NEW ASPECTS OF THE TUNGUSKA METEORITE PROBLEM

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Introduction

Any cosmic body flying through the Earth's atmosphere is partially or entirely destroyed. The properties of its remnants may be useful for the reconstruction of the phenomenon that occurred in the past. Unfortunately, our knowledge of the substance of the Tunguska Cosmic Body (TCB) is poor. By and large, the results of studying the forest leveling and the burn of tree surface seem to be fairly reliable (Kulik, 1939; Krinov, 1966; Fast et al., 1983; Vasil'ev, 1984, 1986, 1988). A number of investigators performed a bed–by–bed analysis of the elemental composition of solid particles found in the peats of the TCB fall–site district (Kovalevskii et al., 1963; Il'ina et al., 1971; Golenetskii et al., 1977a; Golenetskii et al., 1977b; Jéhanno, 1989; Nasarov et al., 1990). Longo et al. (1994) presented a comprehensive review of studies along with the original results of their analysis of the resin of conifers. This resin acts as a trap for solid particles. Revealing the TCB remnants by these approaches poses some difficulties because of the presence of background particles which could originate from micrometeorites also as volcanic eruptions, and aerosol degassing of tectonic–activity zones (Alekseev and Alekseeva, 1992).

In this work we consider particles more energetic than those of the background. These particles were found by us in the dense wood of a standing larch tree near the epicentre of the forest devastation in the TCB fall–site district. The wood sample was taken from a split in a tree stem. The increased energy of the particles provides good reasons to believe that their origin was related to the TCB explosion.

We also discuss the similarity between the recently observed phenomena accompanying the interaction of a plasma stream with a solid body in the laboratory device and the natural process of motion of a cosmic body through the atmosphere, which was ended by an explosion.

Revealing and classifying particles that had a significant velocity at the moment of the TCB fall

In this study, we analyze a tree that has survived the Tunguska catastrophe, being located near its epicentre. It has a vertical split in its stem, which penetrated from the bark surface to a depth of more than 10 cm. This tree's contact with the TCB substance, if it took place, should had been preceded by the arrival of the shock wave. The origin of the split could be attributed to the effect of the shock wave which, coming from above, exerted a compressive loading on the growing tree.

We discovered an abundance of small foreign–body particles that have been captured by the material of the sidewalls of the tree–stem split. They had energies high enough to penetrate into the dense wood, although not too deeply, the particles being thus captured by outer layers. In addition, they are concentrated in the portions of the sidewalls close to the bark, which indicates that the velocity vectors of the particles were chaotically distributed in their directions.

The tree continued living for about 40 years after the catastrophe and the split became partially skinned over by the wood tissue. The saw cut of the tree exhibits the characteristic configuration of the annual rings, the particles being localized in the vicinity of the 1908 ring. The alive tissue of the tree coats the foreign–body particles. (This circumstance permits us to discard the conjecture that the particles under cosideration could be the fragments of the instruments used for sampling and polishing the wood).

Of course, some particles of the type considered should be captured by the tree bark. However, the bark is a material not so long–lived as the danse wood and is more substantially subject to external influences. The district of the TCB fall is the crater of an extinct ancient volcano and is swampy. The energetic particles should come to the soil and the swamp surface. At the same time, the TCB explosion should raise a vast amount of terragenic matter together with cosmogenic background sediments. (In particular, the particles of this matter should be captured by conifer resins.) As this mass settled down, the thick layer of 1908 sediments was formed. It is rather difficult to pick up in this layer the particles directly related to the TCB.

Thus, dense wood is a good trap and good container for fairly energetic particles supplied by the TCB fall. Now we consider the morphology of the particles found in the dense wood of the tree. They can be divided into several groups:

1. Metallic particles. Most of them have a clear–cut cristallin structure and jagged edges which are usually produced by disruption. A large particle of this kind, ca. 52×23 μm^2 in size, is shown in Fig. 1. Some particles are potato–shaped.
2. Spherical silicat particles. Figure 2 shows such a particle of diameter about 8 μm.
3. Black plates with keen edges, appearing like graphite. Sometimes the signs of their breaking in the wood are noticeable (see the splinters in the right part of Fig. 2).
4. Whitish, irregular in form particles with keen edges. One of them is as large as 20 μm across.

A unique particle has left a 120–μm–long track behind it, the particle size being very small. Find of such kind could provide an important information on the origin and dinamical caracteristics of fast particles.

The classification proposed here takes into account only the appearance of the particles, being therefore the first step in compiling a catalogue of such hypothetical remnants of TCB.

Multiple explosion of a heterogeneous solid body at high pressure

The TCB is believed to have been destroyed by explosion. Unlike the regular case this event has an important peculiarity: The massive fragments of TCB have not been found or do not exist at all.

This peculiarity, along with some other known features of the TCB fall, can be explained in terms of the mechanism of multiple explosion. We suggest it on the basis of the results obtained in laboratory experiments (Alekseev et al., 1996 a).

At high pressures, solid materials, such as metals, rocks, etc., acquire the property of flowability. The most flowable component of a heterogeneous solid body was observed to be squeezed out of the body and explosively ejected in the direction opposite to the pressure gradient. The less flowable component, which plays the role of the “skeleton” of the body, starts cracking, collapsing and breaking down into small pieces. In turn, the material comprising these pieces differs in flowability from the undisrupted skeleton material, which results again in the phenomena of squeezing out, collapse and breaking down. Hereinafter this avalanche–type process will be referred to as multiple explosion. It produces various sorts of small energetic fragments. The highest energies should be achieved at oblique impacts (Melosh, 1989, Sec. 4.4.1), which accompany the process.

In the laboratory we use a steel piston that extrudes the material of the studied solid metallic sample through a hole in a steel plate, the hole being much smaller than the sample in diameter. The extrusion turns out to be explosive in nature and leads to the fragmentation of the sample into small potato–shaped particles (Fig. 3). The peak of the size distribution of these particles falls in the range 1–4 μm (its position depending on the sort of the metal). For example, the sizes of thus obtained particles of Sn shown in Fig. 3 were in the range 2,5–11 μm with the maximum of the distribution function at 5–6 μm (Alekseev et al., 1996a).

We suggest that the TCB flight was finished by a multiple explosion of the considered type. Owing to the collapse, large fragments could not leave the body and were progressively broken down into smaller pieces, the smallest fragments being squeezed out. Therefore, the TCB solid remnants are small particles. Among them, solidified drops of the substance molten in the course of TCB flight are present, as well as the energetic small fragments produced by the final explosion. In turn, the latter group (see the preceding section and Fig. 1–3) includes jagged remnants of the skeleton and potato–shaped particles produced by squeezing out the material, either flowable or of skeleton origin. Very fast particles could gain their energy in oblique impacts and, in some cases, be molten.

If dirty–ice inclusions were present in the TCB, the squeezed component could contain the ice impurities as well.

The multiple explosion could be responsible for sound bursts repeatedly heard by the eyewitnesses of the event.

Interaction of a body with a high–speed stream

In this section we call attention to a similarity between the interaction of a cosmic body with the atmosphere and the interaction of a solid sample with a high–speed plasma stream in the laboratory. The nature of this similarity is obvious. When flying through the atmosphere, the cosmic body is heated up, givin rise to a luminous plasma cloud, or fireball, enveloping it. Thus, it is the plasma that is the agent immediately affecting the body.

In the laboratorywe observe a series of sharp oscillations with time in the brightness of the substance near the body (Fig. 4), which accompany the repeated overheat explosions of the whole surface of the body. The some effect was recently reported by Borovicka and Spurný (1996) for a cosmic body flying through the atmosphere. In addition, between the shock front and the surface of the cosmic body, near the frontal stagnation point, a small very bright domain was observed. A similar domain of virtually the same shape is seen in our laboratory conditions we can investigate the stream–body interaction in detail (Alekseev et al., 1996b). In particular, the particles blown off the hot sample surface were studied. These particles are melt drops in the case of a metal sample and irregularly shaped splinters in the case of a graphite sample. It was found that the trajectores of the particles are localized within a thin layer adjacent to the body (for a body of size 3 cm, the thickness of this layer in the vicinity of the frontal stagnation point is about 1–2 mm).

Further, an unexpected phenomenon was observed. The number of the particles increases with increasing density of the plasma–stream energy until a saturation is reached at a certain density value – see Fig. 6 (Guseva et al., 1996). This suggests that some mechanism can operate that prevents the body from being attacked by the plasma stream.

The size distribution of the graphite particles is shown in Fig. 7. It has two peaks, near 0,017 and at 2–4 μm. A similar effect was revealed in the case of a metal sample.

On the basis of the data presented by Longo et al. (1994) and Serra et al. (1994), we constructed the distribution function for the particles studied by them. It demonstrates only one peak, which corresponds to the second maximum obtained in our experiments. This fact admits the interpretation that the particles were blown off the surfaces of the TCB and meteorites in their flight but, however, the first maximum turned out to be unobserved because of difficulties with separation of very small particles.

The possibility of thermonuclear reaction on the surface of a cosmic body flying in the atmosphere

An effect of unknown physical nature was recently discovered in our laboratory experiments. When a metallic body is hypersonically blasted with a deuterium plasma, an increased amount of tritium is recorded in the surface layer of the body. The possibility of a thermonuclear reaction in this layer was thus demonstrated (Alekseev et al., 1995). Quantitative data on the generation of tritium in the surface layers of some metals are presented in the table.

A similar situation may also be encountered under natural conditions. Some cosmic bodies, e. g., Halley's comet, are enriched with deuterium. When such a body flies in the atmosphere, its substance comes to the ambient plasma via ablation. The neutral atmosphere also contains background deuterium. Therefore, natural conditions arise that are similar to the laboratory ones in certain respects.

A depletion in deuterium observed at the Tunguska fall site (Kolesnikov, 1984) may be attributed to the interaction of the TCB with a hypersonic stream and subsequent burn–out of deuterium. Revealing an anomaly in ^{3}He and ^{4}He in this district could provide valuable information on the occurrence of the thermonuclear reaction. As tritium is involved in biological

Figures a have not been provide.

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