WAS THE 1908 TUNGUSKA COSMIC BODY A RUBBLE PILE ASTEROID?

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Introduction: A catastrophic collision of cosmic body with the Earth occurred above the Tunguska region of Siberia on June 30, 1908. Studies propose cometary [1] and asteroid [2,3] origin of the Tunguska projectile; some researchers [4] believe it was an iron meteorite though no sizable fragments of iron meteorite have been recovered. J. Anfinogenov proposed a hypothesis that the Tunguska projectile belonged to a new-type planetary-origin meteorite after he found a fresh impact structure produced by exotic sedimentary boulder (John's rock) in the epicentral area; some splinters of John's rock had fusion crust-like surface [5,6]. Nature of the Tunguska projectile remains controversial. Here we propose a hypothesis that the Tunguska cosmic body was a ruble pile asteroid.

Silica anomaly: In mid 1960s, J. Anfinogenov carried out a microscopy study of burn injuries detected in the 1908-growth rings of the branches from the larch trees that survived the catastrophe in the epicentral area. He observed the presence of microspherules and visually heterogeneous fused microparticles. Similar particles were found in the peat layer of 1908. In particular, the discovery of a significantly higher content of glassy silicate microspherules precipitated from the atmosphere was reported [7]. Compared with the adjacent peat layers, the peat layer of 1908 contains up to hundredfold-higher count of gray and colorless transparent silicate microspherules in hundreds of samples taken over the entire area of the Tunguska catastrophe. Data of neutron activation analysis show that chemical composition of these microspherules is distinct from that of industrial glass, local terrestrial microparticles, known stony meteorites, tektites, and Moon rocks [8]. The quartz grains were also found in sediment cores collected from Lake Cheko [9] in the epicentral area suggesting that they might have resulted from dust produced by the explosion in the atmosphere of the main body if the Tunguska cosmic body were silica-rich. The presence of this silica anomaly is consistent with the hypothesis on extraterrestrial origin of silica-rich John's rock.

PGE anomaly: However, the presence of PGE anomaly was also reported [10,11] though these reports were based on data from an insignificant number of samples. Peat cores from singular topographic locations were tested in these studies. Nevertheless, two distinct anomalies have been reported in the 1908 peat layer over the area of interest: (i) above-mentioned anomalous abundance of glassy silicate microspherules precipitated from the atmosphere and (ii) PGE anomaly. Two explanations may be proposed to reconcile these findings. According to the first explanation, two impact events involving silica-rich impactor and chondritic or cometary projectile happened independently within short period of time. The second explanation proposes the rubble-pile asteroid hypothesis.

Rubble-pile asteroid hypothesis: The second explanation is more plausible. It suggests that the impactor had a complex conglomerate composition consisting of multiple pieces that merged due to either collision of parent asteroids in outer space or due to a co-ejection of different adjacent rocks from a parent planetary body after a high-energy impact. It may be a co-ejection of enclosing bedrocks, intrusive igneous rocks, and impactor material where any of these components could partially melt into each other due to impact on parental planetary body. Such processes could produce a rubble-pile asteroid whose fall caused dual anomaly at the 1908 impact site in Tunguska.

Interestingly, no macroscopic pieces of chondritic or cometary projectile have ever been found in the area of the 1908 Tunguska catastrophe. Chyba C. F. *et al*. [3] reported that carbonaceous asteroids and especially comets are unlikely candidates for the Tunguska object and that the Tunguska event represents a typical fate for stony asteroids tens of meters in radius entering the Earth's atmosphere at common hypersonic velocities [3]. In this regard, John's rock may be considered a sound macroscopic candidate for a stony impactor though of a previously unknown type. This hypothesis is consistent with John's rock phenomenon bearing the numerous signs of high-speed impact and glassy fusion crust-like surface on some splinters [5,6]. It is also consistent with the discovery of the quartz grains in sediment cores collected from Lake Cheko [9] in the epicentral area and the glassy silicate microspherules anomaly associated with the entire area of the 1908 Tunguska catastrophe [7,8].

Conclusions: Data showing the presence of two distinct anomalies suggest that the 1908 Tunguska cosmic body may be a rubble pile asteroid partially consisting of a material representing planetary crust of Earth-like planet.

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