EPSC Abstracts
Vol. 8, EPSC2013-473, 2013
European Planetary Science Congress 2013

Dynamics of mass flows and of sediment transport in Amazonis Planitia, Mars

F. V. De Blasio (1)
(1) Department of Geological Sciences and Geotechnology, University of Milan "Bicocca", Piazza della Scienza 4, 20126 Milan, Italy, and Department of Earth Sciences, University of Rome "Sapienza", Piazzale Aldo Moro 5, 00185, Rome, Italy, e-mail: fvblasio@geologi.uio.no

Abstract

The northern plains of Mars are topographically smooth and reminiscent of the ocean bottom. The existence of deep sediments blanketing even large craters and impact basins suggests the need for an efficient sedimentary process. Subaqueous landslides and turbidity currents might have been responsible for re-distributing sediments in the northern lowlands, but require the presence of standing water. Some morphologies attributable to mass flows in the region of Amazonis Planitia suggest that at least some of them might have occurred under water.

1. Introduction

The Vastitas Borealis region of Mars is blanketed with loose materials giving the northern plains a much smooth appearance, but the nature of these rocks and regolite is still obscure [1]. The impact basins of Utopia and Isidis Planitiae in the northern lowlands are respectively 1.2 and 3 km deep, i.e., much shallower that one would expect based on their diameter. Hellas and Argyre Planitiae in the southern uplands, comparable in diameter to Utopia and Isidis respectively, are much deeper (8 and 4 km). Thus the sedimentary filling of Utopia and Isidis is at least some km thick corresponding to an average erosion of more than half a kilometer, assuming uniform erosion of the southern highlands. The sedimentation in the northern lowlands, confimed among the other things by the MARSIS discovery of a buried pristine level, must have been efficient enough to re-distribute the sediments and bury the craters smaller than some hundred km in diameter. An attractive possibility is that sediments are the remains of subaqueous processes, in accord with the "Oceanus Borealis" hypothesis [2].

2. Mass flows in the northern lowlands

1.1 Dense mass flows

A clue as to the nature of this sedimentation is provided by some low to middle latitude mass flows directed northward.

Those shown in Fig. 1 resemble submarine debris flows on Earth, especially from glaciated areas [3]. Subaqueous mudflows can reach distances of several hundreds of km, travelling as much as 1,000 times the fall height [4]; for subaerial counterparts the figure is a mere 15 times. The mass flows of Fig. 1 have descended for 700-1,000 m travelling along a >1,000 km chute, which makes their mobility more similar to subaqueous, rather than subaerial debris flows. Such mass flows maintain a thickness of 50 m all the way along the chute (Fig. 2), which is indication of dense flow. Figure 2 presents further examples of mass wasting similar to terrestrial subaqueous blocks observed in areas of mass instability.

1.2 Turbidity currents?

On Earth, turbidity currents (TCs) typically spread from the continental margins over relatively gentle submarine slopes, carrying gravel, sand, silt and clay over distance of hundreds of km offshore, the so-called turbidites [5]. The upper part of a TC, perhaps some tens to hundreds m high, is a relatively light suspension dominated by the turbulence of the fluid. Particles settling to the bottom tend to accumulate at the base forming a dense fluidized layer.

The equation of motion of a turbidity current is approximated as the result of the gravity pull and drag resistance

$$\frac{dU}{dt} \approx g\frac{\Delta\rho}{\rho}\sin\beta - \frac{1}{2}C_D\frac{\rho_W}{\rho H}U^2 \qquad (1)$$

where H is the thickness, β is the slope angle and

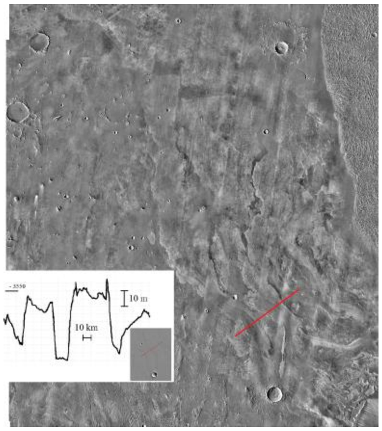

Figure 1. Mass failures west of the western aureole of Olympus Mons seen with THEMIS. Panel: MOLA transverse profile.

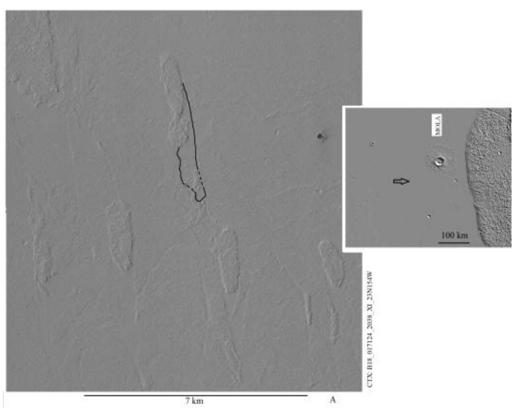

Figure 2. Blocks in Amazonis Planitia resemble certain landslide blocks seen in the ocean. One of the erosion marks left by the travelling blocks is highlighted in black.

$\Delta\rho/\rho = (\rho - \rho_W)/\rho$ is the Archimedean buoyancy ratio, ρ, ρ_W are the densities of the solid and water respectively while C_D is a drag coefficient. If the velocity is about constant, it results from (1) that $U \approx \sqrt{(8/f)\,g\,(\Delta\rho/\rho)\sin\beta H}$ a widely used equation with friction term $f = 4C_D$ with $0.01 < f < 0.05$ and $40\ m^{1/2}\ s^{-1} < C_D < 88\ m^{1/2}\ s^{-1}$. A second equation is

$$\frac{dH}{dt} \approx -u_\infty + u_\uparrow \qquad (2)$$

where u_∞ is the settling velocity of grains while $u_\uparrow$ is the vertical turbulent velocity of water. Pantin's criterion is adopted here, according to which autosuspension occurs if the velocity U of the TC is greater than $\approx 100\ u_\infty / \tan\beta$ or $u_\uparrow = 0.01\, U \tan\beta$ [6].

Eqs. (1-2) are solved iteratively for a realistic slope path. Figure 3 shows the maximum distance reached by the model TC as a function of the particle diameter for Mars's gravity field. If an ocean was present in the northern lowlands, distances of the order of some hundred km would have been in the reach of fine gravel; coarse sand could have travelled to high latitudes from the global dichotomy boundary. This analysis neglects the formation of a dense carpet at the base of the TC, the increase in viscosity due to the presence of a suspension and hindered settling, all processes favouring mobility and capable of transporting larger particles. It is possible that the repeated flow of TCs (possibly accelerated by debris flows such those of Fig. 1) blanketed the northern lowlands with a smooth layer of sediment; perhaps also contour currents played a role in the re-sedimentation, but more refined calculations should be attempted.

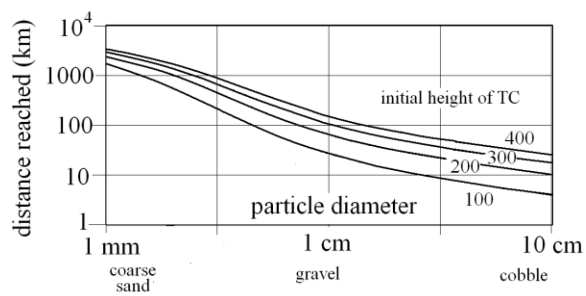

Figure 3: Maximum distance reached by a soil of given particle size in the turbidity current model for different initial heights of the current. Coriolis force and hindered settling are neglected.

References

[1]. Carr, M.H., Head III, J.W., 2003. J. Geophys. Res. 108, doi: 10.1029/2002JE001963; Carr, M.H., 2006. The surface of Mars. Cambridge Univ. Press, Cambridge; Baker et al., 2000. LPS XXXI; Fairén et al., 2003. Icarus 165, 53-67. [2]. Parker, T.J., Grant, J.A., Franklin, B.J., 2010. In: Cabrol, N.A., and Grin, E.A. (Eds.). Lakes on Mars. Elsevier, Amsterdam. [3]. Dowdeswell J.A., Cofaigh, C.O. (Eds). 2002. Geol. Soc. Spec. Publ. 203. [4]. De Blasio et al., Norw. J. Geol. 86, 275-284. [5]. Bridge, J.S., and DeMicco, R.V. 2008. Earth Surface Processes, Landforms, and Sediment Deposits. Cambridge Univ. Press, Cambridge. [6]. Pantin, H.M. 1979. Mar. Geol. 31, 59-99.