EYEWITNESS ACCOUNTS AND MODELING RESULTS FOR CHELYABINSK AIRBURST.

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Introduction: The entry of the 20-m sized meteoroid at Chelyabinsk on 15 February, 2013, stands out from other fireballs for its magnitude and the large zone of destruction on the ground caused by its airburst. This event was extremely well documented [1]. The observational database includes photos, video, infrasound, seismic data and more. In addition, eyewitness accounts of the Chelyabinsk airburst have provided information not recorded by instrumental devices. Accounts were collected from in-person interviews during the field study (March 9-25, 2013) [1], from phone interviews (23-24 February 2013) and from internet surveys starting on Febrary 21, 2013. In total, about 3,000 accounts were collected. They provide information about sensations of heat, smells, sounds, the occurrence of sunburn, and the type of injuries sustained [1, 2]. The impact of small meteoroids such as Chelyabinsk are dangerous mainly because of the damaging effects of the shockwave and the thermal radiation [2]. Here, we discuss the available information about how many and what type of injuries were sustained. All available data (from government reports, from phone and internet surveys shortly after the event, and from newly collected data from local hospitals) are summarized and analyzed. All theoretical approaches to risk assessment need to be verified, and the Chelyabinsk event has provided the most comprehensive observational test to date.

Eyewitness accounts and modeling results: According to the interviews conducted via the internet, respondents had cuts or bruises, reported sunburn, hurt their eyes, mentioned retina burns (no official verification), were briefly stunned by the shockwave, or reported a brain injury in the form of a concussion or headache. A significant number of people were either in panic, or in shock and stressed out following the airburst arrival. Post-event injury reports included effects from stress in dealing with the aftermath. Most reports were obtained at distances smaller than 80 km from the ground-projected point of peak energy release. 51.6% from Internet respondents were outside at the time of the event, and 63% from them felt either hot or warm. Some respondents reported sunburns. This fact was confirmed during the field study (Vladimir Petrov from Korkino and N. A. Rybin from Travniky reported significant sunburn).

The observations were compared to results from modeling the frame work of the quasi-liquid (QL) model [3], which calculated a light curve of the meteoroid, UV and optical radiation, the formation of a shock wave and the overpressure on the ground. Results were also compared to general scaling relations [4,5] used in the impact effects on-line calcualtor [6]. According to the QL model, the maximum received energy in the UV range was estimated to be ~2000 J/m^2 and radiant exposure in Korkino (6-km from the ground-projected point of maximum energy release) is around ~1000 J/m^2 [3], which was enough to cause sunburns.

Most reported injuries were caused by cuts from broken glass and by trauma from the impact of the shock wave (falls and by being hit by objects, causing brain concussions, bruises, etc.). According to the Chelyabinsk impact models, the overpressure on the ground reached a maximal value of about ~4.3 kPa. Most officially reported injuries were located in the area of overpressure exceeding 1 kPa. The phenomena experienced by the eye witnesses also suggests that the overpressure in the shock wave was ≥1.4 kPa [1,3].

Summary: The Chelyabinsk event proved that a 20-m sized meteoroid, previously not classified as hazardous under Asteroid/Comet Hazardous classification, can cause significant damage. Even such small object is able to cause a significant number of injuries if the impact occurs near a populated area. These injuries were of different nature, most of them were cuts from broken glass. The distribution of injuries in general is in agreement with the result of a numerical simulation of the Chelyabinsk event based on the quasi-liquid model [3] as well as with scaling relations [4,5] used in the impact effects on-line calculator [6].

Acknowledgments: S. Korotky and I. Serdyuk developed the web-based survey. We thank the administrations of the Etkul, Korkino, and Krasnoarmeysk hospitals and the district of Uvelsk for their valuable contributions to this work. The work was partially supported by the Russian Science Foundation grant № 16-17-00107. PJ acknowledges support from the NASA Planetary Defense Coordination Office.

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