THE CHELYABINSK, RUSSIA, METEORITE FALL

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On February 15, 2013, at 9:22 am, a spectacular meteor blast above the city of Chelyabinsk, Russia, sent a shock wave across the region. The bright fireball (Fig. 1) was seen by numerous observers in parts of the Kurgan, Tyumen, Ekaterinburg, and Chelyabinsk districts. The shock wave, resulting from the explosive deceleration and breakup of the meteoroid in the Earth's atmosphere, caused structural damage to buildings, shattered windows, and injured an estimated 1200 people in the city of 1.1 million. A part of the roof and a wall of a zinc plant and a stadium in Chelyabinsk were also damaged.

The Chelyabinsk event was literally heard around the world. Infrasound stations (a network associated with the Comprehensive Test Ban Treaty Organization, CTBTO) detected the very low-frequency sound waves of the meteor blast. According to a CTBTO press release (www.ctbto.org/press-centre/press-releases/2013/russian-fireball-largest-ever-detected-by-ctbtos-infrasound-sensors), the infrasonic waves from the Chelyabinsk meteor blast were the largest ever recorded by their International Monitoring System, which included readings from stations in Hawai'i and near the antipode in Antarctica. The infrasonic signals were used to help determine the size and velocity of the incoming meteoroid, the direction it traveled, and the energy released when it exploded over Russia. Preliminary indications reported by NASA Science News (http://science.nasa.gov/science-news/science-at-nasa/2013/26feb_russianmeteor) are that the meteoroid was 17–20 meters wide, weighed about 10,000 tons, traveled into the atmosphere at 18 kilometers/second on a 20°, low-angle trajectory, and shattered 19–24 kilometers above Earth's surface, releasing energy exceeding 470 kilotons of TNT and dropping fragments in a strewn field whose exact extent has yet to be determined.

The shattering of the meteoroid, the streak of the meteor (or fireball) in the morning sky, and the recovery of the meteorites are brilliantly documented by the Laboratory of Meteoritics at the Vernadsky Institute of the Russian Academy of Science. Their website (www.meteorites.ru) offers an extensive collection of photographs and eyewitness videos. The largest piece of the meteorite probably fell about 80 kilometers west of Chelyabinsk into frozen Chebarkul Lake, creating a 6 m diameter round hole in the ice, though this has not been confirmed since divers sent into the lake soon after the meteorite fragments fell encountered only the silty lake bottom. If the meteorite is recovered, it would represent an outcrop-scale piece of the asteroidal parent body. The size of the strewn field is currently estimated at 150 km along the trajectory and 20–30 km across.

Thousands of stones fell as a shower around Pervomayskoe, Deputatsky, and Yemanzhelinka villages about 40 km south of Chelyabinsk. The meteorite pieces were recovered and collected out of the snow by local people immediately after the meteoroid's fragmentation. The falling stones formed holes surrounded by granular snow. About 400 meteorite stones weighing 3.5 kg in total and a few thin sections are at the Vernadsky Institute (Fig. 2). The meteorite stones and fragments range from 1 g to 1.8 kg in weight and from a few millimeters to 10 cm (mainly 3–6 cm) in size. The total mass collected by local people is certainly >100 kg and perhaps >500 kg. The fragments recovered from the strewn field have been classified preliminarily as heavily shocked LL5 ordinary chondrite. Drs. Cyril A. Lorenz and Michael A. Nazarov of the Laboratory of Meteoritics have further determined the stones to be shock-melted breccias (Fig. 3; see also Fig. 4). The meteorite has officially been named Chelyabinsk (www.lpi.usra.edu/meteor/metbull.php?code=57165).

Unlike the 2008 Almahata Sitta event in Sudan, the first observed fall of a tracked asteroid (Jenniskens et al. 2009), the fall over Chelyabinsk came without warning. Bill Cooke of NASA's Meteoroid Environment Office (http://blogs.nasa.gov/cm/blog/Watch%20the%20Skies/posts/post_1361308690869.html) said that this is because the meteoroid was too small to detect ahead of time and that it came at us from the direction of the Sun, making it difficult to spot.

Figure 1 Photo of the fireball created as the Chelyabinsk meteor passed through the sky. Photo credit: Dudarev (www.lenta.ru)

Figure 2 One of the pieces of the Chelyabinsk meteorite collected by Vernadsky Institute scientists. Photo credit: Laboratory of Meteoritics, Vernadsky Institute, Russia (www.meteorites.ru)

Figure 3 Slice of one of the Chelyabinsk meteorite stones showing chondrules and melt-filled veins. Photo credit: Laboratory of Meteoritics, Vernadsky Institute, Russia

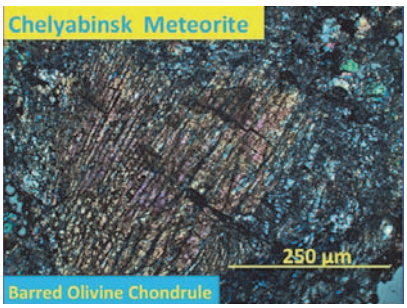

Figure 4 Thin section image (crossed polarizers) of a Chelyabinsk meteorite sample held by the University of Tennessee, Knoxville. It shows a barred olivine chondrule. Photo credit: Larry A. Taylor

REFERENCE

Jenniskens P and 34 coauthors (2009) The impact and recovery of asteroid 2008 TC_3. Nature 458: 485-488

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