THERMOKARST PALEOLAKE ASSEMBLAGES AND CHANNELS IN LYOT CRATER, MARS. N. H. Glines and V. C. Gulick, The SETI Institute / NASA Ames Research Center (MS239-20, Moffett Field, CA, 94035 | natalie.glines@nasa.gov | virginia.c.gulick@nasa.gov).

Introduction: In the process of mapping channels and gullies in and around Lyot Crater [1], these curious circular depressions came to our attention. At first glance, they resemble clusters of secondary impact craters, however, their rims are flush with the surrounding terrain. There is no sign of ejecta around them, and the depressions are not buried. The depressions are flat-floored, circular-to-oblong features, resembling lake basins, connected by channels networks. We mapped and measured these features, then compared them to Earth analogs for similar circular-to-oblong depressions connected by channels.

Lyot Crater itself is in an ice-rich environment with a history of landcover by both liquid water and ice. Lyot is along the martian dichotomy boundary, and may have formed by impact into a regional surface ice sheet [2,3], possibly left over from a frozen ocean. The floor of Lyot lies at the lowest elevation in the northern hemisphere, where surface pressures can exceed 10 mbar in the present-day [4]. Summer temperatures in the recent past would have readily enabled any available liquid surface water to flow and pond.

Mapping & Measurements: We have mapped the distribution of channel and circular depressions in Lyot Crater in ArcGIS. The highest density of features are located within the region of Figure 1, a few tens of kilometers north and northwest of the gullied central peak region of Lyot Crater. Most of these features occur on overall slopes below 6 degrees (green and blue slopes, Fig.1), unlike the local central peak gullies, which originate on slopes greater than 15 degrees.

The average diameter of the circular depressions here in Lyot is ~200m, with a wide range of ~50-600m, although we did not measure smaller pits partially, because it is unclear whether these smallest pits are related to water thaw or flow, or related to sublimation processes, so if they were to be included, the average would be much less than 200m.

The MGS MOLA (MEGDR) DEM has a resolution of ~463 meters/pixel, which is insufficient to record the slopes of the individual depressions, but we note that many depressions correspond with lower slopes, and extended channels correspond to steeper overall slopes. The origin and terminus points of the channel features that we mapped are indistinct, and there is no clear source basin or terminal lake perimeter to define. Some channel-like depressions run perpendicular to the downslope trend, forming a polygonal network pattern. Southeast of the Central Peak, fractures outline polygons from 500-1000 meters across, which suggests thermal contraction fracturing.

Figure 1: Slope map of potential beaded channels (blue) on the floor of Lyot Crater, N/NW of the central peak and its gullies (red). Black inset is HiRISE ESP_252628_2310 footprint. Contours are 100m. North is up. Base is MOLA (-5485m to -6996m) on C T X images D01_27719.2307.XN.50N.331W & G23.027376.2307.XN.50N.330W. Centered at (29°E, 50.65°N).

Analog: The morphology, slope distribution, and diameter range of the depressions and channels indicate these features are most comparable to high-latitude/high-altitude thermokarst lake assemblages. While the overall morphology resembles thermokarst beaded streams, many of the larger diameters we measure are more similar to thermokarst lake basins. Beaded streams are thermokarst river systems, which develop perennially from uneven subsidence following the thawing of excess ice wedges in tundra (ice-rich permafrost thaw) [5,6].

Beaded streams on Earth are located on moderately-sloping mostly medium- to high- ground ice-content permafrost, in low marine terraces, river floodplains, discharge canals of lakes, or the floors of recently drained lakes [7]. Thermokarst lake and smaller beaded stream features are associated with ice-rich permafrost regions. Environments with thermokarst features of beaded streams and lakes include Alaska, Canada, and Siberia.
Beaded ponds on Earth are ~2 m deep and have diameters ~20 m across [7,8]. This is similar to values we measure in northern Alaska and inland of the Alaskan Kotzebue Sound (25.3 meters average diameter). This is much lower than the dimensions of the beads and paleolakes in Lyot, which average ~200 m diameter or less. However, thermokarst lakes on Earth can coalesce to reach diameters of several kilometers [9]. Thermokarst basins studied by Ulrich et al., [10] record lake growth in Eastern Siberia to an estimated size of 120-600 m in diameter and 7.5-15 m depth, and they show that even short-term warming can lead to active permafrost degradation. Controls on beaded-channel morphology include size, pattern, and form of tundra or large local thermokarst landforms, such as drained thermokarst lake basins.

![Figure 2: Potential beaded streams modified by sublimation on the floor of Lyot Crater. View corresponds to Fig.1 black inset. White lines indicate locations of measurements to compare with Earth analogs. Flow direction would be left to right, over an overall 3.2-5.5° slope (MOLA). HiRISE ESP_052628_2310. Contours are 100 m. North indicated by arrow.](image)

Although there needs to be significantly more research done on terrestrial beaded stream networks, the slopes of some beaded ponds on Earth are observed to range from ~0.001 to 0.008 m/m [7,8].

In spring and summer on Earth, water primarily from snow melt flows through beaded streams. Tundra streams have low alkalinity, pH, and conductivity, compared to other high-latitude streams (mountain and spring) [11]. Winter snow cover increases insulation to stabilize liquid water and taliks below many beaded pools [7]. The ice-rich Latitude-Dependent Mantle of Mars may have provided similar insulation in Lyot.

Interpretations: Permafrost wedging would explain the perpendicular channels connecting the bead depressions in Lyot. These also could be fractures formed by thermal contraction without requiring liquid water, instead triggered by a sharp drop in temperature [12,13]. We do not see benches or terraces in thermokarst ponds that are indicative of episodic evaporation or drainage. Since the surface pressure here can exceed 10 mbar, and so high summer temperatures in the recent past would have enabled liquid surface water to flow and pond. While it may be expected to see these beaded channels at the lowest elevation on the floor of Lyot, where liquid water is most likely to be stable, there are no beads or channels below ~6900 m in elevation. While there is no clear perimeter for a standing body of water, it cannot be ruled out since the area is mantled with dust.

The floor or palelakebed of the beaded channels is smooth, flat, and dust-covered. Dust that clung to the ice cover of the beaded streams may have prevented sublimation of some bead pools, while other pools, particularly the largest ones, are less dusty, concave, and of variable texture. This suggests that ice which experienced recent freeze-thaw cycling may be preserved beneath the dust cover, making these beaded streams targets of astrobiological interest. The features would indicate pockets of near-surface ground ice, which could preserve evidence of life, and are relatively accessible in the near-subsurface.

On Earth, where slopes are ≥2°, better drainage prevents water accumulation and restricts lake formation, while affecting the lateral growth of existing thermokarst lakes and channels [9], which may explain why some of these potential Lyot paleolakes are more elongate than others. There is a lack of significant meanders to the channels, probably because of the slope, but mainly because many channels developed along the polygonized ground in the area.

Future work includes the production of a higher resolution CTX DTM to study how subtleties in slope have influenced the distributions of the lakes/ponds, and the channel segments.

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