and ~200m/pixel. We used multispectral survey data for an overall study of the crater's mineralogy; and HRL data to study the part of north-west side of the crater where HRL is available.

Additionally, for the morphological studies we used MRO Context Camera (CTX) ~6m/pixel greyscale images [5].

For mineral identification, we implemented the summary products based on Viviano-Beck et al. (2014) to identify the hydrous and hydrated mineral species [6]. In the multi-spectral images, we used 2*2 average window as the spatial resolution is coarse (~200 m) and for HRL images, we used 3*3 average window to collect the spectra.

**Results and Discussions:** In Lampland Crater, the hydrated minerals occur in the form of light-toned sulfates and phyllosilicates. Sulfates are often associated with water-ice signatures and are mainly observed within the crater wall, while phyllosilicates are found within the central mounds.

The ejecta of the crater is highly degraded and channels/rill/gullies are observed around the crater rim which indicate past fluvial activity. Although, channels are present all around the rim, the northern part of the ejecta deposit shows denser channels compared to the southern part (Fig. 2a). Also, the hydrated minerals are often associated with the channels/rills.

Along the crater rim, a distinct bright material is observed, particularly at the base of the rim (Fig 2b) in the area where the channels dominate. This bright material is also present in the nearby smaller craters (Fig. 2b). This bright material is correlates with the presence of hydrous and hydrated minerals. In HRL data this material shows the signatures of sulfate and water ice (broad absorption at 1.5 and 2.0 µm) [7].

Figure 3 shows the multispectral image, which is a part of CRISM global survey tile T0499, and the corresponding spectral features. Spectra identified in this work contain absorptions at 1.4 and 1.9 µm, which are common to all these mineral species. In places, absorption at 2.2 µm is observed, which suggests the presence of an Al-bearing clay [8]. Spectra in the central mound region is dominated by 2.3 μm absorptions indicating Fe/Mg phyllosilicates [8, 9].

HRL data show absorptions at 1.4, 1.9, 2.09, and 2.4 μm (Fig. 4a and 4b), along with 1.5 and 2.002 mm absorptions. Spectra dominated with 2.09 and 2.4 μm absorptions are characteristic of Szomolnokite ($FeSO_4.H_2O$) [9, 10]. The 1.2 μm image, which is related to $Fe^{2+}$ absorption [9], is dominant throughout the HRL images, also suggesting iron rich mineral species. The 1.5 and 2.002 μm absorptions are probably due to water ice [7].

The presence of sulfates can be attributed to the evaporative precipitation of acidic groundwater that seeped through radial fractures. Additionally, this crater can possibly represent a paleolake formed by the ponding of groundwater. Similar processes have been suggested for Columbus and Cross craters, in which sulfates are observed and their precipitation mechanism is suggested to have been upwelling and evaporation of groundwater [11].

Hydrated sulfates/ice mixed layers mostly occur at higher elevations, along the crater walls, while the phyllosilicates are found at lower elevations, mostly on the crater floor. The phyllosilicates could be of Noachian age, occurring in the subsurface, which had been uplifted and exposed through the crater formation [12]. A second possibility is that these formed during the Hesperian through impact-induced hydrothermal activity and subsequent aqueous alteration [13, 14].

**Summary:** In Lampland crater, hydrated sulfates occur as layers on the crater wall while phyllosilicates are found in the mounds on the floor. Sulfates have possibly formed through evaporation of groundwater seeping through fractures along the crater rim that were created during the cratering event. Also, the possible presence of water-ice could make the target exobiologically significant.

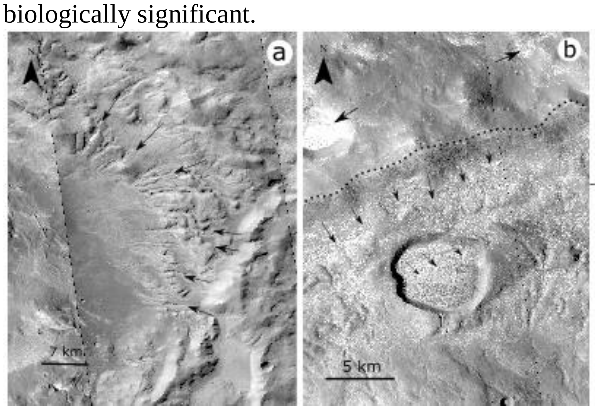


Fig.2. (a) Well developed channels/rills around the rim. Direction of water flow is shown by arrows. (b) Wall of the crater with arrows showing gullies and bright material deposited at the base. The dotted line shows the crater rim and the arrows point towards the deposited material.

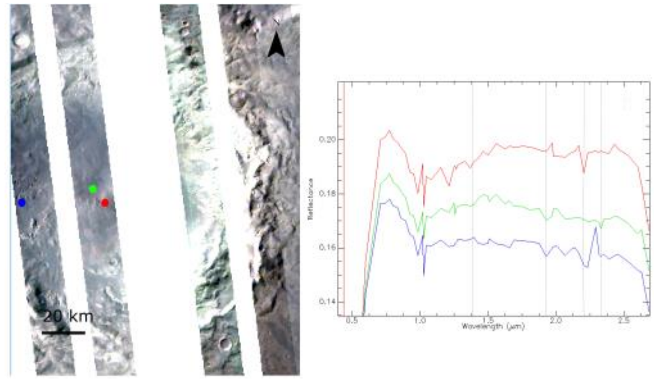


Fig. 3. Multi-spectral image (part of tile T0499) of the crater and corresponding spectra. Location is color-coded with the corresponding spectra. Absorptions at ~1.4 (ranging 1.38–1.46), 1.9, 2.2 and 2.9 μm is observed.

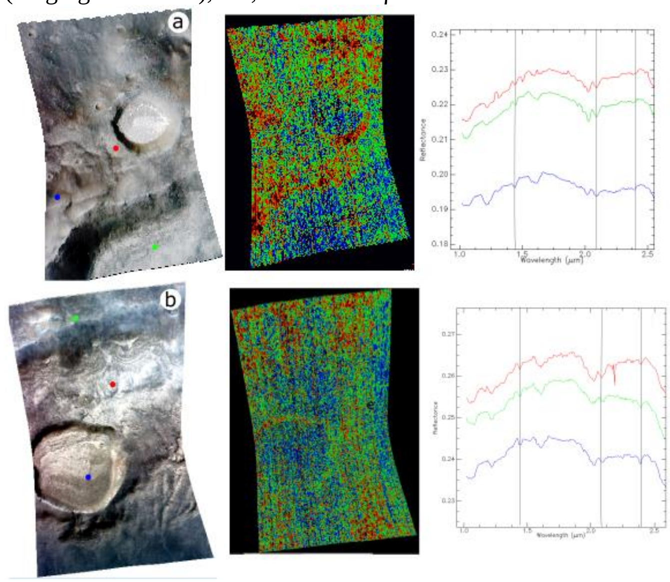


Fig.4. (a) CRISM image (HRL00007A4F) and (b) CRISM image (HRL0000641C) along with the SINDEX summary product and corresponding spectra collected from different parts of the crater (Spectra are color-coded with the location). Absorptions at 1.4, 2.09 and 2.4 μm are observed. Additional broad absorptions at 1.55 and 2.0 μm could be related to water ice.

**References:** [1] Dohm, D. M. and Tanaka, K. L. (1998) PSS, 47, 411-431. [2] Dohm, D. M. et al. (2001a) JGR, 106, 12301-12314. [3] Dohm, D. M. et al. (2001b) USGS Map, I-2650. [4] Murchi et al. (2007) JGR, [5] Malin et al. (2007) JGR, 112(E5). [6] Viviano-Beck et al. (2014) JGR, 119(6), 1403-1431. [7] Clark (1981) JGR, 86(B4), 3087-3096. [8] Clark et al (1990) JGR, 95(B8), 12653-12680. [9] Elhmann et al. (2009) JGR, 114(E2). [10] Cloutis et al. (2006) Icarus, 184(1): 121-157. [11] Wray et al. (2011) JGR, 116(E1). [12] Bibring, J. P. et al. (2006) Science, 312, 400-404. [13] Fairén, A. G. et al. (2010) PNAS, 107.27 12095-12100. [14] Marzo, G. A., et al. (2010) Icarus, 208.2 667-683.