GEOLOGICALLY RECENT LANDSLIDES ON MARS A. Guimpier[1], S. J. Conway[1], A. Mangeney[2] and N. Mangold[1], [1]Laboratoire de Planétologie et Géodynamique CNRS UMR6112, Université de Nantes, France, [2]Institut de Physique du Globe de Paris, France.

Introduction: There is a wide morphological diversity of landslides on Mars [1–3]. These landslides can mobilize from 10^6 to 10^{12} m^3 of material [4]. Landslides formed during the Amazonian (3.1 Gyr to present) are generally interpreted as forming without liquid water [e.g., 5,6]. This study focuses on four landslides not exceeding an estimated volume of 10^7 m^3, located in Nili Fossae region at 27°N latitude, 76°W longitude. We made morphological and rheological comparisons between these martian landslides and terrestrial analogues. We have identified notable rheological similarities between our martian landslides and terrestrial earthflows, which require liquid water to move. We then assess the potential role of volatiles in the formation of these landslides on Mars.

Approach: To conduct the morphological analysis of the martian landslides, we used ConTeXt imager (CTX) at 6m/pix, Colour and Stereo Surface Imaging System (CaSSIS) images with a resolution of 5 m/pix and High Resolution Imaging Science Experiment (HiRISE) images with a resolution of 25-50 cm/pix. We used Digital Elevation Model (DEM) at 2m/pix from HiRISE stereo images produced using the Ames Stereo Pipeline [7] and SocetSet [8] to measure the slopes and topography (*figure 1*).

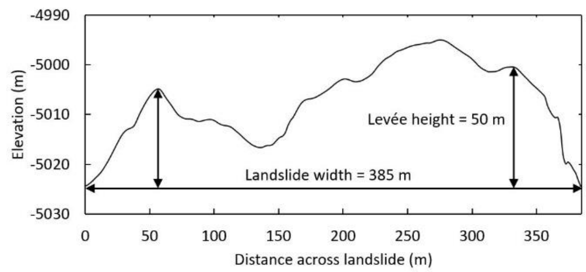

Figure 1: *Cross-section of a martian landslide showing the average structure of the levees.*

To conduct the rheological comparison, we searched for terrestrial analogues with similar morphological features, and we find that the studied martian landslides are most similar to terrestrial mudflows, submarine landslides, earthflows, rock glaciers and andesite lava flows. We then compared the yield strength values of these different flow types in the literature with those obtained for our four landslides. By assuming a Bingham rheology, we calculated the yield strength (Y) of the materials making up the martian landslides using the morphology of the deposit [9–12]. We used the following two relations:

$$Y = hg\rho\sin(\alpha) \qquad (1)$$

$$Y = \frac{\rho g h^2}{W} \qquad (2)$$

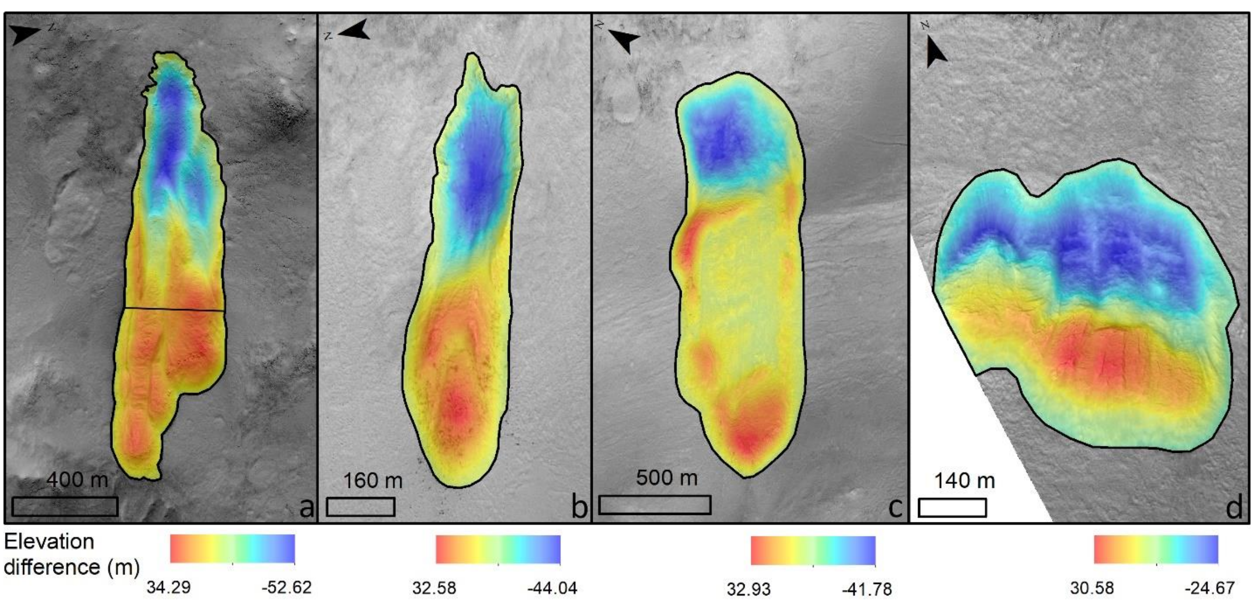

Figure 2: *Thickness map of four martian landslide in Nili Fossae region calculated using the methods in Conway and Balme [13]. Black line in (a) show where the cross profile was taken for figure 1. (a) HiRISE image ESP_027480_2075; (b), (c), (d) HiRISE image ESP_027480_2075.*

Where ρ is the material density, h is the levée height, α the slope inclination, g the gravitational acceleration and W the width of the landslide cross-section.

Morphological and rheological comparison results: The martian landslides are all located on the inner slopes of a 25 km diameter impact crater. There are clearly marked erosion and depositional zones and each landslide has variably expressed lateral levées. From a morphological point of view, these four landslides are similar to mudflows, earthflows, submarine landslides, rock glaciers and lava flows, in that they have: (1) low propagation slopes, (2) lateral levees and (3) high relief lobate flow fronts. Mudflows have an irregular scar and ridges aligned perpendicular to the flow direction which are also observed in landslides *a* and *b* on *figure 2*. Rock glacier also have ridges aligned perpendicular to the flow direction and well-defined lobate flow front as observed on *figure 2a* and *b*. Lava flows have steep angular lateral levees and well-defined compression ridges similar to those in the landslide on *figure 2a*. Some differences are also observed between these terrestrial analogs and the Martian landslides. For example, with regard to lava flows and rock glaciers, the absence of an erosion zone leading to the formation of the different flows. These terrestrial analogues are characterized by fluids which have relatively high yield strengths (Table 1), and the inclination of the levees on either side of the martian landslides is consistent with high cohesion of the material [14].

We made a rheological comparison between our martian landslides and these terrestrial analogues (*Table 1)* and found that the studied landslides have a yield

Terrestrial type	Yield strength range (kPa)
Earth flow	100[15]
Andesite lava flow	1.1 - 400[9],[11],[12]
Mudslides	0.01 - 0.8[16],[19]
Debris flow	0.01 - 25[18]
Submarine landslide	0.02 - 0.5[17],[20]
Terrestrial landslide analogue	
Holmavik (Iceland)	1.5 - 15*
Mt. Rainier (US)	108 - 466*
Martian type	
Nili Fossae landslides	11 - 97*

Table 1: *Yield strength range of some terrestrial flows compare to martian landslides. *This study using the equations (1) and (2).*

strength with the same order magnitude as earthflows and andesite lava flows.

Future work: We will perform numerical modelling using the Bingham rheology to back calculate the viscosity to better understand the rheology of the martian landslides and estimate the potential contribution of liquid water. In addition, we intend to use the liquid limit theory to estimate the amount of liquid water that would be needed to initiate movement in the martian landslides [21].

Conclusions: (1) The comparison between martian and terrestrial landslides reveals similarities to terrestrial geophysical flows, particularly earthflows (2) Earthflows necessarily imply the presence of liquid water, so the morphological and rheological similarities between these landslides and earthflows raises the question of the involvement of volatiles in forming these martian landslides.

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