Paper No. 200-1
Presentation Time: 8:10 AM

THE CHELYABINSK SUPERBOLIDE: CHARACTERIZATION OF METEOROID AND LESSONS FOR THE EARTH IMPACT HAZARD

KOEBERL, Christian, Department of Lithospheric Research, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria, also of the Natural History Museum, Burgring 7, A-1010 Vienna, Austria, christian.koeberl@univie.ac.at, FERRIÈRE, Ludovic, Deartment of Mineralogy and Petrography, Natural History Museum, Burgring 7, Vienna, A-1010, Austria, and BRANDSTAETTER, Franz, Mineralogy and Petrology, Natural History Museum, Burgring 7, Vienna, A1010, Austria

On February 15, 2013, a brilliant fireball (a “superbolide”) entered the Earth’s atmosphere over Russia at a relatively shallow angle of ca. 18 degrees and exploded at an altitude of at least 23 km (maybe closer to 30 km) at about 9:20 a.m. local time (3:20 a.m. UTC). At the time of the maximum brightness the bolide was travelling at about 18 km/s. The fireball and the explosion were observed over a large area of the southern Ural region, followed by an explosion and shock wave that damaged several buildings and injured more than a thousand people in the region around the city of Chelyabinsk. Thousands of relatively small stones fell about 40 km south of Chelyabinsk and were rapidly recovered, bringing some extremely fresh material for scientific investigations. The largest object recovered so far weighs just a few kg. We recently reported on a multi-disciplinary study, involving mineralogy, petrography, magnetic properties, and cosmogenic radionuclide contents of a dozen stones of the Chelyabinsk meteorite that allowed us to confirm its classification and to characterize the initial meteoroid [1]. Petrographic observations and mineral compositions agree with the classification of the Chelyabinsk meteorite as an LL5 chondrite. Magnetic properties indicate a lack of tetrataenite in the meteorite. The Chelyabinsk meteorite is strongly brecciated and cross-cut by many impact melt veins, which are mainly composed of silicate fragments (unmelted chondritic constituents) surrounded by a matrix containing abundant and finely dispersed sulfides and metal grains.

In total, 12 stones (2-400 g) were measured by [1] for the cosmogenic radionuclides ^{54}Mn ($T_{1/2}$ = 312 d), ^{22}Na ($T_{1/2}$ = 2.60 y), ^{60}Co ($T_{1/2}$ = 5.27 y), and ^{26}Al ($T_{1/2}$ = 7x10^5 y). The large variations observed in activities of radionuclides (especially for ^{60}Co) indicate that the samples studied were both from the exterior as well as from the interior of the meteoroid; a pre-explosion meteoroid diameter of 14 to 20 m is indicated [1]. The explosion of this meteoroid, at about 440 kt TNT equivalent, can be compared to the Tunguska event, where no meteorites seem to have fallen, despite a lower explosion altitude. The implications of the two events in terms of danger assessment will be discussed.

[1] Povinec P. et al., 76th Annual Meteoritical Society Meeting (2013), abs. No. 5196.

Session No. 200
T5. Impact Cratering in the Solar System: Fire to Ice—Vacuum to Atmospheres
Tuesday, 29 October 2013: 8:00 AM-12:00 PM

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