INVESTIGATING POTENTIAL THAW OR FREEZE-THAW PALEOLAKES AND CHANNELS ON THE FLOOR OF LYOT CRATER, MARS. N. H. Glines[1,2] and V. C. Gulick[2], [1]University of California Santa Cruz (nglines@ucsc.edu), [2]NASA Ames/SETI Institute, NASA Ames Research Center, MS 239-20, Moffett Field, CA.

Introduction: We have found an intriguing collection of flat-floored highly circular depressions in a network of channels on the floor of Lyot Crater, Mars (Fig.1) [1,7]. These features lack ejecta or raised rims, occur in trends downslope, coalesce seamlessly, appear contemporaneous with water channels, are restricted to low slopes, and terminate along a common elevation, which we interpret as a paleolake margin.

Is this a secondary crater field with a complex history, or could these features have formed by any of the other processes which form ‘circular depressions’ in Mars-analog Earth environments? Here we consider these features from the perspective that not all circular depressions on planetary surfaces must be craters.

We have mapped and measured the depressions, associated landforms, and terrains, and evaluated hypotheses for their identity and formation.

The Setting: Lyot is a large 220 km diameter Amazonian crater on the Martian Dichotomy Boundary, which marks the distinction between the southern highlands, which are heavily cratered and dissected by valleys, and the younger northern lowlands, which are suggested to have held an ancient ocean. Lyot may have formed by impact into a regional surface ice sheet [2], and meltwater channels trail from its ejecta [3]. Meltwater channels within SE Lyot have been identified, and their substrate is a stippled mantle unit dated to 0.8-1.5 Ga and morphologically identical to that on Lyot’s north floor [4]. There is significant ice south of Lyot in Deuteronilus Mensae [5] which had major activity in ~100-500 Ma [6]. Gullies on Lyot’s central peak studied by [7] may have sourced from meltwater of the subsurface and snowpacks. This varied evidence suggest the region has been shaped by water and ice, and that water flowed here in the recent past.

The floor of Lyot marks the lowest elevation in the Northern Hemisphere of Mars. There is high hydraulic head leading into the crater, and sufficient surface pressure today for water to be liquid given adequate temperatures several degrees above the peak temperatures recorded today, and this may have occurred during the last obliquity shift, or given the presence of freezing point depressants (e.g., salts).

Considering These Features: These features were initially observed in HiRISE image pair ESP_052628_2310 and ESP_052694_2310 [8]. Though visible and mapped at CTX-resolution, they are best resolved by HiRISE. They appear seamless and contemporaneous with the channels and there is no visible widening and breaching or deformation.

Mapping. The mapping region presented here is a 90x52 km rectangle, but we may have found more features to the SE and in the same substrate. We mapped the circular depressions, channels or linear fracture-like troughs, and a deposit at a channel mouth. We mapped topographic depressions where water would have ponded as indicated by inlet and outlet channels and curious rock exposed by the channels, as well as craters and textured terrains.

We recorded diameters of the circular depressions and widths of all channels and fracture-like troughs. We used the Ames Stereo Pipeline (ASP; 9] to produce a CTX DTM aligned to MOLA to acquire 3D data.

Measured depressions range up to ~600 m diameter and smaller pits approach the limit of resolution. Mean depression depth is less than 4 m. The depressions are found in the stippled mantle unit on slopes < 6°. Channel/trough widths range from 5 to 362 m. NE of the central peak is a downslope-trending system of depressions, fractures, and channels leading into the deposit. Upslope are coalesced basins, triple in size, ‘open’ upslope and blanketed in a dusty unit, transitioning to scalloped terrain.

Possible Identifications: *Secondaries* reworked by ice and water, *karst sinkholes*, glacial *kettles*, and *thermokarst* thaw lakes or freeze-thaw beaded streams.

Secondaries. Secondary craters are correlated with and centered upon a primary source crater and appear as an annulus or in clusters/chains with rays up to several thousand km from the origin [10]. Secondaries may have raised rims between them, and are not restricted to a certain slope, though may have preferential preservation depending on substrate. Trends of the features point downslope toward the crater floor or perpendicular to slope, rather than to one origin if they were secondaries. Lines fit to the chains indicate multiple points of origin (NE, N, SE).

We do identify 52 distinct craters in this region, ranging from a fresh 6-12 m cluster of 4 seen in HiRISE up to a crater nearly 4 km. > 80% of the remainder have diameters between 37 and 430 m.

Secondary crater fields are rare at high latitudes on Mars [11] which may be due to ice loss [12]. There are inverted egg-like secondaries in Acidalia [13]. These features may be ice-reworked secondaries, but why wouldn’t they resemble the Acidalia high-latitude field? Why would they only be found on low slopes?

Karst Sinkholes. Karst forms by the dissolution, corrosion, subsidence, or collapse of carbonate and evaporite rocks, often triggered by water table flux. Karst has been identified on Mars since Viking, and recently in Tyrrhena, Iani Chaos, and Noctis Labyrinthus. Karst may be markers of climatic changes and water. An analog may be the sinkholes bordering the receding Dead Sea [15], associated with channels and perpendicular-to-slope/concentric fractures.

Kettles. Glaciofluvial depressions in deglaciated outwash areas. They form when ice is left behind by a retreating glacier and covered by debris, resulting in the collapse of the debris when the ice melts. This may form a kettle hole or kettle lake. They may be ringed by till ridges, form on low slopes, and may be larger than terrestrial sinkholes. Kettle-like features on Mars have been identified delineating the north polar cap, and the south circum-polar paleolake, as well as Chryse, Acidalia, and the floors of Maja and Ares Valles. They reflect a change of climatic regime.

Thermokarst. Permafrost that loses structural integrity due to changes in temperature and/or pressure produce thermokarst: thaw lakes and ponds, drained lake basins, retrogressive thaw slumps, thermokarst troughs and pits, flooded ice-wedge polygons, beaded streams, and thermokarst mounds. Beaded streams (Fig.2) develop perennially from excess ice wedge thaw in continuous ice content tundra and are markers of long-term freeze-thaw. Thermokarst is identified on Mars in Utopia, and Peneus and Amphitrites Paterae.

Local Landforms:

Deposit. Planform triangular and cross-sectional wedge geometry, ~960 m long, ~388 m wide, origin at -6865 m in elevation seen in ESP_055384_2310. The deposit has fractures through its upper section. Deposit thickness is 14 m max calculated in the CTX DTM. There is no PEDR point through the deposit center, but its top and bottom verify a thickness > 10 m.

Ridgelines. Located at the same elevation as the deposit. Seen in ESP_052628_2310, a ridge is in-line with upslope channels and may be an inverted channel.

Terrains. Scalloped terrain, which may have developed <10-20 Ma by insolation-driven degradation of icy terrain, emerges upslope from the same material which covers the circular depressions. The scalloped depressions overlay putative TARs. Scallops are also found below the peak gullies. 10m polygons are on floors of the lowest elevation circular depressions. 'Gullygons' are ~10 m but appear 'scalier'. SE of the peak are 100 m-scale fracture-outlined high-centered polygons, which we suppose may be the result of cooling contraction stresses exceeding ground strength, in ice-cemented material, or similar to Antarctic sand-wedge polygons on ice without an active layer [14].

Implications: There has been potential water freeze-thaw and flow on the floor of Lyot Crater in the Late Amazonian. A paleolake fed by a great channel system may have persisted on the floor of Lyot Crater and contained roughly 6 km^3 of water fed by thaw. Scalloped depressions indicate subsurface ice. Polygons and the pits may reflect the freeze-thaw environment above the triple point we could expect to see in higher obliquity conditions.

These circular features on Lyot's crater floor may be secondary craters with a complex icy history, or relict kettles/thaw lakes or freeze-thaw lakes. An analog identification of beaded streams implies a climate favorable to life in the past and that could preserve biological material in the near-subsurface [1,7]. This site may be significant to astrobiology and the search for evidence of life in the solar system.

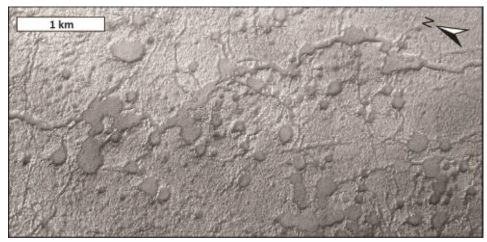

Figure 1: Strand of the circular features and channels NW of the central peak. Downslope is to the right.

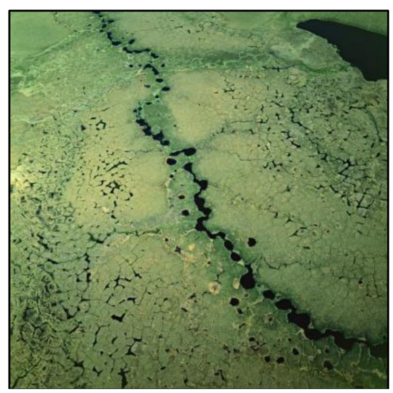

Figure 2: Analog beaded stream in Shingle Point, Alaska, August 2005. Aerial photograph provided by Bernhard Edmaier.

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