DISTRIBUTION, MORPHOLOGY AND STRUCTURAL ASSOCIATIONS OF MARTIAN PIT CRATER CHAINS. D. Y. Wyrick[1], D. A. Ferrill[1], D. W. Sims[1], and S. L. Colton[1], [1]CNWRA, Southwest Research Institute (6220 Culebra Road, San Antonio, TX 78249, USA, dwyrick@swri.org).

Introduction: Pit craters are circular to elliptical collapse features that commonly occur in alignments (chains) and that coalesce into troughs [1], [2], [3], [4], [5]. We have begun systematically mapping the regional distribution of pit chains in the western hemisphere of Mars using the Mars Orbiter Camera (MOC) data. Pit chains are most prominent in the Alba Patera region and along the Valles Marineris. They are also found in Tharsis Montes, the Noctis Labyrinthus and in the cratered region west of Daedalia Planum. Pit chains display many features that are commonly associated with extensional fault systems, and are often found within grabens or transitioning into grabens, although they are also found apart from a graben system. They also occur in en echelon arrays and a few display curved tips similar to interaction at the tips of en echelon faults or extension fractures [6]. Hypotheses regarding the formation of pit chains all require formation and collapse of substantial cavities. The following mechanisms have been proposed for the formation of pit chains: (i) dike swarms [1], [2], [3], [4], [7]; (ii) collapsed lava tubes (http://photojournal.jpl.nasa.gov/catalog/PIA03836); or (iii) fissuring beneath loose material [8]. Of the numerous pit chains mapped during this research, few if any show direct evidence of volcanic eruption or the presence of a dike. The collapsed lava tube hypothesis fails to account for pit chains that cross multiple lava flows. Preliminary results indicate that most pit chains in the western hemisphere of Mars form over fissures associated with dilational normal faults.

Methodology: We systematically mapped large regions of the western hemisphere of Mars using MOC wide angle and narrow angle images. The wide angle images have a resolution of 232 m per pixel and were used to map regional distribution and orientation of pit chains. In the study area approximately 1000 pit chains were mapped with an additional 270 possible pit chains. The MOC narrow angle images, with a resolution of 5 m per pixel, were used to study detailed pit morphology.

Results:

Distribution and orientation. Pit chains are numerous in the Alba Patera region, occurring mainly tangential to Alba Patera in a NE orientation on the eastern side and a NW orientation on the western side. South of Alba Patera these chains trend north-south following the general orientations of the graben system. Pit chains also occur in an east-west orientation along the Valles Marineris, typically coalescing into scalloped troughs. West of the Valles Marineris is the Noctis Labyrinthus, where pit chains are found in numerous orientations with interesting cross-cutting relationships. The pit chains in Noctis Labyrinthus also commonly appear to have coalesced into scalloped troughs. Pit chains were mapped around the Tharsis volcanoes of Ascraeus Mons, Pavonis Mons and Arsia Mons. Pit craters in this region were found in concentric rings on the flanks of the volcanoes and a smaller number were mapped radial to the volcanoes. To the west of Daedalia Planum, in a heavily cratered region, pit chains were mapped radial to several impact craters.

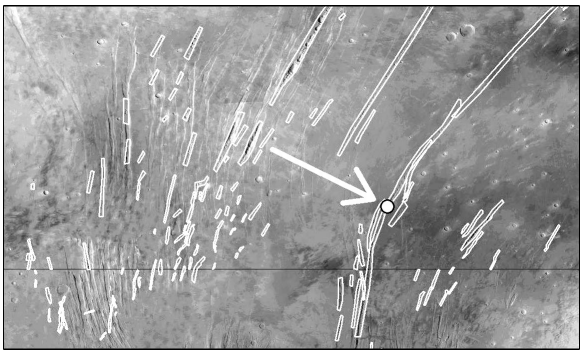

Figure 1: Southwest region of Alba Patera showing distribution of pit chains. MOC wide angle image in areographic projection, which may exaggerate curvature. Arrow points to area in Fig. 2. North is up.

Pit chain morphology. Pit chains are collapse structures, lacking an elevated crater rim, ejecta deposits or lava flows that are typically associated with impact craters or calderas. The individual pits typically have a conical shape with or without a flat floor, stratification and differential erosion; gullies are typical in upper flanks of pit craters. Pits in many cases have an elliptical shape with the long axis parallel to the chain orientation. There are numerous examples of pits coalescing to form scalloped troughs. Pits commonly occur in linear chains, often bounded by a graben, although they are also found apart from grabens. Where associated with a graben, pits commonly occur along the bounding faults. Pit chains sometimes occur in en echelon arrays and a few display curved tips similar to interaction at the tips of en echelon faults.

Discussion: Based on the occurrence of pit chains in areas of extensional faulting and their detailed geometric characteristics, we hypothesize that pit chains may largely originate by dilational normal

faulting and fissuring. Dilational segments on normal faults can occur where the fault traverses mechanically strong stratigraphic layers or where tensile or hybrid mode failure occurs under conditions of low differential stress [9]. Fault dip steepens in more competent beds, and steeper segments dilate as displacement increases; this dilation creates void spaces. Taking into account the influence of Martian gravity on fault geometry, these steep fault segments could extend down to depths of 5 km on Mars [10]. Dilation of these steep segments would provide a large volume in the upper crust to accommodate the formation of pit crater chains.

Figure 2: MOC narrow angle image showing stratification in the walls of the pits and their occurrence along extensional fault scarps.

Pit chains are generally observed in regions that have experienced crustal extension, such as the numerous grabens in the Alba Patera and Valles Marineris region. Pit chains were also found to occur radially from several impact craters in the region west of Daedalia Planum. These chains are notably more eroded and pit craters typically decrease in size away from the impact crater. Although morphologically similar to pit chains found elsewhere, it is not clear whether they are associated with dilational faults.

Pit craters are rare on Earth, possibly due to gravitational differences, but extensive field work has been done studying modern pit craters in Hawaii [11]. Findings from this work in Hawaii show that pit craters have structural origins associated with extensional fissures that in some cases subsequently became pathways for lava flow. Analog modeling has been done to recreate dilational normal faults and was successful in creating pit craters that coalesced into troughs and grabens [12].

Conclusions: We studied regional distribution and orientations of pit chains, detailed pit chain morphology, and structural and volcanic associations of pit chains in the western hemisphere of Mars. Regional distribution and orientation show that pit chains are found in areas that show regional extension or local fissuring. Analysis of detailed pit morphology and structural analysis of pit chains revealed similarities to normal faulting regimes and a strong correlation to graben orientation. Together, these results indicate faulting or fissuring origins. We would expect that these same structural features may locally serve as magma pathways (dikes) [11], [13]. Based on the general lack of direct evidence of formation by intrusive volcanism, dilational faulting and fissuring provides a simpler explanation consistent with Earth analogs.

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