Insight into space collisions from Chelyabinsk fireball

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Scientists from the Czech Republic, Finland, and the Russian Federation are presenting today new findings on meteorites recovered after the Chelyabinsk fireball that exploded over Russia on February 15, 2013. The report was presented by Dr. Maria Gritsevich (Finnish Geodetic Institute and Russian Academy of Science) and Dr. Tomas Kohout (University of Helsinki, Finland, and Academy of Sciences of the Czech Republic) to the American Astronomical Society Division for Planetary Sciences meeting in Denver, CO. The results are of special interest because they not only shed light on potentially hazardous impacts of asteroids on Earth, but also on more violent space collisions which disrupted ancient protoplanets in the early solar system into smaller asteroids we observe today.

The Chelyabinsk daylight fireball, which crossed the sky over Southern Ural in Russia on February 15, 2013, represents an exceptional event. It was the largest extraterrestrial body impacting the Earth since the Tunguska event in 1908. The atmospheric entry of the Chelyabinsk asteroid was observed by many witnesses, and the associated air blast caused significant damage including numerous broken windows and partial building collapses in the city of Chelyabinsk and the surrounding territories. The asteroid was only about 20 meters in diameter, but it disintegrated upon its hypervelocity atmospheric entry, releasing energy of 440 kilotons of TNT, equal to 20-30 times the energy of the nuclear bomb that detonated over Hiroshima. "Such large asteroids collide with Earth approximately once in 100 years. They come usually without any warning and can cause significant local damage," says Dr. Gritsevich, a scientist at the Finnish Geodetic Institute and the Russian Academy of Science. "Luckily for the residents of the Chelyabinsk region, the asteroid disintegrated high in the atmosphere, saving the Earth this time from a more catastrophic impact," Dr. Gritsevich adds.

The Chelyabinsk meteorite fragments dropped by the fireball on Earth's surface belong to silicate-rich ordinary chondrites. The ordinary chondrites are the most common stony meteorites falling on the Earth.

Extensive laboratory studies of the Chelyabinsk meteorite material revealed traces of ancient space collisions even more violent than the recent encounter with the Earth. While some meteorite rocks are bright gray with minor traces of space collisions, others contain signs of extensive impact-related melting and crushing. Some of them were even turned dark black. The dark black (so called shock-darkened) meteorite pieces experienced high pressure loads sufficient to entirely crush the mineral grains and melt metallic material. The molten iron filled tiny fractures within the silicate mineral grains making them to appear black.

The presence of rocks originating from a single asteroid, but modified by space collisions to varying extent, makes the Chelyabinsk meteorites exceptional. They allow us to study how space collisions change the appearance of asteroid surfaces and interiors. A major difference between the bright gray and shock-darkened meteorites was observed in laboratory measurements of their reflectance spectra (spectra of reflected visual-to-short-wave-infrared light). The bright gray Chelyabinsk meteorite spectra show the presence of silicate minerals such as olivine and pyroxene similarly to other ordinary chondrites.

However, the shock-darkened black meteorites have dark featureless spectra because the silicates are obstructed by molten metal. "These dark meteorites are exciting rocks to study. Their spectrum and composition is masked by ancient space collisions. There are many dark asteroids with featureless spectra in our solar system. Some people think that they may be formed of rocks rich in carbon and organic matter. But they can be also made of shock-darkened ordinary chondrites similar to the dark Chelyabinsk meteorites," says Dr. Kohout, a scientist at the University of Helsinki, Finland, and the Academy of Sciences of the Czech Republic. "It may explain why we cannot identify the composition of dark asteroids. We need spacecraft to visit asteroids and return samples back to our laboratories," Dr. Kohout adds.

The Chelyabinsk event reminds us of the existing threat of asteroid impacts for our civilization. Additionally, the study of the Chelyabinsk meteorites reveals even more powerful ancient collisions that occurred in the early solar system and caused some asteroids to appear dark.

Despite their obstructed dark spectra, these dark asteroids can be linked to the ordinary chondrite meteorites found on the Earth.

Provided by Finnish Geodetic Institute