# The Origin and Modification of a Trough in the Nili Fossae, Mars

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**Overview:** The large trough in the Nili Fossae is interpreted to be a graben subsequently modified through sapping channels and mass wasting processes resulting in a floor much younger than the surrounding plains. The orientation of the trough and the sapping channels corresponds to the regional tectonic pattern, a set of fractures concentric and another set radial to the Isidis Basin. The tectonic pattern appears to be related to the Isidis Basin and ring tectonics provides a possible mechanism for the formation of this pattern[1].

**Introduction:** The Nili Fossae, centered at 23° N and 282° W, are a series of curved troughs located to the northeast of the Syrtis Major shield volcano and northwest of the Isidis impact basin. The largest trough begins to the south in Hesperian age volcanic flows, extends through Noachian cratered units, and ends near the North-South dichotomy[2, 3]. The feature has scarp-like walls, a smooth floor, and curves gently, concentric to the Isidis basin. The trough has been interpreted by various authors in large regional maps as a trough, a graben, and a fracture[3, 4]. However, the smooth, flat floor, the development of small tributaries along the trough, and its large size in relation to other regional tectonic features suggest a more complex history, if not a different origin. The purpose of this study is examine in detail the largest trough in the Nili Fossae region to determine its origin, possible subsequent modification and relationship to the regional geology. Mapping was used to constrain origin and modification processes and to provide a regional context.

**Methods:** The area was mapped with Viking 1 and 2 images with a resolution of 0.087 - 0.140 km/pixel. Mapping identified geomorphological features indicating which processes had acted on the trough. The trough has a very low relief, smooth floor relative to the surrounding units. The features mapped on the channel floor include lineaments, channels, and islands of cratered, high topography. In addition to mapping, the height of the western scarp wall was measured using a shadow method[5]. The last phase of data collection was the measurement of the orientation of the trough, the tributaries, and the associated tectonic features.

**Origin:** The steep, scarp-like walls, rectangular cross section, and flat floor suggests that the trough is a graben. The wall height data also supports a tectonic origin. The wall height increase toward the southern end of the trough where it meets the Syrtis Major shield volcano. Ideally, a graben displays maximum down dropped displacement in the middle and minimum displacement near the ends [6, 7]. The wall height, which increases to the south, is consistent with a graben assuming subsequent Syrtis Major lava flows covered the southern half of the trough. The orientation of the trough was also compared to the pattern of regional tectonics (figure 1a, b). The trough has a northeast/southwest orientation, the same orientation as the nearby large faults.

**Modification**: While fluvial processes do not appear to have been involved in the formation of the trough, they have significantly influenced subsequent modification of the graben. The tributaries entering the trough have a number of unusual characteristics such as theater-shaped heads of first order tributaries, relatively constant width from source to outlet, high and steep valley walls, a rectangular intersection pattern, and hanging valleys. Using the criteria established by *Laity and Matlin*, we interpret these tributaries to be sapping channels fed by ground water[8]. The orientations of these channels corresponds directly to the pattern established by the surrounding fractures, striking at the same orientation as the small fractures (figure 1a, c). The water from these channels most likely played a major role in facilitating debris flows and other

mass wasting by reducing the pore pressure in the sediments. Localized deposition is probably responsible for the smooth floor of the graben.

**Regional Setting:** One interesting aspect of the graben is its proximity and geometric relationship to the Isidis impact basin. The formation of the graben may be linked to the formation of the Isidis Basin. The theory of ring tectonics seems to have particular relevance to the Isidis Basin. According to this theory, if an impactor is large enough to penetrate the lithosphere, the between the stiff mesosphere and the more fluid asthenosphere causes mantle to flow in the direction of the crater. This produces inward facing scarps, graben, and outward facing scarps as you move away from the crater. Also, the radial migration of the asthenosphere toward the impact causes radial fractures[1]. The Nili Fossae appears to have this distinctive pattern of graben and fractures concentric to the Isidis Basin. Since the Isidis Basin is one of the largest impact basins recognized on Mars, it seems a likely location for this type of tectonic pattern.

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**References:** [1] McKinnon, W.K. and Melosh, H.J. 1980, Icarus, v. 44, pp. 454-471. [2] Greenley, R. and Guest, J. E. 1987, USGS. [3] Craddock, R. 1994, Houston, Texas, LPC XXV, pp. 291-292. [4] Spitzer, C. R., editor. 1980, NASA, Washington, D.C., pp. 71. [5] Yingst, R. E., and Head, J. W. 1997, Journal of Geophysical research, v.102, pp.10,909-10,931. [6] Burgmann, R., Pollard, D., and Martel, S. 1994, Journal of Structural Geology, v 16, no 12, pp. 1675-1690. [7] Pollard and Segall, 1987 [8] Laity, J. and Malin M. 1985, GSA Bulletin, v. 96, no. 2, pp. 203 - 217.

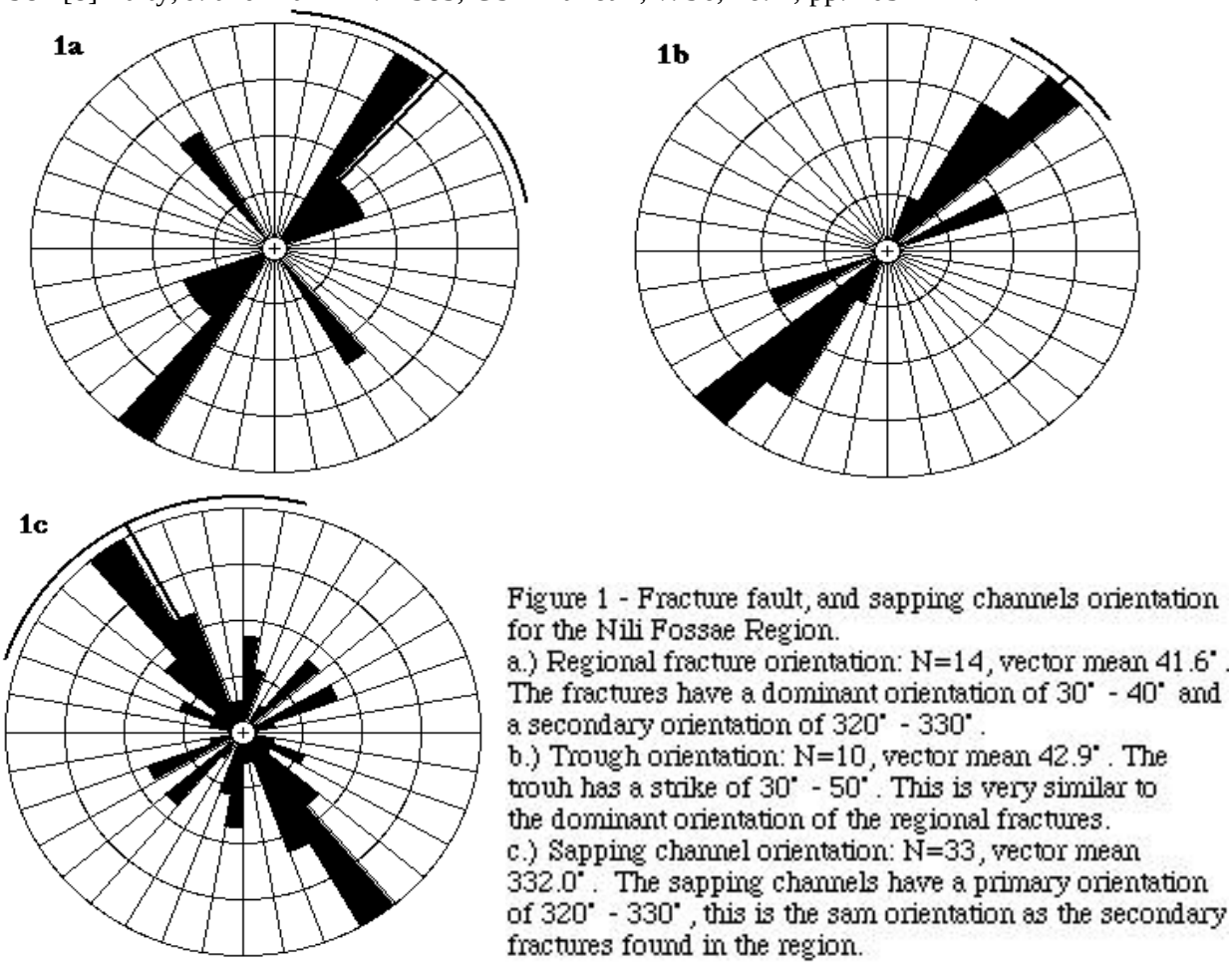


Figure 1 - Fracture fault, and sapping channels orientation for the Nili Fossae Region.
a.) Regional fracture orientation: N=14, vector mean 41.6°. The fractures have a dominant orientation of 30° - 40° and a secondary orientation of 320° - 330°.
b.) Trough orientation: N=10, vector mean 42.9°. The trouh has a strike of 30° - 50°. This is very similar to the dominant orientation of the regional fractures.
c.) Sapping channel orientation: N=33, vector mean 332.0°. The sapping channels have a primary orientation of 320° - 330°, this is the sam orientation as the secondary fractures found in the region.