**ADDITIONAL HEATING: INTERACTION OF IMPACT EJECTA WITH AN EXPANDING FIREBALL.**

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**Introduction:** Ejecta of crater-forming impacts onto the Earth impinge into a disturbed atmosphere. The biggest ones are considered moving ballistically. Initially heated by the impact shock wave they cool down. In [1] melting coats over gneiss bombs deposited in suevitic breccias were interpreted as an effect of a fireball radiation. Also so-called non-ballistic ejecta on a descendent part of their trajectory can get an additional heat by gas drag [2], [3]. Here we examine a possibility of the ejecta additional heating above the Curie temperature and a possibility of their additional melting in a fireball. To define radiation and air parameters around the ejecta a gas dynamic atmosphere evolution, a ballistic motion of the ejecta were calculated, and then heat transfer in ejecta samples have been considered.

**Model constrains:** Courtesy of V. Shuvalov we used his distributions, obtained for an oblique impact of 1 km asteroid with speed of 20 km/s at an angle of 45 degrees as initial ones, getting started at time of 21 s. Calculations have been performed until time of 250 s after the impact . In Fig.1 (left) temperature distribution in the atmosphere and location of the ejecta curtain (magenta crosses) are shown at the initial time moment of 21 s.

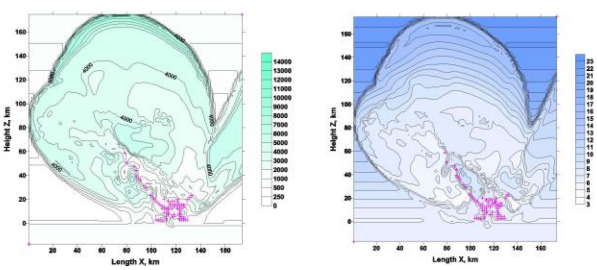

**Fig.1.** Air temperature (K) (the left panel), radiation paths (km) (the right panel) and ejecta location (magenta crosses) versus height z and length x.

At these temperatures atmospheric gas radiates a big portion in the infrared part of spectrum, the disturbed region temperature distribution is rather smooth. In Fig.1 (right) distribution of atmospheric opacities in infrared wavelengths with the location of the ejecta are depictured [4].

The disturbed atmosphere appears to be a semi-transparent over the calculation time. Under expansion the radiation paths and the radiating region are increasing. So radiation on the ejecta is estimated by Stefan-Bolzmann formula diminished by absorbtion [5].

The ejecta, previously heated by the impact shock wave, could undergo to strong heat exchange by molecular collisions with the local hot air. At first we assumed that the ejecta surface temperature follows the local air temperature (model 1). As an ambient temperature on the ascendent portion of ejecta trajectories exceeds the sample temperature, the sample upper layer heats and even melts. At second we calculated the surface temperatures and subsequent heat flow inside the body, taking into account collisional heating and radiative heating and cooling (model 2).

Fig.2 shows a relative internal energy distribution in the atmosphere at time 100 s, a red cross marks an ejecta sample which thermal evolution will be discussed below.

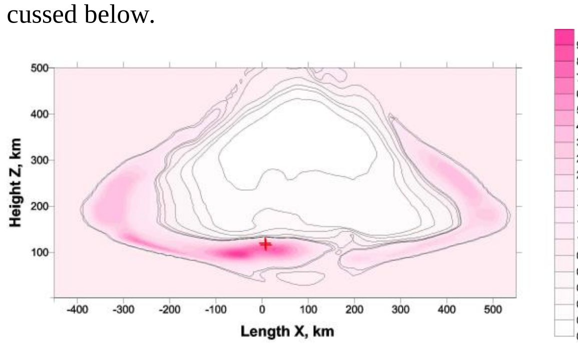


**Fig.2.** Relative internal energy versus length and height, time 100 s, the red cross marks the ejecta sample emplacement.

Ejecta with start vertical velocity exceeding 1.5 km/s fly in the upper atmosphere after 100 s for a rest of the time evolution. Ejecta with start vertical speed of about 1 km/s over the descendant portion of their trajectory impinge into an undisturbed lower atmosphere and they are actually experiencing gas drag (moving non-ballistically, we don't calculate that), but due to a relatively slow speed they are not undergoing to significant heating.

**Results:** Heat conductivity equation was solved for solid ejecta population. Samples with initial radii of 3 cm, 10 cm and 30 cm were selected, their initial temperatures were less than 1200 K, which is lower than feldspatic melting temperature. Thermal constants are typical for granites.

Fig.3 (the upper left panel) shows mass proportions with temperature above the Curie point of magnetite (CP), calculated in frames of model 1 (solid lines) and model 2 (dashed lines). Blue curves are referred to 3 cm bodies, black curves- to 10 cm bodies, red curves- to 30 cm ones.

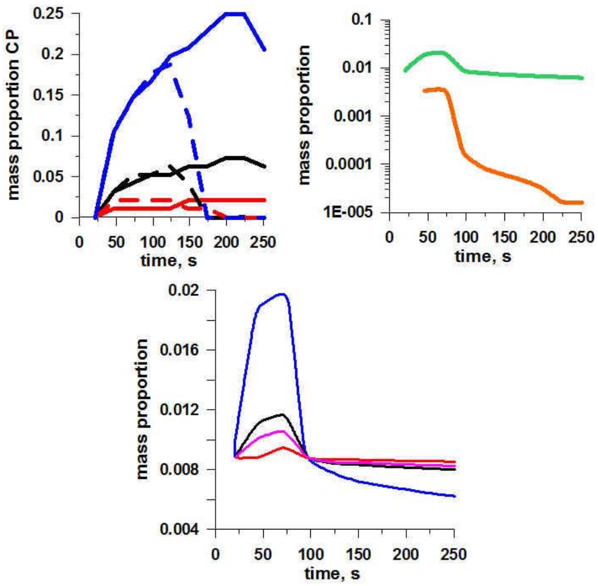


**Fig.3.** Mass proportions CP and MP versus time. The presented curves describe thermal evolution of one of 354 solid ejecta samples.

Melt proportion (MP) is obviously less than the CP. In Fig.3 (the upper right panel) we demonstrate the Curie proportion (green curve) and the melt proportion (orange curve), calculated on a base of model 1 for 3 cm body, summarized over all the population of solid ejecta. The CP curve starts from non-zero value, because some of the samples had initial temperatures higher than the Curie point. The MP curve starts from zero, because we consider solid-state ejecta, but final values are of order 1.0e-05. Results obtained with model 2 look pretty similar. This may hint that radiative cooling works efficiently, while the fireball radiation maybe underestimated.

Mass propotions CP for three samples of different sizes (3 cm- blue, 10 cm- black, 30 cm- red) and the mean CP (magenta curve), averaged over size-frequency distribution (SFD) of fragments are shown on the lower panel in Fig.3, SFD is similar to [2]. The heated upper layer is of order of 1 cm.

Obtained numbers are more sensitive to collisional heating model and less to the atmosphere radiation, but both processes are required to be clarified.

**Discussion:** In many aspects Gneiss Bombs deposited as fragments in clastic or suevitic breccias of Popigai crater [1] resemble the modeling ejecta samples, though Popigai structure exceeds the crater, described here.

**Summary:** The increase of transient demagnetization and total melt production is revealed. The fireball radiation could heat surface layers of solid fragments for some time. The secondary magnetization of ejecta could occur, while their temperature drops down the Curie point in the geomagnetic field, which itself, as was shown in [6] is distorted by the post-impact ionosphere.

**References:**

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