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THE NEA IMPACT THAT CREATED METEOR CRATER, ARIZONA

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ABSTRACT

The first proven NEA impact crater on Earth is Barringer Meteorite Crater (aka Meteor Crater), Arizona. Daniel Moreau Barringer explored the crater over 100 years ago before marshaling a convincing series of geologic observations that supported an impact origin for the structure (Barringer, 1905, Proc. Acad. Natural Sci. Philadelphia 57, 861-886; Barringer, 1910, Meteor Crater (formerly called Coon Mountain or Coon Butte) in northern central Arizona, 24p.). Shortly before the Apollo Program, Eugene M. Shoemaker re-examined the structure and substantially enhanced the evidence of an impact origin with detailed geologic mapping, comparisons with nuclear explosion craters, and new petrologic evidence acquired with his colleague E. C. T. Chao (Shoemaker, 1960, Internat. Geol. Congr. 21st, 418-434; Chao et al, 1960, Science 132, 220-222; Chao et al, 1962, J. Geophys. Res. 67, 419-421).

The energy of a Meteor Crater-size impact event is sufficient to destroy a modern city (Kring, 1997, Meteoritics & Planetary Sci. 32, 517-530). At the time of the impact, however, the region was populated with an ice-age ecosystem with mammoths, mastodons, and giant ground sloths. They were initially affected by a thermal pulse and a shock wave that radiated across the landscape. The shock wave created dramatic overpressures and generated an air blast. Those winds were in excess of 1000 km/hr in the vicinity of the impact event. The winds severely damaged trees in any forested area within a diameter of ~30 km. Grass, small shrubs, and soil were probably stripped from the area near the crater by the high velocity winds. Shock overpressure and wind velocity diminished with distance, falling from 2200 km/hr at a radial distance of 3 km to 800 km/hr at a radial distance of 6 km, but remaining fairly large for distances approaching 30 km. Throughout a circular region up to ~30 km in diameter, the large mammals described above would have been killed or wounded by the pressure pulse and air blast. Some of the

injuries would have been directly caused by the pressure pulse. For example, it would have caused rapid pressure oscillations in air-containing organs and damaged areas between tissues of different densities (*e.g.*, near joints). This would have generated hemorrhaging and edema in the lungs that caused suffocation, air emboli that may have obstructed blood vessels in the heart and brain, and fibrin emboli in the blood that may have damaged the brain and other organs. In addition to these direct blast injuries, animals would have been injured when the blast wave hit them, accelerated their bodies to velocities on the order of a few to tens of kilometers per hour, and then slammed them back onto the ground or they collided with other objects. The air blast also picked up broken branches, rocks, and other types of missiles that created a fusillade of debris that impaled, lacerated, or otherwise traumatized animals.

Meteor Crater was produced by a type IAB iron asteroid, which is important to the outcome. With a diameter of ~1 km, the crater approaches the lower limit of hypervelocity craters on Earth. The atmosphere screens the surface from objects that are smaller or weaker than the NEA that produced Meteor Crater. Because most small craters are associated with iron asteroids, they appear to be stronger than stony asteroids. It is also important to note that the number of craters produced by type IAB irons, relative to other irons, is higher than the ratio of those objects seen in the smaller meteorite population. At least 14 to 15 of the known small craters were generated by irons and, of these, 6 (or ~40%) were produced by type IAB irons. Also, at least 28% of all the small crater impacts were produced by type IAB iron asteroids. In contrast, only 10% of observed iron meteorite falls are type IAB. Even in a combined population of iron meteorite finds and falls, type IAB specimens constitute only 15% of the population. The data suggest one of two conclusions: (1) type IAB asteroids are stronger than other irons and, thus, better able to penetrate the atmosphere or (2) type IAB asteroids are less collisionally evolved than other irons and, thus, less populous among meteorite-size objects.

Smaller and weaker NEA that are unable to penetrate the atmosphere will catastrophically fragment far above the ground. For example, a 6 to 8 m diameter stony asteroid with L-chondrite affinities fell about ~15,000 years ago in northern Arizona, but fragmented into thousands of stones (the Gold Basin meteorites) that showered more than 225 km^2 of the Earth's surface rather than create a hypervelocity impact crater (Kring et al., 2001, Meteoritics & Planetary Sci. 36, 1057-1066). Because strong NEA (like iron asteroids) are required to produce most structures like Meteor Crater, this implies that many more air bursts of similar energy occur than can be inferred directly from the number of small craters.

Additional details and a current summary of the geology of Meteor Crater is available on-line (Kring, 2007, Guidebook to the Geology of Barringer Meteorite Crater, Arizona (aka Meteor Crater), http://www.lpi.usra.edu/publications/books/barringer_crater_guidebook/).