SCIENCE

This Mineral Discovery Ended An Age-Old Debate About Meteor Crater

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I deal with the rocky road to our modern understanding of earth

Jul 25, 2017, 02:16pm EDT

In 1902, Daniel Barringer, a lawyer-turned-geologist and successful businessman, heard about a large crater located forty miles east of Flagstaff, in the desert of Arizona. Around this strange crater of unknown origins, chunks of iron were found. Since 1871, nearly 2,000 fragments of an almost pure iron-nickel alloy had been recovered, which are now referred to today as Canyon Diablo iron. Hoping to find a larger mass of iron underground, Barringer acquired the mining rights for the land.

Aerial view of Arizona Meteor Crater, September 2010. Source and Credit Wikipedia user... [+] TORGERSON

At the time the existence of iron meteorites, material coming from outer space to Earth, was known for almost one century. In 1794 the German naturalist Ernst Friedrich Chladni (1756-1827) described the chemical properties of particular pieces of iron, collected all over the world. He demonstrated that this metal showed significant chemical differences if compared with rocks or minerals as found on Earth, proving its extraterrestrial origin. However, at the beginning of the 20th century, no confirmed impact structure, formed by the impact of large meteorites on Earth's surface, was known.

In 1919, geophysicist Alfred Wegener, of continental drift fame, published his observation about craters. Measuring various craters, he noted a distinct difference between craters of doubted origin and confirmed volcanic craters. Some craters are very wide, relatively flat, sometimes showing a central peak and outer rings, surrounding the central crater. Using such parameters, Wegener demonstrated in 1927 that a strange crater on the island of Saaremaa in the Baltic Sea was not a volcano or the result of a gas explosion, but formed when a meteorite hit Earth. Unfortunately, like Wegener's other great idea, his impact theory wasn't taken seriously until the 1960s. Nobody believed that impacts were as common as Wegener, looking at the cratered face of the Moon, suggested.

Also, Barringer believed that the crater of Arizona was an impact crater. Upturned rock layers of the crater's rim, ejected debris, shattered and pulverized rocks and the iron-nickel alloy, of confirmed meteoric origin, convinced Barringer that the crater in Arizona formed by the impact and subsequent explosion of a large meteorite in prehistoric times.

Shatter cones are often found associated with impact craters, as the shock waves caused by the... [+] BRESSAN

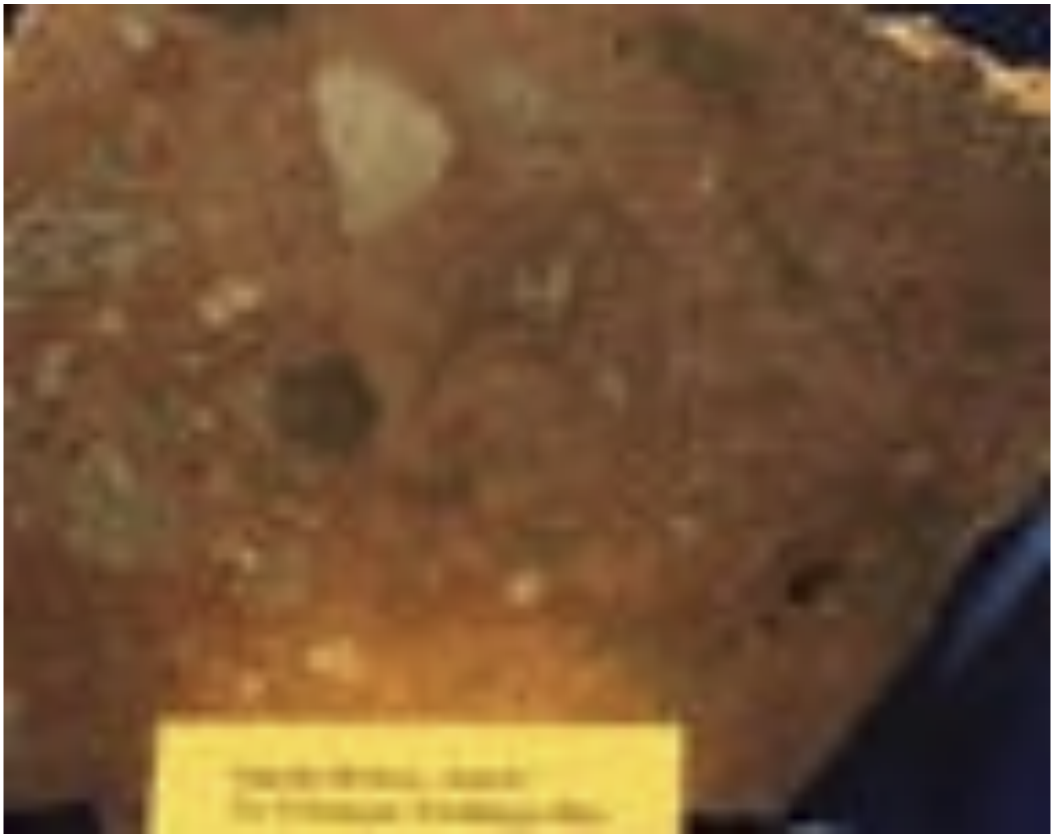
Barringer also believed that the larger mass of the meteorite was still to be found, buried inside the crater. He presented the results of his investigations before the Academy of Natural Sciences of Philadelphia in 1905. Grove Karl Gilbert, U.S. Geological Survey, had also heard of Barringer's research. As an experienced field-geologist, Gilbert had mapped the area in 1900 and also found iron fragments. However, he didn't see a connection between the fragments and the large crater. He concluded that the crater was of volcanic origin, and the iron found nearby were merely the remains of small meteorites found there just by chance.

Gilbert, influenced by the eruption of Krakatoa in 1883, suggested that the crater of Arizona was the result of a steam explosion, caused by the contact of magma with groundwater. Gilbert presented his observations (including a geomagnetic survey) before the Geological Society of Washington, also noting that no large iron mass, as proposed later by the Barringer's meteorite hypothesis, was discovered inside the crater. The debate between Barringer (who died in 1929, never finding the hoped-for meteorite) and Gilbert (who died in 1918) continued for years, but in the end, none of the two experts could provide a convincing explanation for the crater.

In 1950, a young geologist, Eugene Shoemaker (who was unfortunately killed in July 1997 in a car accident during a field trip studying craters in Australia), studied the mysterious crater comparing it to craters formed by the detonation of atomic bombs, tested at the time in the desert of Nevada.

Eugene Shoemaker (with a hammer) lectures to a group of astronauts at Barringer Crater, Arizona.... [+] USGS

Shoemaker noted some similarities in the general shape. But more importantly, the explosion of an atomic bomb shattered and shocked the bedrock in a specific way. That sudden peak in pressure and temperature of the detonation forms very peculiar minerals, not found in rocks of common volcanic origin. USGS mineralogist Edward Chao identified in samples coming from Barringer Crater a particular variety of silicon dioxide. Coesite, as it was named, was synthesized in 1955 for the first time, exposing common quartz to very high-pressure conditions (350,000 to 500,000 times Earth's atmospheric pressure). This mineral can also form during an atomic blast in the shocked rocks. The discovery that coesite could be used as an indicator of high-pressure metamorphism, as experienced during an artificial explosion or a natural meteorite impact, was published in July 1960 in the prestigious journal Science. One year later, Shoemaker and Chao published the discovery of coesite in suevite, a decorative rock quarried in the Nördlinger Ries, Germany.



A sample of suevite from the Nördlinger Ries. Embedded in the reddish glass matrix, formed by melted... [+] BRESSAN

Pyrope-quartzite of the Dora-Maira massif, Alps. This rock contains small grains of coesite, formed... [+] BRESSAN

The Nördlinger Ries is a large, circular plain, found in the terrain of the Prealps. The shape suggests already that it is an impact crater, but again, until then there was no convincing geological evidence to support this hypothesis. The presence of coesite proved that the Nördlinger Ries is indeed the result of a large, 15 million-year-old impact.

Also, the coesite in rocks coming from Barringer Crater demonstrates its violent origin, and today Barringer Crater is better known as Meteor Crater, visited by tourists, geologists, and even astronauts, hoping to understand cosmic impacts better.

Modern geological surveys have revealed more than 160 large craters on Earth's surface, and images of the other planets and moons, provided by modern space probes, show that impacts are nothing really extraordinary in our solar system.

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I'm a freelance geologist working mostly in the Eastern Alps. I graduated in 2007 with a project studying how permafrost, that´s frozen soil, is reacting to the more...

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