Flow in Martian valleys: dynamical models

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Abstract

Two kinds of structures are probably a result of flowing water on Mars: outflow channels and valley networks. We try to model flow of water in these structures to determine erosion, transport and deposition of the material using dynamical numerical model. Preliminary results indicate some advantages of our approach in explaining shape of cross-section of the valleys.

1. Introduction

There are a number of signs indicating past existence of water on Mars. Two kinds of structures are probably a result of flowing water on Mars: outflow channels and valley networks [e.g. 1]. The outflow channels are large (sometimes > 100 km wide and > 1000 km long) – Figure 1. They formed probably by catastrophic floods of liquid released from large reservoirs.

The valleys of the networks are usually narrow comparing to the outflow channels (< 5km) – Figure 2. The valleys form interconnected branching networks draining into local topographic lows [1].

Although generally the origin of valleys of the networks as well as the outflow channels are attributed to flowing water there are many indications that these processes are substantially different than their terrestrial counterparts [e.g. 4]. We think that the numerical model of flow and material transport could help to better understand flow processes on Mars.

2. Equations of the model

We use package of numerical program developed by NCCHE [5]. The program solves two-dimensional depth-averaged hydrodynamic equations, based on the Reynolds approximation of momentum equations and the continuity equation - see e.g. [3]:

\[ \frac{\partial \overline{u}}{\partial t} + \frac{\partial \overline{u} \overline{u}}{\partial x} + \frac{\partial \overline{u} \overline{v}}{\partial y} = -\frac{1}{\rho} \frac{\partial p}{\partial x} + \tau_x - \nu \frac{\partial^2 \overline{u}}{\partial x^2} \]

\[ \frac{\partial \overline{v}}{\partial t} + \frac{\partial \overline{u} \overline{v}}{\partial x} + \frac{\partial \overline{v} \overline{v}}{\partial y} = -\frac{1}{\rho} \frac{\partial p}{\partial y} + \tau_y - \nu \frac{\partial^2 \overline{v}}{\partial y^2} \]

where \( \overline{u} \) and \( \overline{v} \) are depth-averaged velocity components in the x and y directions, respectively. Moreover \( t \) is the time; \( \zeta \) is the surface elevation; \( h \) is the flow depth; \( g \) is the acceleration of gravity; \( \tau_x \) and \( \tau_y \) are friction shear stress terms at the bottom in the x and y directions, respectively. Additional equations included in the package describe erosion, transport and sedimentation of material. These equations are discussed in [5].

Figure 1. Topography map of Kasei Valles, Mars. Colorized Terrain of Mars from NASA in Google Earth. Areong
**Figure 2.** The picture of the valley network on Mars near Warrego in Thaumasia (42.5 degrees south latitude and 91.4 degrees west longitude) taken by Mars 2001 Odyssey by THEMIS system. The photo credit is NASA/JPL/Arizona State University. After Wikipedia.

4. Preliminary results

On one hand our calculations generally confirm that there are substantial problems to explain some properties of observed valleys and channels, especially origin of the source of the liquid. On the other hand we have found that substantial amount of salt dissolved in water and existence of water ice could help to explain some valleys’ properties like the shape of their cross-sections.

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References


