Landslide on Valles Marineris: morphology and its flow dynamics

Hiroyuki Sato[1]; Kei Kurita[1]; DAVID BARATOUX[2]; Hiroki Ichikawa[1]

[1] ERI,Univ. of Tokyo; [2] OMP, UMR 5562 LDTP, UPS TOULOUSE III

The walls of Valles Marineris on Mars are affected by numerous landslides which are well preserved.. In comparison with terrestrial landslides or other mass movements, martian landslides are distinctive in their size and morphology. Due to the collapse of the huge canyon wall, the averaged drop height of these landslides is about 6.5 km and the averaged volume is about 10^{24} km^3[1], which is 2~3 orders of magnitude larger than terrestrial ones (at the exception of marine landslides)[2]. As for the morphology, clear levees with longitudinal lineations are typical features, whereas rather chaotic bodies with transverse ridges are dominant in the terrestrial mass movements.

These characteristics should reflect the dynamics of the emplacement of collapsed materials and could be considered as an indicator of the properties of the material composing the slides. In particular, there is a long-standing debate, which is not yet settled, about the long run-out length and the existence of subsurface volatiles (water ice, clathrates, ground water)[1,3,4,5,6,7]. If material property could be deduced from the morphology predicted from flow dynamics, we will be able to know the surface or subsurface characteristics at the time the collapse occurred, and thus evaluate also their evolution along 2 Gy of Martian history.

This study focuses on the longitudinal grooves which are found on the surface of landslide deposits at Valles Marineris. This pattern is unique feature in the martian landslides, but rarely observed in the terrestrial mass movements. The origin is not well clarified. To determine the origin of lineated deposits, we first measured the geometric parameters of the landslides affected by these features, such as volume, thickness, length, width and depth of the longitudinal ridges, by remote sensing technique with high resolution images (MOC, THEMIS visible, and HRSC nadir images) and digital elevation models (MOLA and HRSC high resolution DTM). Then these parameters were compared to those of non-lineated landslides. The results were also analyzed in light of the characteristics of the features produced in laboratory experiments.

Because the direction of lineated pattern and surface slope are crossing, and also there are no lineations at surrounding basal floor, this pattern was not produced by secondary surface erosion after deposition of collapsed materials. It is supposed to be produced autonomously during the flow and preserved after the deposition. By the precise measurement of the deposit shape at the distal edge, we found that the ratio of thickness to width of lineation is about 1:1.8. Among possible flow process accompanied with longitudinal lineation, dry particle flow in acceleration regime[8] show similar morphology as martian landslides and the ratio of the flow thickness to the width of lineation has similar value of 1:2. Thus we estimate the martian landslides with longitudinal lineation could have been produced under quite dry conditions.

References:[1] Quantin C. P. et al. (2004) Planetary and Space Sci., 52, 1011 1022.[2] Legros F. (2002) Engineering Geology, 63, 301 331.[3] Luccitta B. K. (1979) JGR, 84, 8097 8113.[4] Harrison K. P. and Grimm R. E. (2003) Icarus, 163, 347 362.[5] Bulmer M.H. and Zimmerman B.A. (2005) GRL, 32, doi:10.1029/2004GL022021.[6] Soukhovitskaya V. and Manga M. (2006) Icarus, 180, 348 352.[7] Lucas A. and Mangeney A. (2007) GRL, 34, doi:10.1029/2007GL029835.[8] Forterre Y. and Pouliquen O. (2002) J. Fluid Mech., 467, 361 387.