Chelyabinsk meteorite had previous collision or near miss (Update)

August 26 2013

Fragment of Chelyabinsk meteorite, showing the fusion crust -- the result of a previous collision or near miss with another planetary body or with the sun. Credit: Dr. Victor Sharygin

The Chelyabinsk meteorite either collided with another body in the solar system or came too close to the Sun before it fell to Earth, according to research announced today at the Goldschmidt conference in Florence.

A team from the Institute of Geology and Mineralogy (IGM) in Novosibirsk have analysed fragments of the meteorite, the main body of which fell to the bottom of the Chebarkul Lake near Chelyabinsk on 15 February this year.

Although all of the fragments are composed of the same minerals, the structure and texture of some fragments show that the meteorite had undergone an intensive melting process before it was subjected to extremely high temperatures on entering the Earth's atmosphere.

"The meteorite which landed near Chelyabinsk is a type known as an LL5 chondrite and it's fairly common for these to have undergone a melting process before they fall to Earth," says Dr Victor Sharygin from IGM, who is presenting the research at the Goldschmidt conference. "This almost certainly means that there was a collision between the Chelyabinsk meteorite and another body in the solar system or a near miss with the Sun."

Based on their colour and structure, the IGM researchers have divided the meteorite fragments into three types: light, dark and intermediate. The lighter fragments are the most commonly found, but the dark fragments are found in increasing numbers along the meteorite's trajectory, with the greatest number found close to where it hit the Earth.

The dark fragments include a large proportion of fine-grained material, and their structure, texture and mineral composition shows they were formed by a very intensive melting process, likely to have been either a collision with another body or proximity to the Sun. This material is distinct from the 'fusion crust' - the thin layer of material on the surface of the meteorite that melts, then solidifies, as it travels through the Earth's atmosphere.

"Of the many fragments we've been analysing, only three dark samples show strong evidence of earlier metamorphism and melting," says Dr Sharygin. "However, many fragments of the meteorite were picked up by members of the public, so it's impossible to say how large a portion of the meteorite was affected. We hope to find out more once the main body of the meteorite is raised from Chebarkul Lake."

The fine-grained material of the dark fragments also differs from the other samples as it commonly contains spherical 'bubbles' which are either encrusted with perfect crystals of oxides, silicates and metal or filled with metal and sulfide.

Surprisingly, the IGM team also found small quantities of platinum group elements in the meteorite's fusion crust. The team are only able to identify these elements as an alloy of osmium, iridium and platinum, but its presence is unusual as the fusion crust is formed over too short a time period for these elements to easily accumulate.

"Platinum group elements usually occur as trace elements dispersed in meteorite minerals, but we found them as a nanometer-sized mineral (100-200 nm) in a metal-sulfide globule in the fusion crust of the Chelyabinsk meteorite," explains Dr Sharygin. "We think the appearance (formation) of this platinum group mineral in the fusion crust may be linked to compositional changes in metal-sulfide liquid during remelting and oxidation processes as the meteorite came into contact with atmospheric oxygen."

The findings are part of ongoing research into the meteorite, using a scanning microscope, electron microprobe and gas chromatography-mass spectrometry, through which the IGM team are producing a detailed mineral analysis of the Chelyabinsk meteorite.

Provided by European Association of Geochemistry