Classification and ages of landslides within Valles Marineris. A. Hager[1] and A. D. Schedl[2], [1]Deptartment of Geology, Marshall University, hager142@live.marshall.edu, [2]Department of Physics, West Virginia State University, schedlad@wvstateu.edu .).

Introduction: Valles Marineris is a canyon 4000 km long and up to 7 km deep running along the Martian equator. Within the canyon are large (>100 km^2) landslides. Quantin et al [1] determined ages for the landslides by measuring the areal density of craters. However, recent work suggests that crater densities must be measured over areas ≥ 1000 km^2 for a reproducible age [2]. Generally, Quantin et al [1] examined areas <100 km^2, so the isochron ages are probably unreliable. Furthermore, better quality images are available today than in 2004, so the landslides were re-dated and remapped.

Our ultimate goal is to determine the cause of the landslides: meteorite impact, mars-quakes [3] and glacial retreat [4, 5]. If a meteorite impact is linked to a landslide, then the two must be the same age. Impacts and mars-quakes release seismic energy. As a seismic wave passes through the ground surface, it causes the surface to accelerate upward. This upward acceleration initiates landslides. The equations relating mars-quake magnitude or impact size to the probability of initiating landsides vary according to the type of landslide [6]. For this reason, we also determined the type of landslide.

Results: Often our and Quantin et al.'s [1] estimates of ages and landslide size were consistent. However, for example landslide 44 our estimate of size is 2592 km^2 and age is 1.9 Ga, whereas Quantin et al. [1] size is 1348 km^2 and age is 0.1 Ga (Table 1).

Table 1: Comparison of Data for Landslides > 1000 km^2

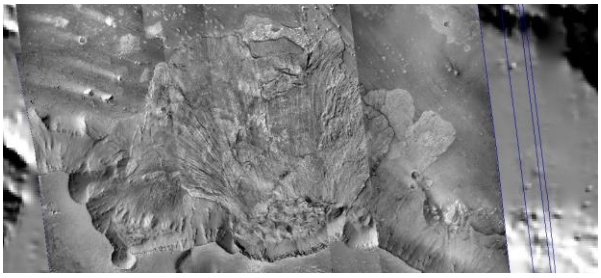
This study				Quantin et al. [1]	
Landslide Number	Area (km^2)	Age (Ga)	Classification	Age (Ga)	Area (km^2)
13	3624.653	0.5	Cx** D* Fall	0.3	3735
37	3267.008	0.1	Cx D Slide	1	740
42 D&E	2695.815	0.6	Cx D Slide	>1	4435
44	2592.017	1.9	Cx D Fall	0.1	1348
38	2327.37	>1.1	Cx D Slide	0.4	1927
29	2219.351	3.4	Cx Planer D	>2	2099
46	2037.121	1.7	Cx D Flow	1	2082
42 A&C	1686.474	2.2	Cx D Slide	>1	4435
60B	1549.895	1	Cx D slide	0.05	2334
11	1532.85	0.3	Planer Slide	0.08	1232
7	1532.332	0.3	Cx D Flow	0.1	1400
33	1517.914	0.6	Cx D Flow	>1.5	800
3	1490.075	1.5	Cx D Slide	0.3	1400
27	1403.539	1.8	Cx D Slide	0.8	1464
23	1327.284	0.9	Cx D Fall	>0.1	979
15	1307.671	0.5	Planer Slide	0.06	1130
53	1051.154	0.1	Cx D Slide	>1	869
26 Fan	1030.178	0.7 (?)	D Fan	0.2	585
17	995.464	>1.5	Cx D slide	0.9	1142

**** Complex Landslide**

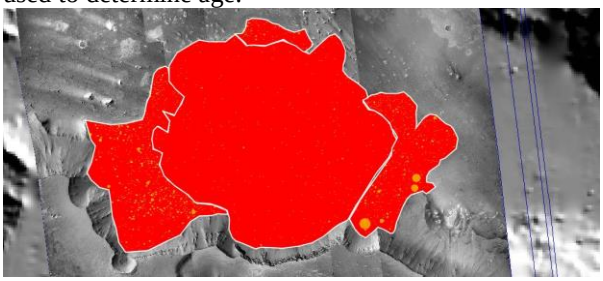
*** Debris**

Dates for this study in table 1 were obtained using Craterstats2 [7]

In addition, we found that landslides 9, 21, 26, 42, 57 and 60 consist of multiple landslides. Shown below are CTX images of landslide 60, which contains at least two landsides.

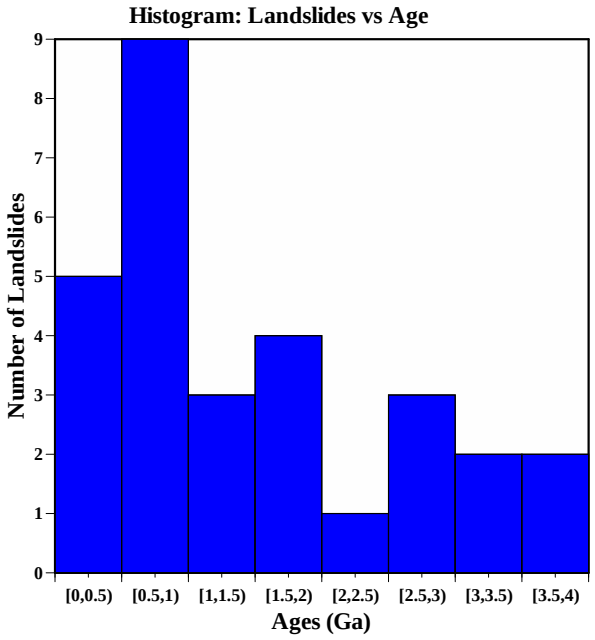


Shown below is our mapping of this landslide. The filled in yellow circles are the meteorite impact craters used to determine age.

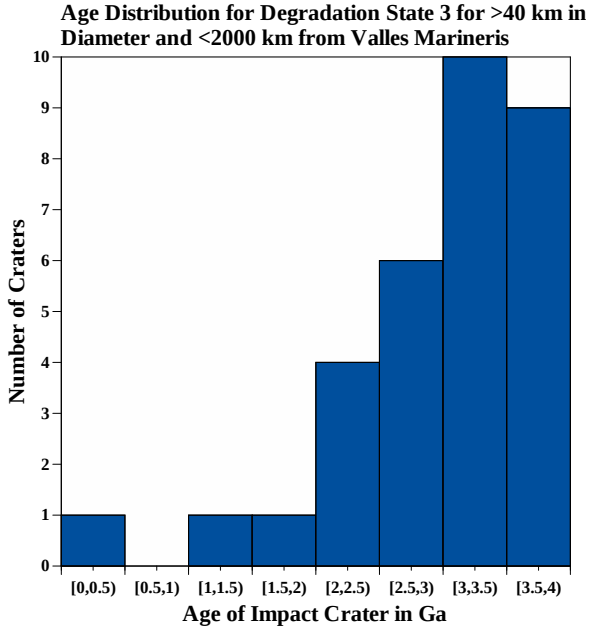


The stratigraphically highest landslide gives an age of 1.0 Ga, whereas the lower pieces of landslides give consistent ages of 3.5 Ga. The consistent ages suggest that these pieces may have been part of a larger landslide.

Based on consistent cross cutting relations and comparison of degradation of landslides, suggest landslides ≥500 km^2 may provide reliable ages. Of the 29 landslides >500 km^2, most are classified as complex. On the following page is a histogram of the ages and it shows that 14 out of 29 dated landslides are < 1 Ga. This result is robust, since a similar distribution of ages is present in landslides >1,000 km^2 (**See Table 1**).



Discussion: Akers and Schedl [3] dated 36 craters of degradation state 1 and 2 [8] and obtained ages >3.4 Ga for all craters. Shown below are dates of craters with a degradation state 3 [8] from Duffy and Schedl [9].



The age distribution of craters of degradation state 4 [8] are unknown. However, [9] found that all crater >10 km in diameter of degradation state 4 lie at least 250 km from landslides identified in [1] and are substantially few in number than those of degradation state 3. These observations suggest that meteorite impacts could not be the major cause of landslides <1.0 Ga in Valles Marineris.

References: [1] Quantin, C. et al. (2004) *Icarus, 172*, 555–572. [2] Warner, N. H. et al. (2015) *Icarus, 245*, 198-240. [3] Akers, C. and Schedl, A. D. (2012) *LPSC 43rd*, Abstract #1932. [4] Mège, D. and Bourgeois, O. (2011) *EPSL 310*, 182-191. [5] Makowska et al. (2016) *Geomorphology 268*, 246-252. [6] Wilson, R. C. and Keefer, D. K. (1985) *U. S. Geol. Surv. Prof. Paper*, *1360*, 317-345. [7] Michael, G. G. and Neukum, G. (2010) *EPSL*, *294*, 223-229. [8] Robbins S. J. et al., (2012) *JGR*, *117*, E05004. [9] Duffy, A. and Schedl, A. D. (2015) *LPSC 46th*, Abstract # 2501.