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Setting criteria for distinguishing meteorite-producing fireballs

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In this study, we analyze results of cosmic bodies' collisions with planetary atmosphere and planetary surface. Using the basic differential equations [1] one can introduce dimensionless parameters describing a problem. Then we distinguish two key dimensionless parameters with the following physical meaning: (1) the *ballistic coefficient* α, which shows the ratio between the mass of the atmospheric column along the trajectory and the body's pre-entry mass; (2) the *mass loss parameter* β, which depends on the ratio between the fraction of the kinetic energy arriving at the unit body's mass as heat and the effective destruction enthalpy. These parameters explicitly characterize the ability of entering body to survive during atmospheric entry and to reach the ground [2]. The processes accompanying atmospheric entry essentially depend on values of these two parameters as well. Thus different events could be associated with different groups with similar predictable consequences. The ballistic coefficient and mass loss parameter can be derived by several existing techniques [3]. Based on these values we can forecast falls of meteorites on the basis of observed part of bolide atmospheric trajectory and separate cases into 3 main groups:

The range $\alpha \ll 1$, $\beta \ll 1$: the impact of a unified massive body with the Earth's surface results in the formation of a vast crater. The large body's mass minimizes the effect of the atmosphere. Most likely, the atmosphere is penetrated by a cosmic body without its fracture.

The range $\alpha > 1$, $\beta < 1$: fracture of the meteor body in the atmosphere and deposition of a cloud of fragments onto the Earth's surface take place with the formation of a crater and meteorite fields. The ablation effect of the fragments is of minor importance.

The range $\alpha \sim 1$, $\beta \sim 1$: These conditions are characterized by a more significant role of ablation. Depending on exact α - β values, relatively small meteorites (no crater formation), expected to be found in these cases.

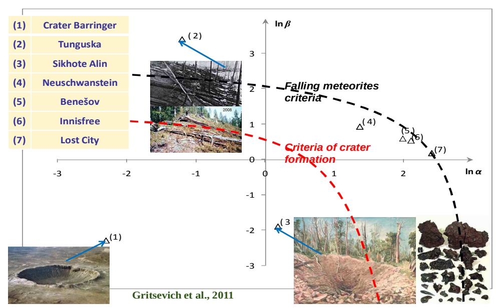

Figure 1: Setting criteria for crater formation and falls of meteorites: The found theoretical dependences on ballistic coefficient (α) and mass loss parameter (β) of a meteor body. Decreasing values leads to increase in collision consequences.

Further analysis of the risk from collisions of cosmic bodies with the planetary atmosphere and surface serves as good application of the proposed model. Currently the model was tested on three historical impact events (Barringer crater / Canyon Diablo meteorite, Sikhote - Alin meteorite fall and Tunguska fireball) and was found to reasonably predict the consequences for these events (Fig. 1). Thus the model is suitable to categorize various impact events in terms of meteor survivability and impact damage.

References

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