INTERACTIONS OF TECTONIC, IGNEOUS, AND HYDRAULIC PROCESSES IN THE NORTH THARSIS REGION OF MARS; P.A. Davis[1], K.L. Tanaka[1], M.P. Golombek[2], and J. Plescia[2]: [1]U.S. Geological Survey, Flagstaff, Ariz. 86001; [2]Jet Propulsion Laboratory, Pasadena, Calif. 91109.

Recent work on the north Tharsis region of Mars (lat 15° to 50° N., long. 80° to 120°) has revealed a complex geologic history involving volcanism, tectonism, flooding, and mass wasting [1-8]. Our detailed photogeologic analysis of this region found (1) many previously unreported volcanic vents, volcaniclastic flows, irregular cracks, and minor pit chains; (2) additional evidence that volcanotectonic processes dominated this region throughout Martian geologic time, and (3) the local involvement of these processes with surface or near-surface water. Also, we have obtained photoclinometric profiles within the region of troughs, simple grabens, and pit chains, as well as average spacings of pits along pit chains. We have used these data, together with techniques described in [9-11], to estimate depths of crustal mechanical discontinuities that may have controlled the development of these features. In turn, such discontinuities may be controlled by stratigraphy, presence of water or ice, or chemical cementation.

The trough depths indicate base levels of erosion at 0.4 km and 1.5 km. The shallower depth, obtained on the Tempe Terra plateau, is close to the thickness range of the Tempe Terra Formation in this region [12]. The 1.5-km trough depths, obtained within the Tempe Terra and Alba Patera regions, are close to the average depth found for a widespread discontinuity within the megaregolith in the equatorial region south of the current study area [10]. This discontinuity may have involved ice, water, or chemical cementation.

The faulted-layer depths estimated from 172 graben measurements have a large range (0.6 km to 7.2 km), similar to graben depths found in the equatorial region (0.4 km to 5.0 km [10]). The pit spacings have a narrower range between 0.8 km and 2.8 km. The frequencies of both faulted-layer depths and pit spacings show concentrations at 1.4 and 2.0 km, which is in marked contrast to the unimodal (at 1.0 km) distribution obtained within the adjacent equatorial region [10]. There is no obvious spatial correlation among faulted-layer depth and elevation, latitude, or pit spacing in the north Tharsis region. However, the <u>average</u> faulted-layer depth (within a 100-km radius) does increase logarithmically from 1.0 km near the base of Alba Patera to 3.5 km near its summit caldera, but the higher average values have a large standard deviation. Despite this <u>apparent</u> relation, the faulted-layer depths within 500 km of the Alba Patera summit cover the entire range of reported values and have a random distribution.

The concentrations of faulted-layer depths and pit spacings at 1.4 km and 2.0 km and of trough depths at 1.5 km, and the random areal distribution of these data, indicate at least two widespread mechanical discontinuities (at about 1.4 km and 2.0 km) within the north Tharsis region. Because these measurements were obtained on a variety of geologic units of Noachian to Amazonian age, the discontinuities are probably independent of local geology and geologic time. The model presented by [13] predicts the base of the proposed ice layer to be 1.5 km to 2 km between lat 30° and 45° N. Our photogeologic analysis in this region has found evidence for the existence of ground water or ice throughout recorded geologic time. This evidence includes etched, channeled, and smooth units of Noachian age, lahars and channeled pyroclastic(?) deposits of Hesperian age, and shallow fracture-controlled troughs in Tempe Terra and a braided channel system (Olympica Fossae) of Amazonian age that originates from an enlarged crack of Ceraunius Fossae. The water that produced these features may have been entrapped and possibly frozen in the megaregolith, and it may have been released by magma heating with fractures acting as conduits. Small volcanic shields formed along fractures at about the same time as the formation of the channels and troughs.

The depth to consolidated basement around Alba Patera may be 5-7 km, if we assume a 3-4 km total accumulation of Amazonian volcanic material (based on elevation) and a 2-3 km average depth to basement in surrounding regions [10]. Thus, the greater depths (5-7 km) indicated by graben measurements may correspond to the megaregolith-basement interface.

The drainage of pit chains in this region may have been facilitated by the opening of tension cracks or dikes beneath particular grabens. This hypothesis is supported by the simple geometry of the grabens; the formation of similar structures on Earth; photogeologic evidence of lava flows emanating from grabens, fractures, and fissures; and mechanical models and failure criteria relating the extension in the grabens to opening of the subsurface cracks [14]. Collapse of the overlying poorly consolidated material into the widened tension cracks would have been facilitated by hydraulic relaxation and subsidence of the magma. Magma eruption near the pit chains may have been inhibited by the frozen ground. Secondary subsurface erosion caused by turbulent flow of ground water along cracks may have induced further collapse in places. At Tempe Terra, scalloped troughs indicate coalescence of pits, perhaps due to mass wasting of icy slope material.

Calculations using measured pit volumes and pit chain lengths and a reasonable estimate of tension crack width (25-90 m), based on the extension across faults bounding grabens, indicate that cracks 1-3 km deep can provide the space for the material evacuated from the pits. Cracks of these dimensions are reasonable on the basis of similarity in scale to terrestrial analogs and simple failure criteria applied to Mars [14].

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