

TUNGUSKA EYEWITNESS ACCOUNTS, INJURIES, AND CASUALTIES

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Introduction: Dangerous effects of the impact of small cosmic bodies are due mainly to the action of the shock wave in the air and due to thermal and UV radiation. Overpressure can harm people by creating a pressure differential between the body's internal pressure and the ambient pressure. People can suffer from lung damage, eardrum rupture, concussion, being rendered unconscious, etc. In addition, strong winds can throw people against objects or vice-versa, resulting in cuts, bruises, bone fractures, and other internal and external injuries [1]. Thermal radiation can cause skin burns and indirect burns due to the ignition of materials in the environment. The burns can be of a different level of severity and nature, depending on the source and duration of radiation. UV and optical radiation can cause sunburns, retinal and conjunctival burns, temporal blinding, as well as heat sensations. The effect of thermal radiation from nuclear explosions are often used in radiation hazard assessments. However, the spectral dependence of radiation emitted during an asteroid impact can be different from the spectral radiation emitted by a nuclear explosion. Therefore, all theoretical approaches to risk assessment should be verified by observations, and the Chelyabinsk and Tunguska events provide rare opportunities to do so.

Tunguska eyewitness accounts. The powerful 10 - 20 Mt Tunguska event on 30 June 1908 occurred in an area with low population density. Nevertheless, there are many recorded eye witness reports, although most were collected long after the event in 1921-1930, 1938, 1959-1969 [2] and many accounts retell the stories of other people. Scattered in the region were local reindeer nomads (Evenks). The trading post Vanavara was located at about 65 km from the epicentre of the event. Eyewitness reports that contained information on injuries were extracted from the catalogue of eyewitness accounts [2]. The locations of reported injuries are only approximately known.

The locations of injuries are mainly in the region up to 300 - 500 km from the epicentre. Furthest from the event, injuries were mainly in the form of signs of stress and panic, sometimes accompanied by reports of objects falling from high places (bench, roof, Russian stove). About 50 eyewitness reports describe events in locations closer than 130 km from the epicentre. More serious injuries occurred there. The injuries mentioned include concussions, being stunned or fainting, a broken arm, burns, aphasia and blindness. Concussion and fainting were the most often mentioned. Fainting could be long lasting, up to two days.

The most reliable reports were gathered at an Evenk meeting in 1926, from which 3 casualties were reported. According to the information recorded by ethnographer I. M. Suslov, these losses might have occurred at distances 30 - 50 km from the epicenter[2], but again locations are only approximate known.

There is also information on glass damage reported at distances from 65 to about 300 km from the epicentre. These data look reliable, despite the fact that they were collected only in the 1960's. A few reports mentioned roof damage. According to [3] an approximate boundary of glass damage corresponds to 200 - 500 Pa of overpressure. Based on the constructed glass damage contour, the model for the rapid assessment of hazardous effects from asteroid impacts [4] predicts an overpressure level at that distance to be 500 - 700 Pa for a 10-Mt event, in reasonable agreement.

Summary: The eye witness accounts of the Tunguska event at various distances from the epicenter confirm a more significant impact than the recent Chelyabinsk airburst event, with more dramatic consequences. Even though the impact was in a sparsely populated region, there is strong evidence in the written record of at least three casualties from this event. The overpressure level predicted by a model for the hazard assessment of such impacts is in agreement with the reports of broken glass.

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References: [1] Glasstone, S. and Dolan, P. J.(1977) *The Effects of Nuclear Weapons*. U. S. Government Printing Office, Washington D. C., 653 pp. [2] Vasilyev, N. V. et al.(1981) *Testimony of witnesses of Tunguska fall (catalogue)*, Tomsk, 304 pp. (in Russian). [3] Gi N. et al.(2018) *Meteoritics and Planetary Science* (in press) [4] Glazachev D.O. et al.(2018), *this meeting*, abstract 6032.