Waste Isolation Pilot Plant

Compliance Certification Application

Reference 176

Dietz, R.S., August 1961.
Astroblemes, Scientific American, Vol. 205, #2, p 50-58.

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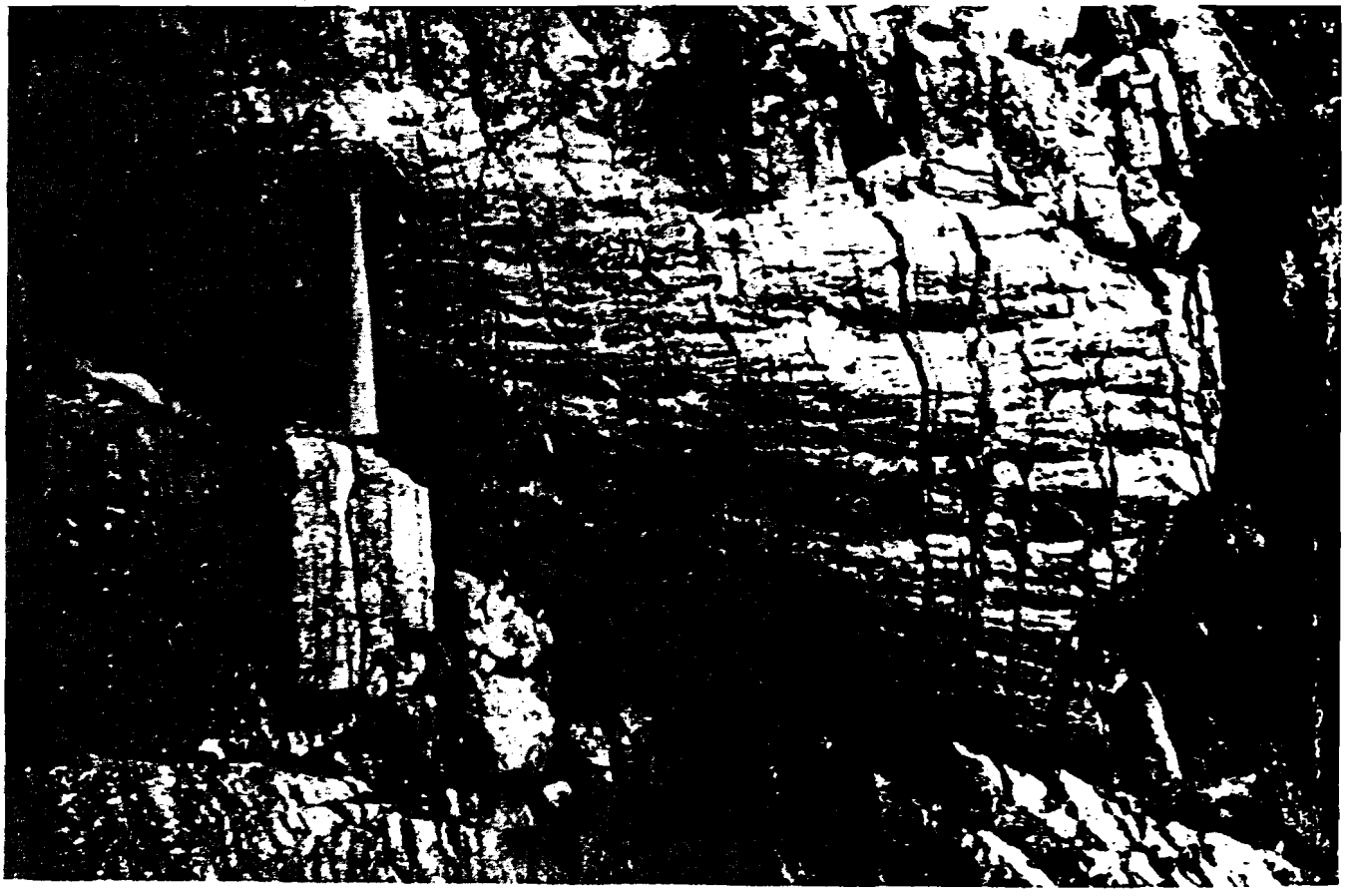
SHATTER CONE four inches high is one of many in igneous rock of the Vredefort Ring in South Africa, a structure that is probably the remains of the largest meteorite crater known on earth.

NEST OF CONES in dolomite, a type of limestone, is from Wells Creek Basin structure in Tennessee. This group is 11 inches high. Shock pressures generated by meteorite impact create such cones.



GIANT SHATTER CONE, over four feet long, is shown in place at the Kentland limestone quarry in Indiana. These cones found among jumbled rocks in a flat, geologically undeformed terrain indicate that the quarry is an ancient meteorite-impact site.

ASTROBLEMES

This newly coined word refers to ancient scars left in the earth's crust by huge meteorites. The evidence for such impacts is largely the high-pressure mineral coesite and "shatter cones" in the rocks

by Robert S. Dietz

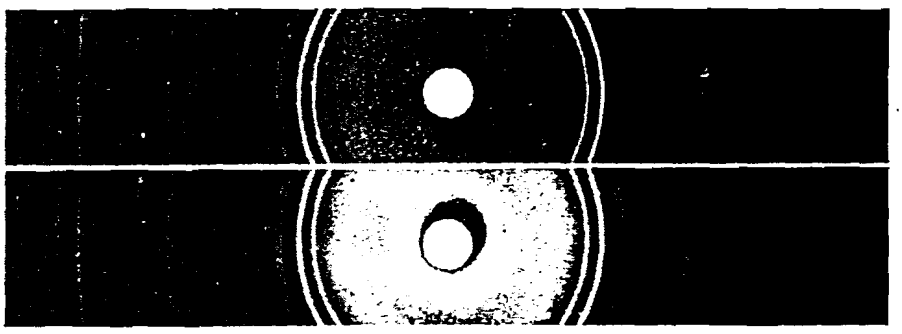
It is an awesome experience to stand on the rim of Barringer Crater in Arizona and reflect on the cosmic cataclysm that opened up this gaping hole, three-quarters of a mile across and 600 feet deep, in the crust of the earth. The Hopi Indians are said to retain the legend that one of their gods descended here from the sky in fiery grandeur. White sheepherders who came upon the crater a century ago found numerous lumps of metal lying about and intuitively concluded that a star had fallen at the site. Upon later analysis the lumps of metal proved indeed to be fragments of nickel-iron meteorite. Studies at the site have now established beyond doubt that the crater records the impact of a large meteorite that plunged to earth some 25,000 years ago. Barringer Crater is the first of an increasing number of geological structures to be recognized as the scars of an agelong and still continuing bombardment of the earth by rubble from elsewhere in the solar system.

An extraterrestrial explanation of terrestrial events finds a readier acceptance today than it did in the past. One persuasive body of evidence supporting the meteoritic origin of Barringer Crater and craters like it is represented by the pockmarked face of the moon. As long ago as 1893 G. K. Gilbert, the most distinguished U.S. geologist of his time, advanced the hypothesis that the craters of the moon had been caused by the impact of meteorites. His explanation of these lunar features stands little changed even today. Yet after a visit to Barringer Crater, Gilbert read a philosophical paper entitled "The Origin of Hypotheses" to the Geological Society of America in Washington, in which he argued that the crater had a purely terrestrial origin—in a volcanic explosion—and dismissed the notion of a meteorite fall. Gilbert's authority was such that it took more than 30 years to reverse his judgment. But the sciences progress not so much by the discovery of new truth as they do by the correction of old error. Overwhelming evidence was forthcoming by 1928, and Barringer Crater was firmly identified as the site where a large meteorite had struck.

Acceptance of this prototype terrestrial meteorite crater opened the way for speedy recognition of others. In 1933 L. J. Spencer of the British Museum listed eight more, all of which have withstood closer inspection. Among them is the great Ashanti Crater (Lake Bosumtwi) in Ghana, which has a diameter of six miles. More recently discovered is the two-mile New Quebec Crater in subarctic Canada [see "The Canadian Meteor Crater," by V. B. Meen; SCIENTIFIC AMERICAN, May, 1951]. Four craters in Australia have also been identified as scars of meteorite falls.

The list of 14 well-certified terrestrial meteorite craters is impressive, but the record of bombardment preserved on the face of the moon plainly suggests that the list should be longer. At the conservatively estimated rate of one great fall every 10,000 years, some 50,000 giant meteorites must have struck the earth during the past 500 million years. Where are the craters they made? The answer is that on the earth's surface such craters are ephemeral features. Tectonic processes alter their round shapes, erosion wears away their rims and sedimentation fills them up; gradually they disappear as recognizable features in the terrain. On the airless, waterless and tectonically inactive surface of the moon, meteorite craters have remained unchanged from the most distant past except through the impact of later meteorites. The craters that remain clearly visible on earth today must all have been created by impacts during the last million years.

To lengthen the list of terrestrial meteorite craters one must now look for less obvious signs. A few "fossil" craters, scarcely discernible on the ground, have shown up in aerial photographs, appearing as faint circular features [see "Fossil Meteorite Craters," by C. S. Beals; SCIENTIFIC AMERICAN, July, 1958]. Geological maps of surface and subterranean rock formations have revealed still other



X-RAY-DIFFRACTION PATTERNS of synthetic coesite (*top*) and natural coesite found at Barringer Crater in Arizona are virtually identical. Coesite is a silica formed at high pressure. Diffraction patterns were made by E. C. T. Chao of the U.S. Geological Survey.