NEW SUPPORT FOR HYPOTHESES OF AN ANCIENT OCEAN ON MARS.

Dorothy Z. Oehler[1] and Carlton C. Allen[1]. [1]NASA, Johnson Space Center, Houston, TX 77058. dorothy.z.oehler@nasa.gov, carlton.c.allen@nasa.gov.

Summary: A new analog for the giant polygons in the Chryse-Acidalia area suggests that those features may have formed in a major body of water – likely a Late Hesperian to Early Amazonian ocean. This analog ***-terrestrial polygons in subsea, passive margin basins-*** derives from 3D seismic data that show similar-scale, polygonal fault systems in the subsurface of more than 50 terrestrial offshore basins. The terrestrial and martian polygons share similar sizes, basinwide distributions, tectonic settings, and association with expected fine-grained sediments. Late Hesperian deposition from outflow floods may have triggered formation of these polygons, by providing thick, rapidly-deposited, fine-grained sediments necessary for polygonal fracturing. The restriction of densely-occurring polygons to elevations below ~ - 4000 m to -4100 m supports inferences that a body of water controlled their formation. Those same elevations appear to restrict occurrence of polygons in Utopia Planitia, suggesting that this analog may apply also to Utopia and that similar processes may have occurred across the martian lowlands.

Introduction: The potential for an ancient martian ocean has been discussed for more than 20 years [1-14] though the subject is still controversial [15-20]. This study adds to that discussion with a new analog for the martian giant polygons [21] that implies their development in a major body of water [22].

Giant polygons are extensively developed in both Chryse/Acidalia and Utopia of the martian lowlands (Figs. 1-2), and although they have been recognized since the 70's, their origin and significance are still debated [summarized in 22]. These polygons range up to ~10-15 km across, and their large size distinguishes them from a variety of smaller-scale polygons (usually < 250 m) that have been observed on Mars.

Until recently there were few recognized examples of such large-scale polygonal features on Earth. However, with the advent of 3D seismic data, kilometer-scale polygonal fracture systems have been recognized in more than 50 offshore basins on Earth (Fig. 3) [23-29].

Terrestrial kilometer-scale polygons: The terrestrial polygons are thought to result from sediment compaction/dewatering in fine grained materials (muds) that have been rapidly deposited in settings lacking strong horizontal stress (passive margins) [21-22]. These subsea polygons occur in water depths of tens to thousands of meters and at burial depths from the near surface to ~1000 m below the sediment-water interface. They can have basinal extent (to > 10^6 km^2) and are commonly associated with fluid expulsion structures such as mud volcanoes (MV's) and depressions called pockmarks that result from subaqueous gas release.

Giant polygons in Chryse-Acidalia: Giant polygons are widespread in northern Chryse and southern Acidalia (Figs. 1-2) where they cover more than 10^6 km^2. Their distribution was mapped in 1986 using Viking data [30-31]. In this region, the giant polygons range to ~10 km across and are associated with thousands of bright mounds (Fig. 1), most recently interpreted as mud volcanoes [32]. Superposition relationships suggest that most of the mounds are younger than the giant polygons.

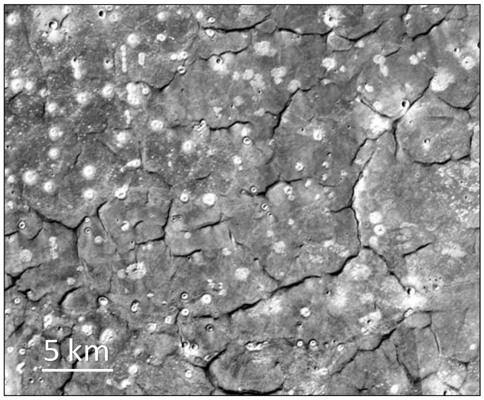

Fig. 1. Giant polygons and bright mounds in Acidalia (Context Camera [CTX] mosaic).

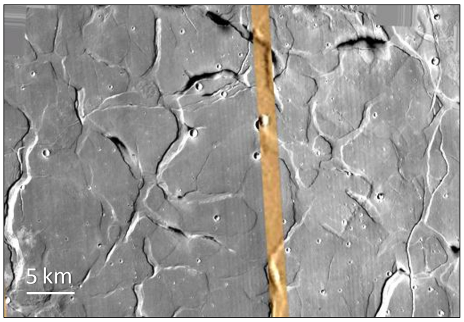

Fig. 2. Giant polygons in Utopia (CTX mosaic).

Comparison of terrestrial and martian giant polygons: ***Size***: Terrestrial large-scale polygons range from ~ 0.5 to 4 km across, while the martian features are typically larger, 2-10 km across. Nevertheless, in images from the High Resolution Imaging Science Experiment (HiRISE), many of the martian giant polygons appear to be composed of smaller 2nd-order polygons ~2.5-5 km across and other HiRISE images show subtle polygons, about 1 km across, in the region. In addition, the sizes of the terrestrial polygons

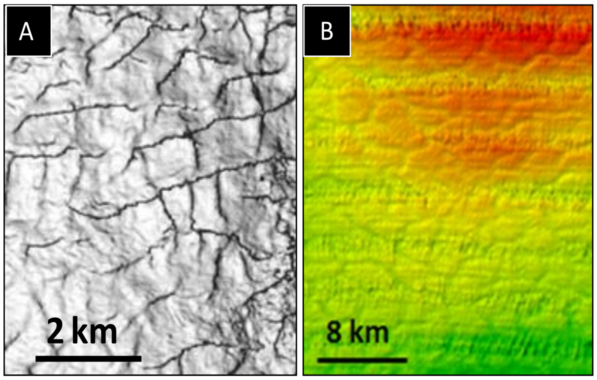

Fig. 3. Terrestrial offshore polygons. **A**. Map from 3D seismic data, offshore Norway [28]. **B**. Seafloor bathymetry showing exposed polygons, Hatton Basin, offshore Ireland; colors, water depths: red = -1150 m below sea level (bsl) and green = -1350 m bsl. Image courtesy of Dr. C. Berndt & the Geol. Survey of Ireland.

scale with burial depth and grain size, such that larger features are expected in areas with least burial (*e.g.*, Fig. 3B) and/or smallest grain size. These may be most comparable to the martian giant polygons. ***Geologic Context***: The terrestrial features form in passive margins – often in subsea deltaic deposits that have accumulated rapidly. On Mars, the general lack of plate tectonics would have resulted in many basinal settings being similar to passive margins (lacking strong horizontal compressive stress). ***Sediment type and rate of deposition****:* The large-scale polygonal fractures occur exclusively in fine grained sediments and rapid deposition has been implicated in several occurrences. On Mars, previous work has suggested that the catastrophic, late Hesperian outflow floods would have resulted in massive amounts of rapidly-deposited distal facies (fine-grained) sediments being deposited in northern Chryse and Southern Acidalia. [32-33]. ***Association with mud volcanoes****:* The terrestrial large-scale polygons commonly occur in basins with fluid expulsion features such as mud volcanoes and pockmarks. Spatially, the polygons, mud volcanoes and pockmarks can overlap, they can be adjacent to one another, or each may occur in isolation. In most terrestrial offshore basins with giant polygons, mud volcanoes are found in the tens to hundreds while pockmarks can occur in the thousands. In Acidalia, the mud-volcano-like mounds have been estimated to number ~ 40,000 [32] and although they appear to be related to the giant polygons (in that both features are densely developed in similar regions), their great number may be a result of fluid expulsion processes unique to Acidalia [32]. Few comparable mounds occur in Utopia (though possible pingos have been described [34-35]). This disparity between Utopia and Chryse-Acidalia is likely to reflect their distinct histories (*e.g.*, timing and amount of sediment infill, temperature history, hydrology, etc.). ***Elevation****:* Both the mounds and giant polygons in Chryse-Acidalia are densely developed below elevations of - 4000 to - 4100 m and they are absent above elevations of - 3900 m [22]. Giant polygons in Utopia appear to be restricted by similar elevations. This elevation range spans the recently discussed "Acidalia Level" [36] in east Acidalia as well as the earlier described "Contact 2" of Parker *et al.* [1-2] (-3800 m to -4000 m), which was noted by Head *et al.* to be close to an equipotential line [7-8] (implying a relationship to a body of water). Terrestrial polygons exclusively occur in subsea basins.

Conclusions: Giant polygons in the martian lowlands may reflect major standing bodies of water that were also sites for deposition of fine-grained sediments. These characteristics would have produced habitable environments with high preservation potential for organics [33] due to the history of water combined with accumulation of fine-grained materials.

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