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Large-Scale Extinctions

The earth has been the scene of many extinctions during its long history. Some of them have occurred relatively slowly and are readily explained, for example, by gradual large-scale climatic changes or the appearance of successful competitors for ecological niches. But extinctions have occurred that have involved a large fraction of the existing life-forms. Suggestions have been made that such events might have been due to impacts of large bodies from elsewhere in the solar system. However, it was only a few years ago that evidence was presented for the simultaneity of a very large asteroid impact and extinctions at the end of the Cretaceous period (65 million years ago).*

The evidence took the form of a very large iridium anomaly in a thin layer in marine sedimentary rocks laid down at the end of the Cretaceous. This work was followed by reports of related occurrences in both marine and nonmarine sedimentary rocks in many different localities around the world. Attention was accordingly focused on questions about the frequency of large-scale impacts and their immediate and longer term signatures. These important questions came to involve efforts by geologists, geochemists, geophysicists, paleontologists, chemists, and physicists and led to a very lively interdisciplinary meeting in Snowbird, Utah, in October 1981. The papers presented at the meeting were recently published in a book† that would make good reading for a wide audience.

There are about 1000 asteroidal bodies with diameters greater than 1 kilometer whose orbits cross that of the earth. About three of these hit the earth every million years. Smaller bodies are more abundant and collide more frequently. The postulated Cretaceous projectile had a diameter of about 10 km. Objects of this size are not very abundant and they may strike the earth about once every 40 million years. A 10-km object having a velocity of 25 km/sec would bring with it an energy of about 4×10^{30} ergs.

Evidence of many collisions is found on the moon, Mars, Mercury, and Earth. On the earth the best studied impact feature is the Ries crater in West Germany. It is 26 km in diameter and about 800 meters deep and was formed about 15 million years ago by the impact of an object 1 to 2 km in diameter. Studies of the ejecta provide a picture of tremendous manifestations of energy in the form of high pressures, high temperatures, and high-velocity projectiles.

Aside from the iridium anomalies, the principal evidence for a major event 65 million years ago comes from paleontology. Effects differed widely among the various genera on land and sea. Those most affected were planktonic calcareous shelled organisms living in near-surface regions of the tropical oceans. Benthic creatures and siliceous shelled organisms were less affected. John Lewis and colleagues have suggested that a substantial lowering of the pH of surface waters was involved. They point out that, with the high temperatures associated with a large impact, tremendous quantities of nitrogen oxides would be formed. These would be converted to nitrous and nitric acids and would descend to the earth in the form of acidic precipitation. On land the large buffering capacity of soil would neutralize the acid, but at sea the top layer has little buffering capacity and mixes only slowly with deeper waters.

Not all scholars agree that a major impact occurred at the end of the Cretaceous.‡ We are only at the beginning of discovering and interpreting phenomena connected with impacts of large bodies on the earth. The new book provides a valuable benchmark of the state of knowledge and speculations in this important field.—PHILIP H. ABELSON

*L. W. Alvarez, W. Alvarez, F. Asaro, H. V. Michel, *Science* **208**, 1095 (1980). †L. T. Silver and P. H. Schultz, Eds., *Geological Implications of Impacts of Large Asteroids and Comets on the Earth*, Special Paper 190, Geological Society of America, Boulder, Colo., 1982 (\$40). ‡For example, see C. B. Officer and C. L. Drake, *Science* **219**, 1383 (1983).