TEKTITES: MODEL VERSUS REALITY. N. Artemieva[1,2], [1]Institute for Dynamics of Geospheres 119334 Moscow, [2]Planetary Science Institute 85719 Tucson artemeva@psi.edu.

Introduction: The name "tektite" originates from Greek "tektos" – molten. Official geological definition of tektites may be found in [1]: "Impact glass formed at terrestrial impact craters from melt ejected ballistically and deposited as aerodynamically shaped bodies in a strewn field outside the continuous ejecta blanket". Another one [2] adds: "they are fairly homogeneous rock (not mineral) melts; they generally have low water contents and a very small extraterrestrial component; and they seem to have formed from the uppermost layer of the target surface". Translated into the language of physics, both definitions may be summarized as follows: tektites are high-temperature (homogeneity and an absence of volatiles), high-velocity (distal) molten (amorphous) silica-rich ejecta from terrestrial craters (similarities with target rock).

In this paper I use this definition to make tektites in numerical models and to compare modeled characteristics with available data. Apart from the standard problems (total amount of tektites, their flight in the atmosphere, and their final spatial distribution), the following questions are addressed: 1) are all tektites from the uppermost target layer; 2) why there are no tektites originated from small km-sized craters; 3) is it possible to find tektites at proximal sites and/or within an impact crater; 4) how big are tektite strewn fields relative to a parent crater size; 5) are tektites rare; 6) do solid distal ejecta exist?

Numerical model: I model an oblique impact and high-velocity impact ejecta motion using 3D hydrocode SOVA [3] complemented by the ANEOS equation of state for geological materials [4]**.** All materials above the surface, subjected to tension (i.e. with density below normal for a given temperature) are disrupted into particles with size-frequency distribution defined by maximum shock compression [5]. The motion of these fragments in the post-impact plume is described in the frame of two-phase hydrodynamics: each fragment is characterized by its individual parameters (mass, density, position, and velocity) and exchanges momentum and energy with surrounding vapor-air mixture.

Standard model output: Total mass of high-velocity ejecta (measured in a projectile volume) and its pressure-velocity distribution (PVD) do not depend on the projecilte size D_{pr}. 18 km/s-impact at 45° to horizon into silica-rich target (quartz EOS) has been modeled to receive ejecta PVD at the early stage of crater growth. Cumulative volume of ejecta is shown in Fig.1 separately for solid and molten materials. At low velocities (< 1 km/s) total amount of solid ejecta exceeds molten ejecta by an order of magnitude. However, there are no solid ejecta with velocity above 5 km/s (maximum ejection velocity from spallation zone is highly sensitive to computational resolution, see [5] for discussion). The presented results are valid for homogeneous target, i.e. give maximum estimates for any non-homogeneous target (precursor material for moldavites, Tertiary sand, formed a discontinuous layer at the pre-impact surface of the Ries, 0–50 m thick [6]).

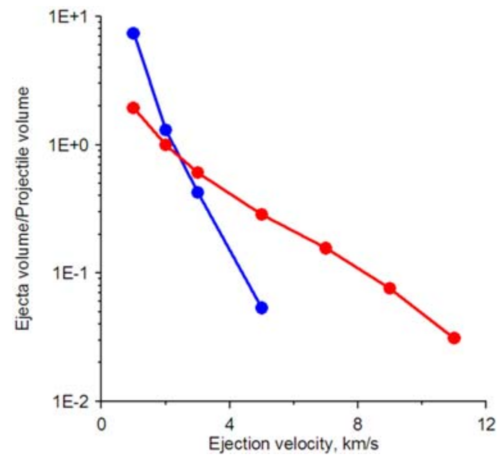

Fig.1 Cumulative (volume of ejecta with initial ejection velocity above shown on the X-axis) distribution of solid (blue line) and molten (red) ejecta measured in projectile volume.

^{10}Be content. Excavation depth (initial position of ejecta in the target) drops quickly with increasing ejection velocity: from 0.25D_{pr} for 2 km/s to 0.02 D_{pr} for 11 km/s. I.e. ejecta with the highest velocity (and hence – the most distal) originate from a very thin surficial layer. This result is in a good agreememt with ^{10}Be distribution in Australasian microtektites [7]. The Bosumtwi crater was created by a 1-km-diameter projectile, i.e. all tektites (and especially distal microtektites) originated from the uppermost 20 m of the target, which could be rich in ^{10}Be. At the same time, larger impacts could excavate "tektites" from deeper layers without any ^{10}Be-anomaly (as there are no large terrestrial young craters, this hypothesis can not be proved).

Homogeneity and volatiles deficiency. Tektites are extremely dry and volatile free. There are at least two explanations of this fact: a slow diffusion of gas through melt during long-lasting tektite flight [6] and a rapid loss of volatalites during initial "jerking" of high-temperature, low-viscosity melt [8]. The latter is more preferable as it allows to explain an absence of diffusion profile within tektites.

Strewn field size: Modelled strewn fields for the Ries and the Bosumtwi craters [6,9] are in a reasonable agrement with known tektites-microtektites distirbutions. The largest strewn fields originate after a ~30°-impact (more oblique impacts eject a lot of high-velocity melt but it moves through the low dense atmosphere, while less oblique impacts eject melt into steep trajectories). Seems, a hypothesis of an extremely oblique producing Australasian tektites impact (without large crater formation) is in a contradiction with huge area covered by these microtektites.

Impact glasses from small craters: While initial ejecta PVD does not depend on the scale of cratering event, ejecta fate in the Earth's atmosphere does depend. If a projectile is ~10 times smaller (hundreds of meters) all ejected material is quickly decelerated by the atmosphere; molten droplets cool quickly, and descend at the distances of a few crater radii (still beyond continious ejecta blankets). – see Fig.2. Most probably they are not as homogeneous as real tektites, contain vesicles, volatiles and are not aerodynamically shaped. Examples of impact melt particles (but not tektites) are well known at the Meteor crater [10]. Numerous glasses were found in a 400 km^2 strewn field surrounding 1.2-km-diameter circular depression known as Darwin Crater [11].

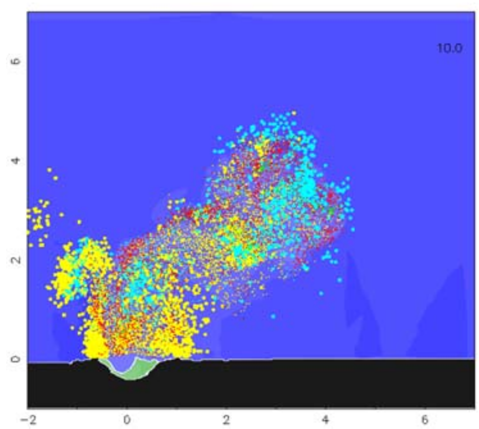

Fig.2 10 s after the impact tektites (cyan color) ejected from 1-km-diameter crater reach their maximum altitude and begin to descend vertically.

Fallback "tektites": Although most high-velocity molten ejecta leave the parent crater at the very early stage of the crater growth, some solid/molten particles may be found within the ejecta plume exactly above the crater at the end of crater formation (tens of seconds after the impact). These particles vary in size (from 100 μm – minimum modeled size - to decimeters) and degree of shock compression (from lightly shocked to partially vaporized). Large (> 1cm) solid particles (total mass of about $3{\cdot}10^{11}$ kg for 1-km-diameter projectile) are already descending and reach the surface within a couple of minutes, i.e. during the crater modification stage. However, small (< 1 mm) solid (~$3{\cdot}10^{10}$ kg) and molten (~$5{\cdot}10^{8}$ kg) particles are deposited during the next 30 minutes and, hence, AFTER crater modification in quiet environmental conditions forming fallback breccia. Total thickness of the fine fallback breccia varies from site to site within a few cm. Modeled results for the fallback layer are in agreement with uppermost microbreccia found recently during the Bosumtwi drill project [12]. A microbreccia containing microtektite-like glass spherules and glass fragments of compositions similar to Ivory Coast tektites, was found in a 30-cm-length core from borehole LB-05B in Lake Bosumtwi at the interface between impact breccias and post-impact lake sediments. The fallback layer is normally graded from fine-grained in the top part (which is rich in shocked quartz and glass) and relatively coarser-grained towards the bottom of the section.

Solid distal ejecta: According to Fig.1, ~1 km^3 of solid material is ejected from the Ries crater with velocity above 2 km/s. Only 10% of high-velocity solid ejecta was compressed below 10 GPa, i.e. is not disrupted into tiny particles and move ballsitically without substantial deceleration to the distances exceeding hundreds of km. These ejecta are mainly (70%) in the downrange direction (within 60-degree fan), but the rest is outside and even in the uprange direction. Samples of solid distal ejecta (Reuter blocks) were found at the distances up to 100 km from the Ries crater and in Switzerland [13].

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