IDENTIFICATION OF METEORITE-PRODUCING EVENTS IN MARTIAN AND TERRESTRIAL ATMOSPHERE. D. Kuznetsova[1] and M. Gritsevich[1,2], [1]Institute of Mechanics and Faculty of Mechanics and Mathematics of the Lomonosov Moscow State University, Michurinsky pr., 1, 119192, Moscow, Russia, morven9@yandex.ru, [2]Finnish Geodetic Institute, P.O.Box 15, FI-02431 Masala, Finland, maria.gritsevich@fgi.fi.

Introduction: Meteorite production on Mars is a new and dynamically developing subject of scientific investigation e.g. [1,2]. In this study, we develop the theory describing a meteoroid entry into an atmosphere of a planet and apply our results to the atmosphere of Mars. Based on physical parametrisation, we introduce two key dimensionless parameters, which allow to construct the criterion for the meteorite fall identification in a simple analytical form. The described approach is very convenient for analysis and classification of the possible impact consequences.

Problem formulation and main results: We consider a meteoroid with the pre-entry mass M_e, pre-entry velocity V_e, bulk density ρ_b, and the local angle between the trajectory and the horizon γ, which is supposed to be constant. For describing the motion we use the classical equations of the model of meteor body deceleration [3,4]. The analytical dimensionless solution for the mass-velocity dependence and the height-velocity dependence can be expressed using two main parameters [5-7]: the ballistic coefficient $\alpha=c_d\rho_0 h_0 S_e/(2M_e \sin\gamma)$ and the mass loss parameter $\beta=(1-\mu)c_h V_e^2/(c_d H^*)$, where c_d is drag coefficient, h_0 - height of the homogeneous atmosphere, c_h - coefficient of heat exchange, S_e - initial area of middle section of the body, ρ_0 - atmospheric density near the planetary surface, H^* - effective enthalpy of destruction, μ - constant parameter relating the middle section s and the mass m of the body in dimensionless units as $s=m^\mu$ [8]. The ballistic coefficient α characterizes the aerobraking efficiency as it is proportional to the ratio of the mass of the atmospheric column along the trajectory having cross section S_e to the meteoroid initial mass. The mass loss parameter β is proportional to the ratio of the fraction of the kinetic energy of the unit body's mass arriving at the body in the form of heat to the effective destruction enthalpy. These parameters uniquely characterize an atmospheric trajectory of a given meteoroid.

The values of these parameters can be used to determine the impact consequences. The meteorite fall condition can be set as $M_t \geq M_{min}$: the terminal mass of the meteoroid should exceed or be equal to a certain chosen value M_{min}. This condition can be written using α and β, while the equality sign represents boundary curve in (α,β) space, so the impact consequences are described by the position of the case-under-investigation point relatively to the boundary curve.

We consider two types of meteoroids: chondrite, with the density ρ_b=3.5 g/cm^3 and entry velocity V_e=10 km/s, and the iron meteoroid, with ρ_b=8 g/cm^3 and V_e=15 km/s (the values of the velocity considered here are close to the mean atmospheric entry velocity [9,10]). For the Martian atmosphere the following parameter values are used: h_0=11 km and ρ_0=0.0154x10^{-3} g/cm^3. The obtained results are compared with the similar meteoroid entry into the atmosphere of Earth (h_0=7.16 km and ρ_0=1.29x10^{-3} g/cm^3). We show that for the certain M_e range a meteoroid entering the terrestrial atmosphere would be fully ablated, while a fraction of the body reaches the planetary surface if a meteoroid with similar properties would be entering the Martian atmosphere. In Fig. 1 the example is shown. A full line represents the boundary curve for Mars, and a dotted line - for Earth. One can see that the point corresponding to the meteoroid entering the Martian atmosphere lies to the left of the boundary curve, which means meteorite fall, and point corresponding to the meteoroid entering the terrestrial atmosphere lies to the right of the boundary curve, which means its full ablation.

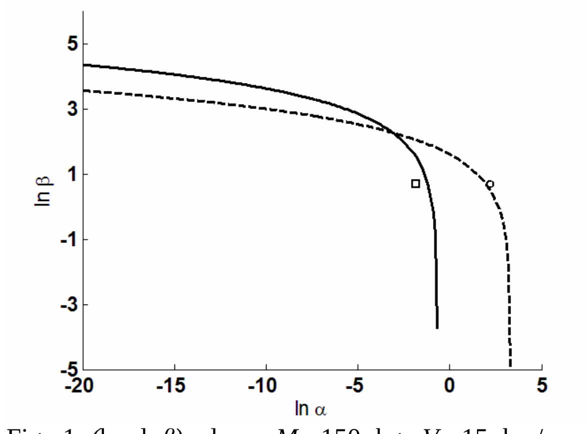

Fig. 1 $(\ln\alpha,\ln\beta)$ plane. M_e=150 kg, V_e=15 km/s, ρ_b=8 g/cm^3, $\sin\gamma$=0.3. The full line represents the boundary curve for Mars, the dotted line - for Earth. □ represents relevant values of ballistic coefficient α and mass loss parameter β for the meteoroid entering an atmosphere of Mars; ○, recalculated values for the case of terrestrial atmosphere.

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