

DIKE INTRUSIONS ALONG PRE-EXISTING GRABEN BORDER FAULTS SOUTH OF ARSIA MONS.C. L. Goudy¹ and R. A. Schultz¹, ¹University of Nevada, Reno/ 172, Reno, NV, 89557, clgoudy@mines.unr.edu.

Introduction: Graben in the area around the Tharsis region that extend several thousands of kilometers: including Memnonia, Sirenum, Icaria and Thaumasia Fossae have most recently been suggested to result from a radiating dike swarm [1,2]. The most common models of dike-related graben formation associate lithospheric deformation with the formation of Tharsis [3]. Graben that result primarily from a volcanic process have a characteristically unique topographic profile to graben resulting from the combination of dike intrusion and faulting (Fig. 1). A combined process will produce a profile where the two peaks are concave-up, and a volcanically controlled profile has two peaks that are concave-down with a much smaller uplift (tens of meters or less) [4,5]. MOLA profiles in the Tharsis region reveal both volcanic and tectonic graben formation. The purpose of this study is to locate and differentiate zones of volcanically and tectonically controlled graben in the area south of Tharsis.

Methods: Raw MOLA data are used to extract topography profiles over “narrow graben” south of Arsia Mons. The area is separated into three zones based on the topographic shape of the profiles (Fig. 2). The “narrow graben” in this study are less than 5 km in width, hundreds to thousands of kilometers long, and have vertical uplifts (of their footwalls) up to hundreds of meters, as described in previous investigations [e.g., 6,7]. The long length of a Martian graben compared to its depth is not a significant factor in fault mechanics; normal terrestrial fault displacement length scaling applies to Martian graben when fault linkage is considered [8].

Graben are analyzed based on concavity and dimensions. From the concavity of the MOLA profiles we can differentiate between fault-controlled and dike-controlled topographic uplift; depth of faulting and fault spacing associated with dike dilation can be calculated [5]. Dikes that extend to a depth of 20 or 30 kilometers would produce tens of meters of topographic displacement; smaller dikes produce less vertical displacement [5]. The width of the graben produced by a dike would be on the order of hundreds of meters [5]. Therefore, where the vertical uplift is greater than tens of meters and/ or the profile is concave-up, fault-controlled topography is inferred. Dike-induced graben formation is interpreted based on a profile where the vertical uplift is tens of meters or less and the profile is concave down. Where the profile shows a vertical uplift of greater than tens of meters but is concave down, a combined fault and dike forma-

tional mechanism is inferred, where a dike intrudes a pre-existing graben [5,12].

Results and Discussion: MOLA profiles in Zone 1 reveal that the majority of graben there are formed primarily by dike-intrusion. In the southwest corner of Zone 1, the DEM shows large graben interpreted to have fault-controlled topography being covered by lava flows from Arsia Mons. In contrast, Zones 2 and 3 show that the majority of graben are fault controlled. However, in both of these regions some graben are observed to change concavity along strike. This is interpreted as a fault controlled graben underlain and probably intruded by a dike that is influencing its topographic signature. Zone 3 differs slightly from Zone 2 in that there appear to be a larger number of dike-related graben.

The observations made in this study reveal a similar formational mechanism to terrestrial rift zones, where the dikes connect deep-magmatic and surficial-tectonic processes [e.g., 9,10]. In classic terrestrial models, dikes grow vertically from a source and then propagate laterally [11]. In an extensional setting, graben formation may occur without dike emplacement and subsequent dikes would propagate along these graben opening perpendicular to the least compressive stress, causing additional slip on the border faults as it propagates [12].

Volcanic centers, collapse pits, and lava flows are associated with graben formed later than the Hesperian Epoch, and are thought to be the age of the lava flows in this area [13]. Prior to graben formation in Tharsis lithospheric stretching began; when magma was later generated, via decompression melting and thermal anomalies, it was directed toward these areas of extension [2,13,14]. As magma near Arsia Mons began to rise, the magma most likely flowed from this area creating lava flows on the surface and the shallow dike-related graben we observe in Zone 1 toward the outer regions. The lava flows south of Arsia Mons cover the tectonic graben observed in Zones 2 and 3. With distance from the magma chamber dikes appear to follow graben, where the dike top occasionally comes close enough to the surface to produce the concavity of a dike related graben, with the vertical uplift of a tectonically controlled graben, as we observe in Zones 2 and 3.

Conclusion: The giant dike swarm hypothesis [1,2] is not sufficient to explain graben formation based on the topographic profiles observed through MOLA. Profiles perpendicular to graben in the three

zones of this study reveal a combination dike-related and fault-controlled topography. The pattern of narrow graben observed south of Arsia Mons is best explained by a model that incorporates a combined formational mechanism for graben of dikes and faults.

References: [1] Wilson L. and Head J. W. (2002) *JGR*, 107, 10.1029/2001JE001593. [2] Mege D., et al. (2003) *JGR*, 108, 10.1029/2002JE001852. [3] Banerdt W. B. et al. (1992) in *Mars., chap. 8*, 249-297. [4] Rubin A. M. and Pollard D. D. (1988) *Geology*, 16, 413-417. [5] Goudy C. L. and Schultz R. A. (2003) *EOS Trans. AGU*, 84(46), Abstract #P31C-02. [6] Golombek M. P. (1979) *JGR*, 84, 4657-4666. [7] Tanaka K. L. and Davis P. A., (1988) *JGR*, 93, 14893-14917. [8] Schultz R. A. (1997) *JGR*, 102, 12009-12015. [9] Ernst R. E. et al., (2001) *Annu. Rev. Earth Planet. Sci.*, 29, 489-534. [10] Forslund T. and Gudmundsson A., (1991) *JSG*, 13, 443-457. [11] Ernst R. E. and Baragar W. R. A., (1992) *Nature*, 356, 511-513. [12] Rubin A. M., (1992) *JGR.*, 97, 1839-1858. [13] Scott D. H. and Tanaka K. L., (1986) *U.S.Geol. Surv. Misc. Invest. Ser., I-1802-A*. [14] Phillips R. J. et al., (2001) *Science*, 291, 2587-2591.

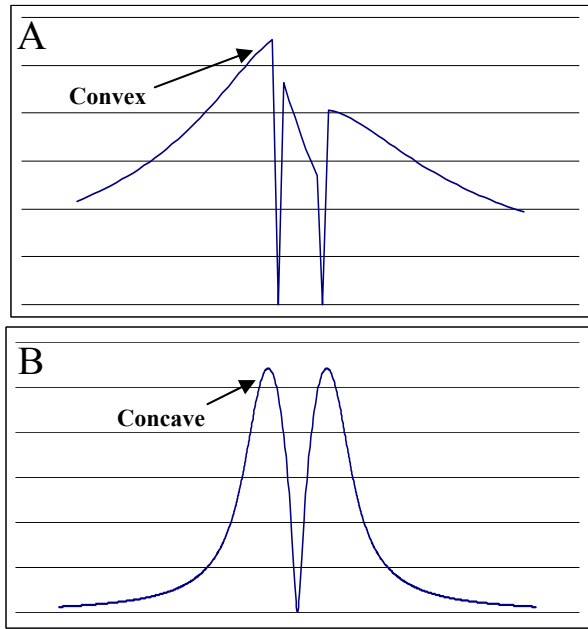


Figure 1: (A) Topographic profile of a graben that results from faulting, where the vertical uplift is about 30 meters. (B) Dike controlled topographic profile, where the vertical uplift is about 3 meters.

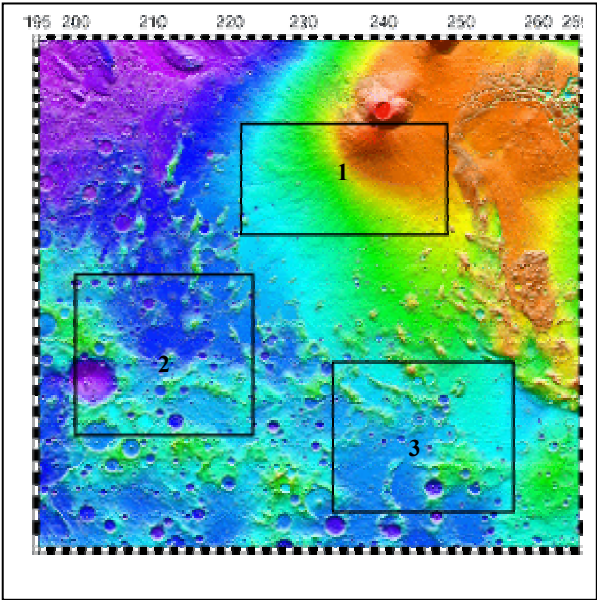


Figure 2: Three morphologic zones south of Arsia Mons shown on a Digital Elevation Model (DEM), where red indicates a topographic high and blue indicates a topographic low. Zone 1 is dominated by volcanically controlled graben. Zones 2 and 3 consist mostly of graben that show a topographic profile consistent with a combined process of dike intrusion and faulting or faulting alone.