An Integrated Study of Light-toned Layered Outcrops (LLOs) in Iani Chaos.

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Introduction: We describe the geomorphological, mineralogical and thermal characteristics of light-toned layered outcrops (LLOs) in Iani Chaos. In conducting an integrated GIS-based study, we map LLOs at high-resolution, elucidate the LLOs relationship with the chaotic terrain in which they are found, highlight how they may have been affected during the outflow events that formed Ares Valles [1] and work towards clarifying their pre-chaos mode of formation.

Data processing: Data from Mars Global Surveyor's Mars Orbiter Camera and Laser Altimeter (MOC and MOLA), Mars Express' High Resolution Stereo Camera (HRSC), Mars Odyssey's Thermal Emission Imaging Spectrometer (THEMIS) and Mars Reconnaissance Orbiter's Context Imager (CTX) was processed, georeferenced (in a Sinusoidal projection with a meridian of 342°E) and ingested into ArcGIS. THEMIS IR images were processed using the THEMIS processing web interface at thmproc.asu and subsequently used with HRSC (where available) and 128 pixel degree^{-1} MOLA topography to derive best-fit thermal-inertia and albedo [2].

Geomorphological description: We mapped light-toned layered outcrops in Iani Chaos to the scale that data resolution and coverage allowed. The main outcrops are found in depressions, often interspersed with chaotic mounds and are labelled a–d in figure 1. These have been previously mapped by [3] at the scale of Mars Orbital Camera Wide Angle images ($\sim$240m pixel^{-1}).

Typically, LLOs in this region show a pitted, fractured texture and have virtually no small craters. Outcrops towards the head of Ares Valles in region b (figure 1) often show directional erosion features and yardangs (parallel wind-formed ridges). They are $\sim$20–50m in width and adjacent depressions are infilled with a dark material that appears to be wind-blown sand (THEMIS thermal inertia of 300 tiu). HiRISE (PSP_008100_1790) shows fine layering in b with beds at the $\sim$5m scale, apparently exposed by weathering processes.

Yardang-like features in region b show a predominantly NW-SE ridge orientation and, along with the lack of craters, indicate wind-erosion. Similar features on the deposit in region d tend to be oriented roughly SW-NE. Region d's outcrop also shows a pronounced bench-cliff structure which is most prominent on the NE face, perhaps suggesting a SW-NE direction of paleo fluid flow. This orientation is commensurate with a flow direction towards the head of Ares Valles. Yardang-like features

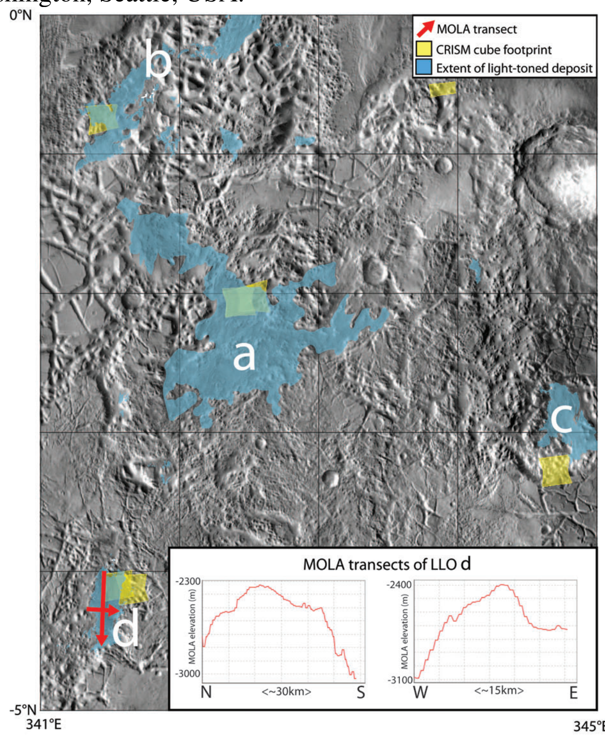

Figure 1: Distribution of LLOs in Iani Chaos, regions a – d (blue). CRISM footprints of the region are shown in yellow. The backdrop is a THEMIS daytime IR mosaic available through JMars (jmars.asu.edu).

atop LLO d are heavily streamlined, indicating strong erosion. Bench-cliff layered surfaces are etched and pitted at the decameter-scale (HiRISE PSP_082628_1760), strongly reminiscent of similar surfaces in LLOs elsewhere (e.g. Aram Chaos). Yardangs, windblown sand, etching, pits and lack of craters all indicate a continuing process of deflation of the LLOs.

Topographic analysis: Using MOLA gridded 128 pixel degree^{-1} data we extracted and calculated statistics for MOLA pixels contained in the blue polygons in figure 1. LLOs in Iani Chaos are spread over an elevation range of $\sim$2100m (figure 3). The elevation overlap may suggest previously more extensive deposits. Formations in region b, towards the head-water of Ares Valles, appear to be topographically depressed by $\sim$300m relative to the average for LLOs in Iani Chaos. These features lie in depressions that are below the elevation of the beginning of the main channel in Ares Valles. Outcrops in regions b and d appear to have a dome-like shape (figure 1, MOLA transects). Those in regions a and c show a

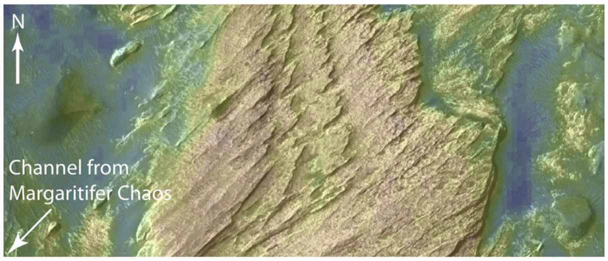

Figure 2: The scoured surface of the main LLO in region d. THEMIS derived thermal-inertia (blue = 250, red = 700 J m^{-2} $s^{-1/2}$ K^{-1}) overlain on CTX image P03_002206_1758_XI_04S018W.

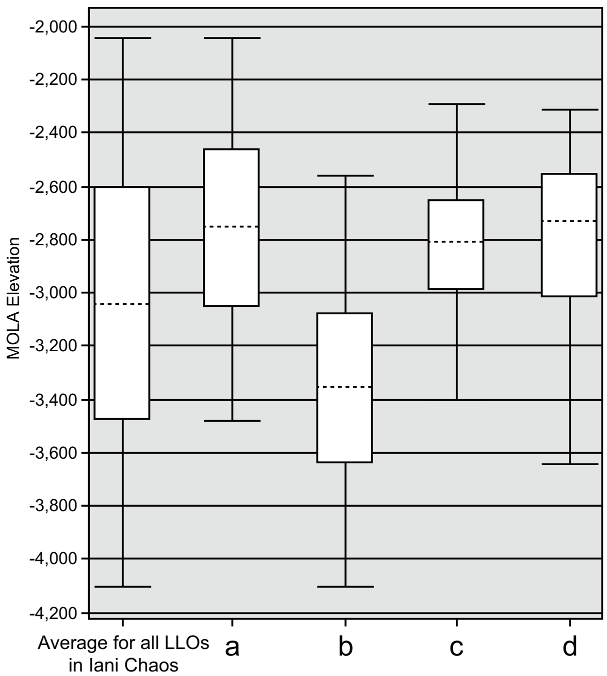

Figure 3: Box and whisker plot showing the elevation range of LLOs in Iani Chaos according to 128 pixel degree^{-1} MOLA gridded topography. Whiskers mark the maximum and minimum elevations, while the 25$^{\mathrm{th}}$ and 75$^{\mathrm{th}}$ percentiles are marked by the lower and upper edge of the box, respectively. The mean is marked by the central dashed line.

more complex shape, but generally exhibit higher elevation than the depressions they lie in.

Analysis of CRISM data: Eight CRISM data cubes with footprints in Iani Chaos were corrected for the effects of the atmospheric absorption and an off-nadir incidence angle, then cleaned via despiking and destriping routines built into the CRISM Analysis Tool (CAT) for ENVI. Spectral summary products [4] were produced and the resulting data was georeferenced. We

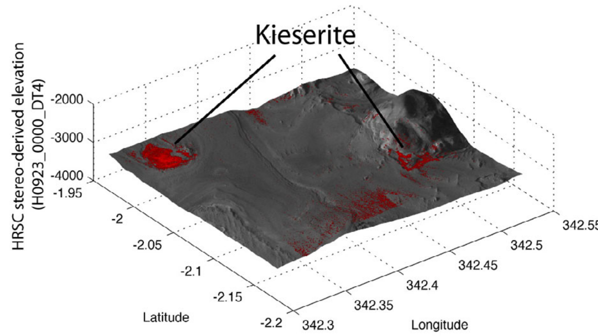

Figure 4: Central region 'a' (CRISM cube frt00007e16_07_if165l): The spectral summary parameter BD2100 (indicative of monohydrated minerals) overlaid and draped on HRSC nadir imagery and stereo topography. Two localities in this cube allowed positive identification of kieserite by comparison of ratioed spectra with laboratory spectra.

conduct targeted analysis of specific outcrops and positively identify kieserite ($MgSO_4$ H_2O) in multiple locations (and spanning a large range of elevations (e.g. figure 4). Mono-hydrated sulfate minerals [5] and hematite [3] have previously been detected in region a, while gypsum was reported atop the LLO in region d [6].

Discussion and Conclusions: The exposures of LLOs in Iani Chaos occupy $\sim$5500km^3. We conduct a regional scale study to elucidate their stratigraphic, mineralogical and morphological relationships with each other and the chaotic terrain in which they are found. We deduce they are remnants of a previously more extensive deposit(s), with a common origin, that has since been buried, saturated and exhumed. Erosional and bedding features suggest it is likely that deposits in regions a and c were likely subject to far less energetic fluvial activity during outflow than those in regions b and d.

References: [1] Warner, N. et al. (2009) Earth and Plan. Sci. Letters 288, 58–69. [2] Catling, D. C. et al. (2006) Icarus 181 (1), 26–51. [3] Glotch, T. D. and Rogers, A. D. (2007) J. Geophys. Res. 112(E06001), 1–11. [4] Pelkey, S. M. et al. (2007) J. Geophys. Res. 112(E08S14), 1–18. [5] Noe Dobrea, E. Z. et al. (2006) LPSC (37th) Abstract #2068. [6] Gendrin, A. et al. (2005) Science, 307, 1587-1591.