DIKES AND LINEAR TROUGHS: NEW OBSERVATIONS ON THE SOMALI PLATE. D. Mège[1], P. Purcell[2] and F. Jourdan[3], [1]WROONA Group, Institute of Geological Sciences, Polish Academy of Sciences, Research Centre in Wrocław, ul. Podwale 75, 50-449 Wrocław, Poland (daniel.mege@twarda.pan.pl), [2]P&R Geological Consultants, Scarborough, WA, Australia (ppurcel@tpgi.com.au), [3]Western Australia Argon Isotope Facility, Curtin University of Technology, Perth, WA, Australia (F.Jourdan@exchange.curtin.edu.au).

Summary: The idea that some linear troughs ("narrow grabens") of very large length/width ratio on Mars and other planetary bodies are underlain by (and somehow related to) volcanic dikes suffers from the absence of good terrestrial analogs. We report on the existence of such relationships in the northern Somali plate in East Africa. Karstic dissolution along dikes hundreds of km long appears to be the primary mechanism of linear trough formation. Melting of ice lenses in permafrost might produce a similar effect on Mars.

Introduction: Many grabens having typical length 10^5–10^6 m, width 10^2–10^3 m, and depth 10^{-1}–1 m on Venus, [e.g., 1], the Moon [e.g., 2], and Mars [e.g., 3, 4], have been interpreted to have formed by dike-induced faulting. This interpretation is based on observation of fractures formed in terrestrial rift zones during dike emplacement and their experimental and elastic modeling [e.g., 5, 6]. A problem in this interpretation is that it predicts dikes tens or hundreds of meters thick. Emplacement of such thick, multi-pulse dikes is very different from emplacement of the single-pulse dikes not more than ~1 m thick, and most commonly investigated in terrestrial studies. These dikes are involved in the formation of grabens a few tens of cm deep, casting doubt on the validity of using these terrestrial analogs. For this reason, relationships that are more complex than '1 dike ↔ 1 graben' have been suggested for Mars [7] but also for the Earth [8].

In 2008, linear troughs were identified on the northern Somali Plate that have similar size as the narrowest linear troughs on Mars, each of them underlain by a single dike. Trough-dike relationships are investigated here.

Linear troughs and dikes on the Somali Plate: The eastern Ogaden region of Ethiopia (Fig. 1) displays a series of segmented linear troughs of length tens of kilometers, width 100-300 m, and depth a few meters (Fig. 2). They are identified on the ground and on satellite imagery by contrasts of vegetation density. High-frequency aeromagnetic data obtained by Pexco Exploration (East Africa) N.V. in 2008 indicate that these troughs correlate with individual, linear negative magnetic anomalies (Fig. 1, inset); at one site the anomaly corresponds to an outcropping 24.85 ± 0.5 Ma-old basaltic dike [9,10].

The SRTM-3 digital elevation model indicate that a large fraction of the eastern Ogaden topography is characterized by ovoid depressions a few kilometers wide and similar in depth to the linear troughs. Some ovoid troughs are aligned and follow one of the dike-related high-frequency magnetic anomalies (Fig. 3).

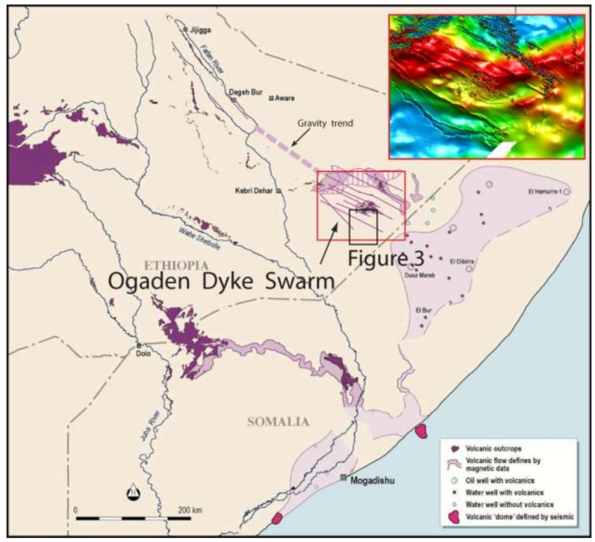

Figure 1. Volcanic outcrops of the Ogaden, and high-frequency TMI aeromagnetic data obtained in 2008 over the Ogaden Dike Swarm area.

Figure 2. Linear troughs overlying individual dikes from the Ogaden swarm. Left image is view of Site 33 (Fig. 3).

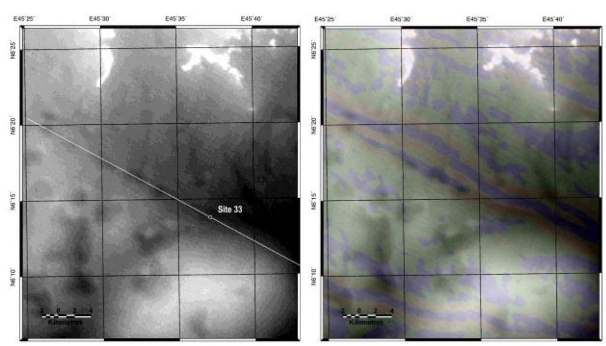

Figure 3. Left: Ovoid depressions of karstic origin in the dike swarm area (SRTM-3 DEM). Site 33 is located along a line of ovoid depressions. Right: DEM draped over magnetic anomaly map [9].

Origin of linear troughs: The exposed rocks are the thick Cretaceous-Paleocene Jessoma and Eocene Auradu formations [11]. The rare outcrops of Jessoma Formation indicate that its typical sandstone facies is here replaced, at least in part, by gypsum. The Auradu Formation is made of transgressive marine carbonates with gypsum levels.

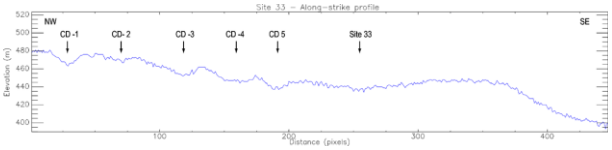

Figure 4. Topographic section across ovoid depressions (CD-1 to CD-4) and along the Site 33 linear trough (location on Fig. 3).

The ovoid troughs are interpreted to have a karstic origin (Fig 5). The linear troughs are interpreted to be karstic as well, with geometric control of groundwater circulation and host rock dissolution by fracturing in the dike process zone [12]. Observation that the reflectance of the linear trough margins is occasionally modified (Fig. 6) might result from host rock compositional change in response to hydrothermal flow associated with dike emplacement [13].

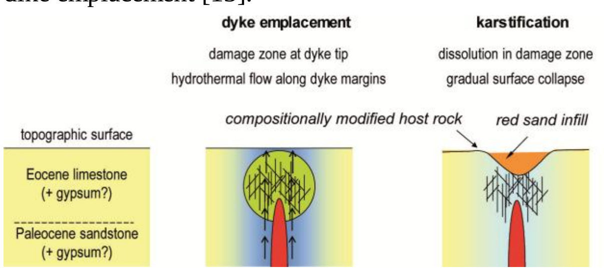

Figure 5. Suggested mechanism of linear trough formation above dikes from the Ogaden Dike Swarm.

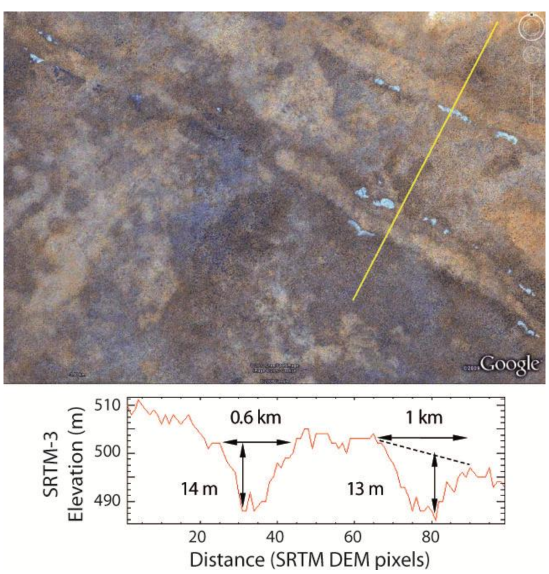

Figure 6. Topographic section across two linear troughs in the Ogaden. Note the light blue patches along the trough margins on the Geoeye image, indicating local modification of host rock composition.

Implications for planetary linear troughs: Evaporites are widespread on Mars and may provide conditions for similar mechanisms of formation of linear troughs of similar size (Figs. 6, 7). Alternatively, liquefaction or sublimation of ice lenses in permafrost in response to emplacement of dikes underneath could probably produce linear troughs along the dike path as well. Volcanic gas starts to exsolve at greater depth on Mars than on Earth (e.g., [14]), which may increase global ice content in permafrost in basaltic regions by increasing (1) the porosity of the intruded lava and the lava flows, and (2) magma explosivity, i.e. the proportion of pyroclastic deposits vs. flows compared to the Earth.

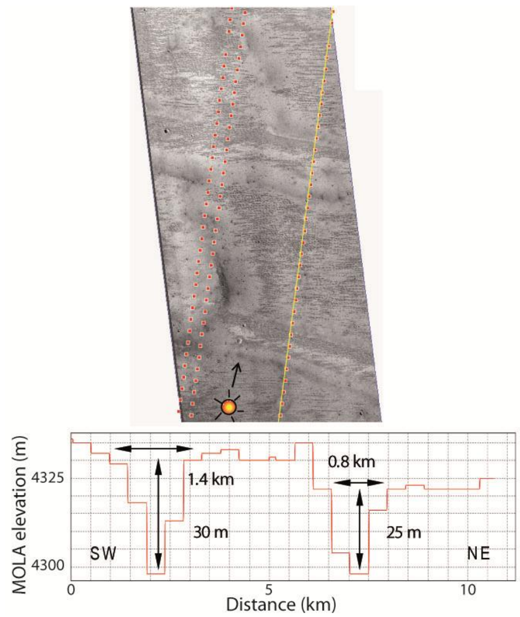

Figure 7. MOLA track profile across two linear troughs between Ius and Tithonium chasmata viewed by HiRISE, Valles Marineris, Mars.

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