GRAPH-ANALYTICAL METHOD IN ICE AVALANCHE STREAMS MODELING ON MARS. E. V. Zabalueva[1], S. S. Krasilnikov[1] and R. O. Kuzmin[1,2], [1]Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, 19 Kosygin St., 119991 Moscow, Russia, zabal2013@mail.ru, [2]Space Research Institute RAS, 84/32 Profsoyuznaya St., 117997 Moscow, Russia.

Abstract: On Mars, few places with lobate moraine ridges (LMR) can be found. We assume that these ridges have ice avalanche or high-speed surge origin. In our research we consider ice avalanche origin of these ridges. Using graph-analytical approach, the largest speed and limit distance of avalanche stream have been calculated. We have got maximum distances of avalanches from longwise of LMR, calculated speeds and compare our results with previous modeling using RAMMS::AVALANCHE software.

Introduction: In our research we consider possible long-distance snow-ice type of avalanches with some content of silicate material (~5 – 30%) in two impact craters (70.3°N 266.45°E (A) and 67.25°N 249.45°E (B)) and on the plane (74°N 95°E) in the places with lobate moraine ridges (LMR). In our previous modeling [4] we used more complicated random kinetic energy method, implemented in Rapid Mass Movement Simulation (RAMMS)::AVALANCHE software [2].

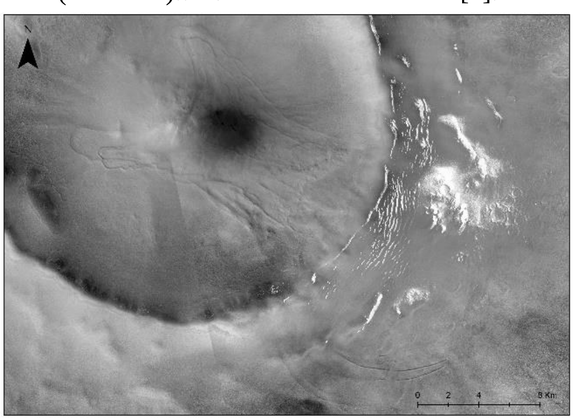

Fig.1. Lobate moraine ridges in crater 70.3°N 266.45°E

Graph-analytical approach: An evaluation of the largest velocity and limit distance of the ice avalanches has been obtained using the graph-analytical method [3]. This method has been destined for approximate estimation of snow avalanche velocities and runout on the Earth. The analytical approach – solution of the differential equation (1) with initial condition v_0=0 (moment of the avalanche separation). $\frac{\partial(v^2)}{\partial s} = 2(a - bv^2)$ (1), where $a = g(\sin a - f\cos a)$, v – speed, s – distance, g – gravity, f – friction coefficient, b – environmental resistance coefficient.

We have longitudinal profile that is divided into almost linear segments, each of which is characterized by its projections (Δx_i, Δy_i) and inclination α_i= arctg ($\Delta y_i/\Delta x_i$). The movement of avalanche is considered as the movement of a solid body along inclined surface and its mechanics description follows Coulomb's law. Environmental resistance is comprised of the roughness of the underlying surface and air pressure on the front of avalanche. Following [3], environmental resistance, compare to the friction, is sufficiently small. The largest velocities and distances in the given point can be achieved by absence of environment resistance (b=0) and minimum value of coefficient of friction ($f=r_{min}$). Then the equation (1) takes the following form: $\frac{\partial(v^2)}{\partial s} = 2a$ (2). Solution of equation (2): $v^2 = v_0^2 + 2g(\sin a - r_{min}\cos a)s$ (3), where the solution is given for surface fragment with almost constant slope and v_0 = 0 and v are values of avalanche front rate in the start point and in the end. Our profiles consist of segments that are almost linear, so computation of speeds of the total profile consists of the sequential calculation rate of next segment v, where v_0 is equal v of the previous segment. There are inclination a_i, $S_i = \sqrt{\Delta_i x^2 + \Delta_i y^2}$, friction coefficient r_{min} are known for each segment. The avalanche's speed for the start point and the end of each segment in the profile, using inclination a_i, r_{min} and length of segment can be computed. The acceleration on Mars is 3.71 m/s^2.

For the computation of maximum distance and speed in different points on the profile, graphical approach can be used also even if for control of analytical calculation. The graphical approach is very useful for pointwise estimation of speed and forecast runout of future avalanche. We used formula (4) for direct computation of speed in the same points of the given profile also $\frac{v^2}{2g} = y - r_{min}\,x$ (4), where (x,y) – coordinates of the profile point. The right part of (4) is graphical interval in addition the axes of taken Cartesian coordinate system have the same scales. Where v – velocity, (x, y) – coordinates of the profile's point. If height (H) and runout (L) of avalanche are

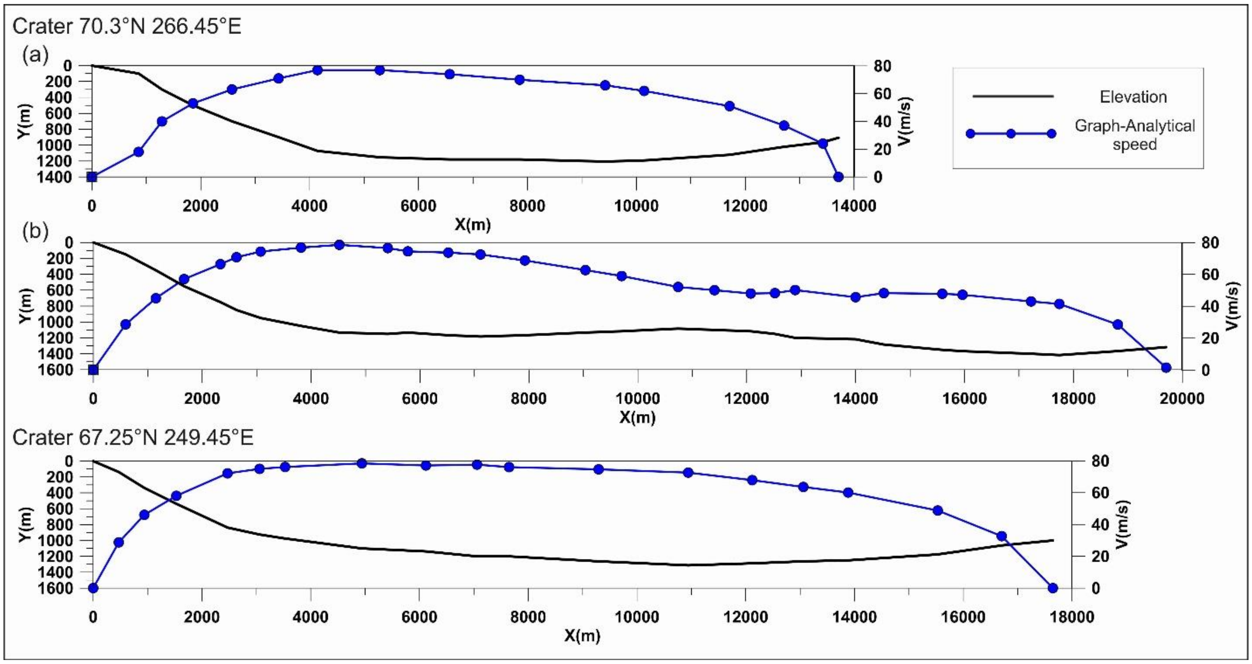

Fig. 1. Speed profiles of avalanches in crater 70.3°N 266.45°E (A) with central peak (a) and without central peak (b) and in crater 67.25°N 249.45°E (B), using Graph-analytical method.

known then r_{min} = H/L and $v = \sqrt{2g(y - r_{min}x)}$, $Y1 = r_{min}x$ – equation of straight line.

Results: Using graph-analytical approach, the largest velocity and distance of the avalanche front have been calculated for profiles that are presented in craters A and B respectively (Fig. 1). The variation of avalanche velocities are 18m/s to 77m/s in crater A and from 29 m/s to 77 m/s in crater B. Friction coefficients r_{min} are 0.066 (A) and 0.056 (B). This friction coefficient characterizes property of underlying surface material. Because the acceleration on Mars is in 2.64 times smaller than on the Earth, consequently the friction force will be also smaller.

Our results of graph-analytical approach [3] were compared with previous models [4] using random kinetic energy (RKE) model [1] in RAMMS software [2]. Both models have approximately the same speed results.

References:

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