LAVA COILS AND DRIFTING PATTERNED GROUND IN CERBERUS PALUS, MARS. A. J. Ryan[1] and P. R. Christensen[1], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287; andy.ryan@asu.edu

Introduction: Athabasca Valles in Elysium Planitia is one of the best-preserved valley networks on Mars. Fluid emanating from the Cerberus Fossae, flowed Southwest through Athabasca Valles, and solidified ~300 km downstream in Cerberus Palus. Many large plates of rubbly material ('primary plates' hereafter) have clearly fractured, rotated, and drifted over many km in Cerberus Palus, leading to interpretations of pack ice rafts [1] or flood lava crust [2,3]. The inter-plate 'troughs' are patterned with meter-scale up-bowed polygons, similar to both periglacial patterned ground [4, 5] and lava crust contraction polygons [6]. Low crater densities indicate that these features may be very young (late-Amazonian; 1.5 to 200 Ma ago) [7]. It is therefore important to understand the potentially ongoing processes at work in this region and/or explain why crater densities are so low.

Observations: HiRISE image PSP_007250_1840 contains approximately 4 km^2 of relatively dust-free troughs that are patterned with polygons 5 to 15 meters in diameter. This terrain contains many spiral patterns 5 to 30 m wide (figure 1). The spirals are typically doubly voluted (like the letter "S") and crosscut by the polygon-forming cracks. In total, 269 spirals have been identified in this area (figure 2). 174 spirals have a clockwise-in orientation, 43 are counterclockwise-in, and 52 circular features remain unclassified due to resolution limits.

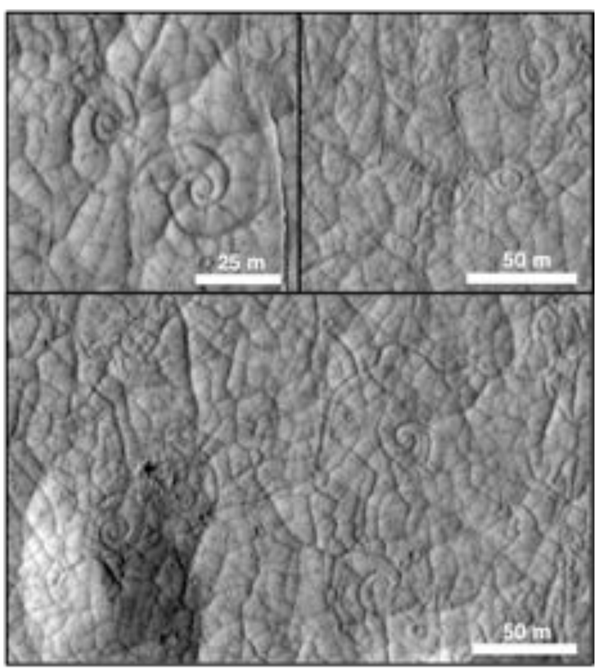

Figure 1. Spirals interpreted to be lava coils in the inter-plate troughs of HiRISE PSP_007250_1840.

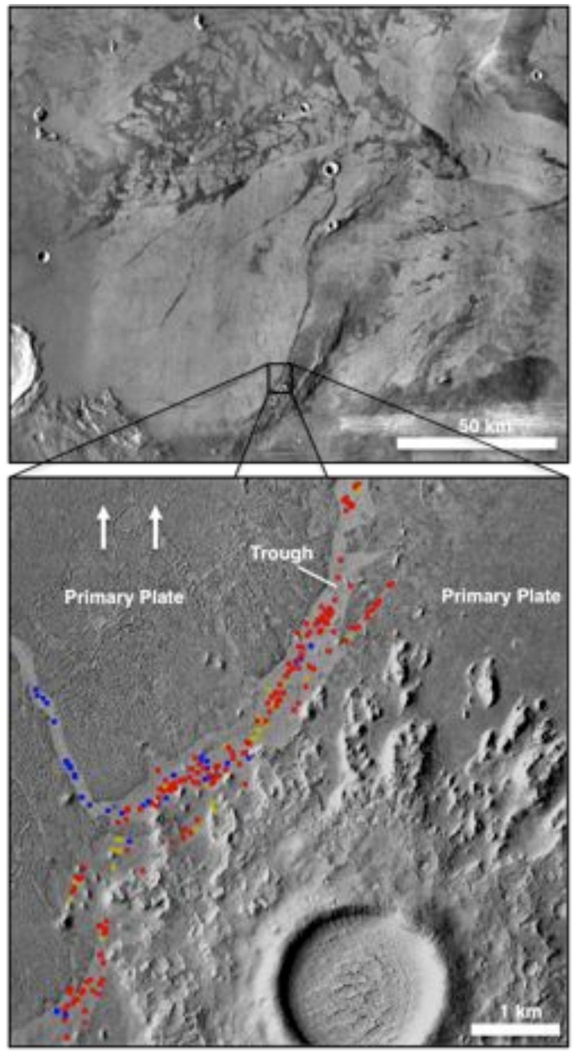

Figure 2. (Top) THEMIS day IR mosaic of Cerberus Palus. Primary plates near top of image have lighter tone than surroundings. (Bottom) Preliminary map of lava coils in HiRISE PSP_007250_1840 overlain on CTX P16_007250_1841_XI_04N209W (approx. 4.1° N, 150.1° E). Colored markers show lava coil orientation. Red are clockwise-in, blue are counterclockwise-in and yellow are undetermined. Arrows show general direction of plate drift.

In several locations, the troughs themselves have fractured into 'secondary plates' that have drifted apart much like the primary plates (figure 3). When pieces of these secondary plates are reassembled like a puzzle, it is apparent that the polygons and spirals are continuous across the zones of fracture. Therefore, they must have been present on the plates before the secondary fracture and drift occurred.

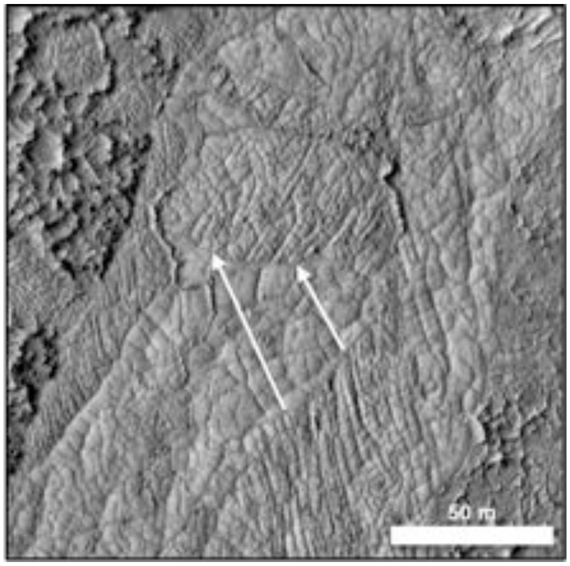

Figure 3. Oval-shaped secondary plate has fractured and rotated north within trough. Primary plate present on western edge of image. Note the lava coil near the NE corner. HiRISE PSP_007250_1840.

Discussion: The spiral patterns and convex polygons in Cerberus Palus are morphologically consistent with lava coils that form on the surface of active and stagnated pahoehoe lava flows and lava lakes in Hawaii [8]. Terrestrial coils range from 5 cm to at least 10 m in diameter and form in shear zones on the surface of active lava flows and lava lakes. With few exceptions, the orientation of the coils indicates the shear direction (e.g. clockwise-in indicates right-lateral shear) [8].

The polygons present in the troughs are the same size and shape as those that form on contracting, solidifying crust atop stagnated and inflated pahoehoe flows and lava lakes in Hawaii [9]. The up-bowing of the polygons may be attributed to the accumulation of gas exsolved from the underlying molten lava [6].

We propose that the primary plates formed as an early solidification crust atop an active lava flow. This crust fractured and drifted apart, exposing underlying molten lava. Lava coils formed on the surface of these exposed flows and were eventually preserved when a crust solidified, forming inter-plate troughs like those in figures 1, 2, and 3. This trough crust then fractured into smaller secondary plates, thus exposing underlying lavas and repeating the process of lava coil and secondary plate formation (e.g. figure 3).

The geometry of the primary and secondary plates indicates an overall N-S drift (figure 2 arrows). This is consistent with the shear direction in the troughs, as indicated by trends in lava coil orientation. This plate movement style of volcanism is morphologically similar to historical platy-ridge Icelandic lava flows [10].

Figure 4. Surface of December 31, 1974 pahoehoe northeast of Pu‘u Koa´e, Hawaii. Lava coils is 10 m diameter. Photo by Elliot Endo (U.S. Geological Survey) [11].

Conclusion: The plates, polygons, and lava coils in Cerberus Palus are primary volcanic structures. There are no known mechanisms to naturally produce spiral patterns in ice-rich environments on the scale and frequency observed in this area. It is also unlikely that ice-rich patterned regolith, which takes decades to centuries to develop, could fracture and drift. The lava coils and drifting polygonal and platy-ridge lava crust described above are therefore most consistent with known volcanic analogs, rather than ice-related processes.

References: [1] Murray J. B. et al. (2005) *Nature, 434,* 352–256. [2] Plescia J. B. (1990) *Icarus, 88,* 465–490. [3] Jaeger W. L. et al. (2007) *Science, 317*, 1709–1711. [4] Paige D. P. (2007) *Icarus, 89,* 83–117. [5] Balme M. R. and Gallagher C. (2009) *Earth & Planet. Sci. Lett., 285,* 1–15. [6] Peck D. L. and Minakami T. (1968) *Geol. Soc. Am. Bull., 106,* 351–370. [7] McEwen A. S. et al. (2005) *Icarus, 176,* 351–381. [8] Peck D. L. (1966) *USGS Prof. Paper 550B,* B148-B151. [9] Zimbelman J. R. et al. (2011) *LPS XLII,* Abstract #2443. [10] Keszthelyi L. et al. (2004) *Geochem. Geophys. Geosys., 5,* Q11014. [11] Lockwood J. P. et al. (2000) *USGS Prof. Paper 1613,* 10-13.