K-Pg ME

Discoveries during the past few decades have established beyond a reasonable doubt that the collision of an asteroid with Earth caused the terminal Cretaceous mass extinction. The first of these discoveries, reported in 1981, was a high concentration of the rare heavy metal iridium—an *iridium anomaly*—at the stratigraphic level of the extinction. Iridium is rare in Earth's crust but is more highly concentrated in meteorites that are asteroids or fragments of asteroids. Other discoveries followed quickly (Earth System Shift 17-1).

Some geologists have favored the idea that the terminal Cretaceous mass extinction resulted not from an asteroid impact, but from the volcanic eruptions that produced the Deccan Traps of peninsular India. The Deccan Traps constitute a huge body of basalt, up to 2 kilometers (1.2 miles) thick, that occupies an area of west-central India about the size of the states of Oregon and Washington combined. They were formed when the triangular landmass that now forms peninsular India moved over a hot spot, long before it collided with Asia. It turns out, however, that the bulk of the Deccan eruptions occurred during an interval that spanned about 500,000 years and ended about 100,000 years before the time of the terminal Cretaceous crisis (66 million years ago).

An asteroid big enough to scatter the estimated amount of iridium in the worldwide spike at the K–T boundary may have been about 10 km (6 miles) across. Computer models suggest that if such an asteroid collided with Earth, it would pass through the atmosphere and ocean almost as if they were not there and blast a crater in the crust about 100 km across. The iridium and the smallest pieces of debris would be spread worldwide by the impact blast, as the asteroid and a massive amount of crust vaporized into a fireball.

The K–T impact crater has been found. It is a roughly egg-shaped geological structure called **Chicxulub**, deeply buried under the sediments of the Yucatán peninsula of Mexico (Fig. 16.4). The structure is about 180 km across, one of the largest impact structures so far identified with

Opinions have varied as to how the impact of an asteroid 10 kilometers in diameter would disturb environments on Earth. Here are some consequences that many scientists have attributed to the Chicxulub impact:

1. *Perpetual night.* Dust particles and tiny droplets of liquid called aerosols would have been blown high into the atmosphere and spread around the world, screening out nearly all sunlight. Many of these particles would have remained aloft for many months, perhaps preventing plants from conducting photosynthesis.

2. *Heat from the settling microspherules.* As microspherules that were blasted into the atmosphere returned to Earth, friction caused by their descent would have produced a vast amount of heat. Calculations show that the heating would have begun quickly after the microspherules' reentry began and, for a few minutes, air temperatures at Earth's surface would have risen to the broiling temperature of an oven. Except along their margins, the oceans would have been little affected by this sudden heating because of their great volume and the high heat capacity of water.

3. *Global refrigeration.* After the sudden heating, darkening of the skies by dust and aerosols would have plunged the entire planet into cold, wintry weather for several months. Sulfate evaporites, including anhydrite (see Table 2-1), were blasted by the impact, and we know that sulfates that are emitted by volcanic eruptions and dissolved in water droplets cause climatic cooling. The same phenomenon would have contributed to the inferred terminal Cretaceous cooling, which has been termed an *impact winter*.

4. *Greenhouse warming due to release of carbon dioxide.* Longer-term global warming would have resulted from the release of CO_2 from a body of carbonate rock 3 kilometers (2 miles) thick that the asteroid penetrated. This warming would have occurred after the brief impact winter, although it would presumably have immediately strengthened the greenhouse effect and reduced the severity of the global cooling. The carbonates would have released CO_2 when they were heated and sheared at the time of impact, as happens less abruptly when limestone or dolomite is subjected to metamorphism in a mountain belt (p. 237). It is estimated that the volume of the carbonate rock thus affected by the impact was so large that the CO_2 released would have elevated the average global temperature of Earth's lower atmosphere by 7°C (13°F)—possibly even more. In fact, fossil plant leaves provide evidence of a brief but dramatic rise in

5. *Acid rain.* As already noted, some of the rocks that the asteroid penetrated in forming the Chicxulub crater were sulfate evaporites. The impact must have released oxides of sulfur from these evaporites, and the chemical reaction of these compounds with water in the atmosphere would have produced sulfurous and sulfuric acid. These compounds, along with the elevated CO_2 concentrations mentioned above, would have produced acid rain, which may have harmed many forms of life.

6. *Fires.* Wildfires would have raged across some areas of the Americas, triggered by the fiery cloud that burst from the impact site. The most severe fire damage to life should have been relatively close to the Chicxulub site.