GEOLOGY AND CLIMATE CHANGE: MECHANISMS OF EXTINCTION

By Kevin Pope

The giant meteorite impact that formed the Chicxulub crater was one of the largest in Earth's history. Only Sudbury crater in Canada and Vredefort crater in South Africa are perhaps as large. It is difficult to study a crater Chicxulub, which is deeply buried by sediment, so we chose to look for other evidence of the impact that killed the dinosaurs. In Belize, we found rocks ejected from the craters preserved at the surface. These exposures of ejecta deposits are the closest known to the Chicxulub impact site. The tremendous size of the Chicxulub impact, the proximity of Belize to the crater, and the excellent preservation of the ejecta deposits found in Belize make this Planetary Society research unique among impact crater studies.

One of our most exciting discoveries was that the ejecta contained millimeter – to centimeter-sized spherical bodies (spherules) of carbonate rock. Some of these spherules are made of the mineral calcite (calcium carbonate, $CaCO_3$), which forms fiber-like crystals radiating out from the center of the spherule. Others are made of the mineral dolomite (calcium magnesium carbonate, $CaMgCO_3$), which commonly forms concentric bands of large and small crystals around fragments of dolomite rock. Where did these strange balls of rock come from? Our current hypothesis is that they formed as material within the expanding plume of rock vaporized by the impact condensed and coagulated into larger particles. The spherules ultimately fell like hail on Belize.

A Lethal Plume

The vapor plume rising over the Yucatan landscape 65 million years ago must have been an awesome sight. When the incoming asteroid or comet struck, so much energy was released as heat that it instantly vaporized rock. Computer models suggest that the Chicxulub impact would have vaporized rocks within 6 to 12 kilometers (4 to 7 miles).

These rocky vapors were composed of trillions of tons of sulfur dioxide (SO_2) gas, carbon dioxide (CO_2) gas and water (H_2O) vapor once peacefully contained in a 3-kilometer-thick (2-mile) layer of carbonates and sulfates at the impact site. Superheated to thousands of degrees Celsius, these gases expanded rapidly, eventually encircling Earth.

Many scientists believe that these gases, along with soot and dust ejected into the atmosphere, caused climate changes that ultimately helped kill off over 50 percent of the living species following the impact. Especially lethal was the sulfur dioxide, which formed sulfuric acid (H_2SO_4) clouds in the stratosphere. These clouds could have blocked sunlight, preventing photosynthesis for a few months and cooling Earth's surface to near freezing for about 10 years. In addition the sulfuric acid production would have depleted ozone (O_3) and also would have led to years of severe acid rain.

Another proposed cause of the mass extinctions is greenhouse warming from carbon dioxide released by the impact, although recent impact models indicate that this warming was probably less than a couple of degrees Celsius. Furthermore, our discovery of carbonate spherules in Belize suggests that some—perhaps much—of the carbon dioxide vapors did not reach the stratosphere. Instead, these vapors combined with particles of calcium oxide (CaO) or magnesium oxide (MgO) that had also been carried aloft in the plume. They coagulated into carbonate particles and fell.

If this proves correct, then greenhouse warming can be exonerated as the cause of the mass extinctions at the end of the Cretaceous period. Impact "winter" caused by the vaporization of sulfate rocks remains the favored theory.

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