GEODYNAMIC EVOLUTION OF SOUTHERN THARSIS PROVINCE, MARS: INSIGHTS FROM GEOMORPHIC LANDFORMS IN KOVAL’SKY CRATER. A. Chavan¹, K.B. Kimi¹, R. Aditi¹, U. Thahira¹, and S. Vijayan¹, ¹Planetary Sciences Division, Physical Research Laboratory, Ahmedabad. ²Department of Geoinformatics, Anna University, Chennai. ³Department of Remote Sensing, Bharathidasan University, Trichy. (asac.anil@gmail.com)

Introduction: The evolution of the Tharsis volcano-tectonic province started in Noachian and prolonged during Hesperian and Amazonian with peak deformation values during Late Noachian and Early Hesperian [1,2]. The formation is dominated by extrusive and intrusive volcanism accommodated by lithospheric flexure. Volcanism in Tharsis induced radial faulting caused by the upliftment, leading to the formation of grabens and wrinkle ridges [3]. Tharsis bulge is contemporaneous to the valley network formation [4], leading to the peak of activity during the Hesperian, which influenced the shift from phyllosilicate to sulfate formation at the Noachian–Hesperian boundary. Tanaka and Davis (1988) indicated that the volcanism separates all the tectonic phases in the Tharsis region; hence, inter-relation between the volcanic and tectonic landforms is critical to understand the evolution of Tharsis and associated landforms. The low shield volcano in close proximity to Tharsis and volcanic cones observed on the peripheral parts of the Deccan traps has a close resemblance with the Martian volcanic craters and cones [5].

The geothermal heating by the volcanism throughout the evolution of Tharsis has given rise to surface water flow (groundwater/meltwater), which has led to the formation of outflow channels and hydrous minerals in volcanic terrain [6]. The present study attempts to decouple the volcanic, tectonic, and fluvial processes that reshaped the Koval’sky crater in the southern Tharsis province based on the characterization of geomorphic landforms.

Results: The total number of 135 faults, which are spatially distributed in three different segments of tectonic deformation, were analyzed in the present study. As indicated in Figure 1 histogram, the total number of faults identified are 48, 43, and 44 in the eastern, central and western segments, respectively. The number of fault are relatively homogeneous among the different segments and counts shorter and longer faults as one; hence, their cumulative length is calculated. The results of cumulative lengths for each segment show 23% (2117 km) of the structures are formed in eastern segment, 16% (1520 km) are formed in central segment, 61% (5697 km) are associated with western segment (Figure 1). The linear fault density for eastern segment is 2.4×10^{-2} per sq. km, for central segment 3.2×10^{-2} per sq. km, and western segment is 6.5×10^{-2} per sq. km. The deformation rates for the eastern segment 0.67×10^{-6} km/Myr/km² for the central segment 0.93×10^{-6} km/Myr/km² and for the western segment is 1.89×10^{-6} km/Myr/km² from the observation, and calculation it indicates that the western segment shows

![Figure 1: HRSC-MOLA blended image of Koval’sky crater and surrounding area with attributes of three different sets of grabens](image-url)
densely populated; however, the eastern segment has less density and deformation rates of the tectonic structures. In the western segment, ~28 boulder fall tracks are observed along the walls of grabens. Along the central and eastern segments very few images were available in these two segments, ~5 boulder fall tracks are observed in the vicinity of Koval’sky crater.

A variety of landforms have been observed in and around Koval’sky crater, which includes a large volcanic plug in the eastern portion of the floor of the impact crater, extensive lava flows on the floor, smaller volcanic cones, lava inflation structures, and younger lava flows which breach from the eastern side. The measured height of the plug from east and west is 750m and 1050m, respectively. The plug encompasses an area of 6998.78 km² with a perimeter of 472.88 km, and the volume of the plug is 2247.43 km³. At the highest elevation, i.e., 2475m, the summit of the plug shows a conical shape, indicating the effusive style of the volcanism forming ~ 1 km of high volcanic neck on the floor of the impact crater. This plug shows its alignments along the eastern graben system in the Koval’sky crater.

Koval’sky crater, being the oldest impact structure, might have hosted a well-developed fluvial channel system; however, subsequent geodynamic processes like impact cratering and volcanism would have altered/buried clear evidence. The crater floor does not show any fluvial channels, though there are features that look like fluvial channels; those are thought to be lava inflation structures. Apart from the crater floor, a well-developed radial drainage pattern is observed on the volcanic plug on the eastern portion of the crater floor (Figure 2). Besides the radial drainage system on the volcanic plug within the crater floor, impressions of a well-developed fluvial system have been observed on the outer wall of the Koval’sky crater.

**Discussions:** Morphologically, the Koval’sky crater shows a rectangular shape modified by the older grabens system, which can be connected to the exposed early/late Noachian age deformation observed in Claritas fossae region-oriented E-W direction, which is circumferential to the Syria Planum, arises from the Thromasia highland [1]. The younger lava flow might have buried the interconnected faulting system. In the Koval’sky crater and surrounding area, two graben systems pass tangentially to the crater while one cross-cut the northern wall of the crater but did not pass through the southern wall, which indicates that stress distribution has occurred along the southern wall of the crater that confirms the older E-W fault is a crustal fault or considerably dipper that the younger fault system. The en-echelon pattern in the middle segment of the crater floor also indicates differential stress magnitude; it has been observed that the western segment has more deformation than the eastern and central segments. The western segment of the graben cross-cut one of the crater ejecta in the western portion of the Koval’sky crater with a surface age of 3.7 Ga indicates that the tectonic activity occurred in the area younger than this time frame. The dating and cross-cutting relationship implies that the formation of this graben occurred in the late Hesperian time, which differs from the observation reported by Bouley et al. (2015), which suggested these grabens are Amazonian. Alignment of the volcanic plug having ~1 km height above the surrounding area along the eastern segment of the graben indicates the accommodation of the plug occurred with roots directly connected to the mantle instead of dyke feed magmatism. The age of the flank of the volcanic plug indicates its formation age 3.4 Ga, which is younger than the age of tectonic graben. Based on the calculated ages of the inner and outer ejecta, the outer ages 3.7 Ga while the inner has a surface age of the 3.4 Ga, which coincides with the formation age of the volcanic plug. We interpret and report that the Koval’sky crater floor host one of the largest plug within impact crater on Mars.

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