# VI. Impacting Extraterrestrials Scar Planetary Surfaces

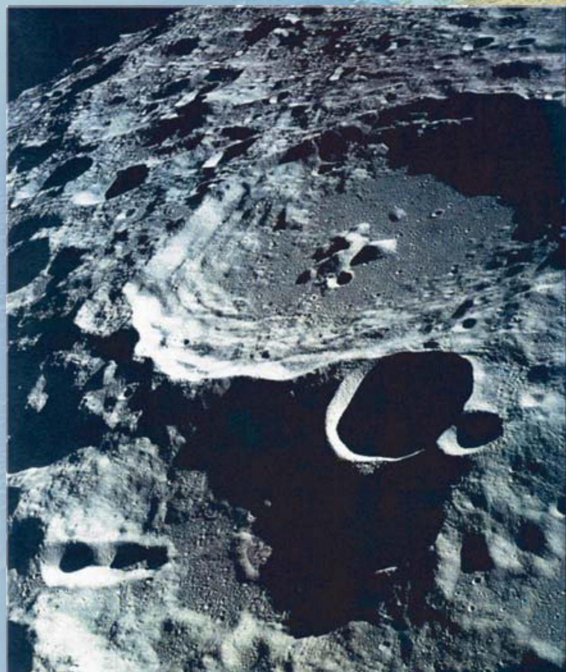

*Figure 1.*—Impact craters dominate barren planetary bodies that lack water, forests, ice, and sediment that hide them on Earth. Other planets also lack the post-impact tectonics and erosion that destroy craters on our planet. This Apollo 11 photograph shows part of our moon's far side. The largest crater shown, Daedalus, is 93 km in diameter. Image from NASA, no. AS11–44–6609.


*Figure 2.*—A northwest-looking, oblique aerial photograph of Barringer (Meteor) Crater, Arizona, showing the well-preserved 1.2-km-wide crater indenting the surface of the arid Colorado Plateau. Photograph by John S. Shelton, used with permission.

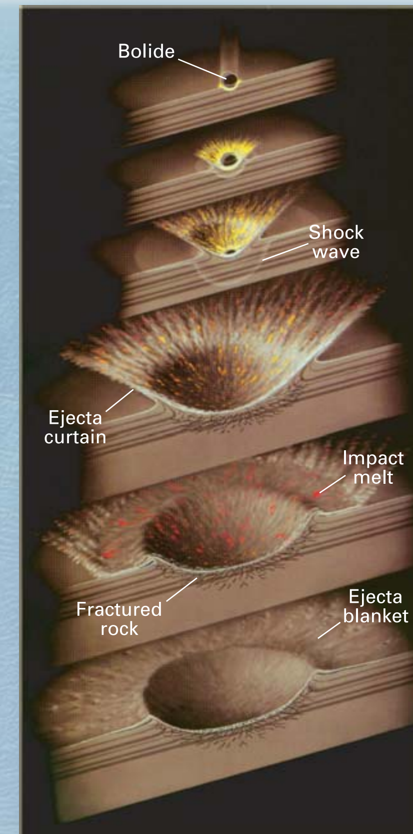


*Figure 3.*—Sequential cross sections illustrating the formation of a simple, small crater by bolide impact. Modified from Shoemaker and Shoemaker (1999). Used with permission of Cambridge University Press.

Crater formation by impact of extraterrestrial *bolides* (comets or asteroids) has been a significant process on the rocky moons and planets of our solar system and was particularly important during the first 500 million years of Earth's history (fig. 1). Although many small meteorites land on Earth every year, the fall of larger extraterrestrial fragments, forming giant impact craters, is (fortunately) infrequent. Evidence for large prehistoric impacts includes not only preserved crater shape and ejecta, but also mineralogic and structural changes caused by high-pressure shock waves. Nearly 170 terrestrial craters have so far been discovered, and they range widely in age (2,000 Ma to A.D. 1947). Their diameters can reach 300 km, and even larger craters may have been eroded away or covered by younger rocks.

One of the best-known and well-preserved craters is the Barringer (Meteor) Crater in Arizona, which was formed about 50,000 years ago (fig. 2). The incoming object is estimated to have measured about 50 m across and to have traveled at 65,000 km/hr (fig. 3). An impact crater this small might be formed somewhere on Earth every 1,000 years on average, whereas a 100-km-diameter crater might be produced once every 25 to 50 million years.

Most scientists—after lively debate—now accept the 1980 hypothesis that a bolide, ~10 km in diameter, impacted Earth 65 million years ago and was largely responsible for abrupt changes in the fossil record. These changes, including the extinction of dinosaurs, define the boundary between the Cretaceous and Tertiary Periods (commonly called the "K/T Boundary") of geologic time (see timeline below). The crater resulting from this impact is thought to be the now-buried 170-km-wide Chicxulub structure in Mexico (fig. 4). This impact involved a huge energy release, equivalent to that of an M13 earthquake, dwarfing the world's largest historical earthquake (M9.5, Chile, 1960).

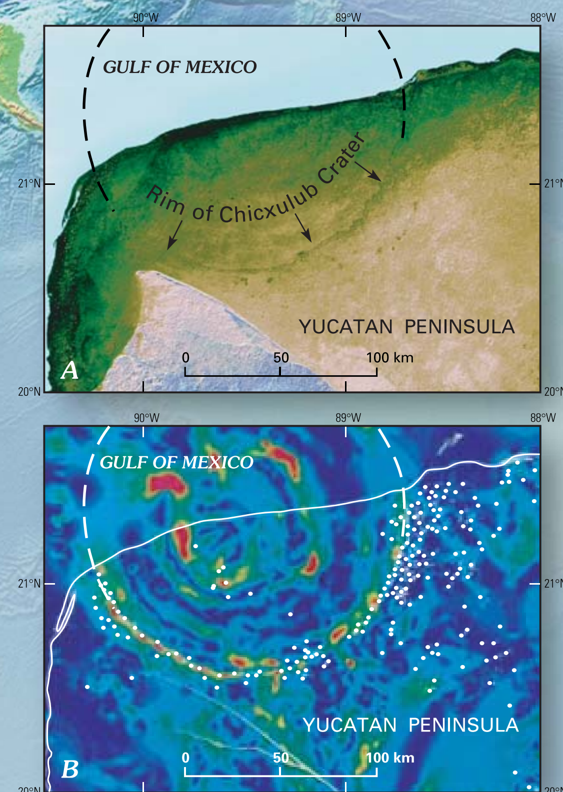


*Figure 4.*—Chicxulub impact crater, on the northern coast of Mexico's Yucatan Peninsula. Circular outline of the crater is indicated by dashed lines. ***A***, View from space of the shallow (3- to 5-m-deep), subtle trough expressing the southern rim of the crater, which is deeply buried by younger sediments. The Chicxulub impact event caused widespread extinctions 65 million years ago. Image from NASA, no. PIA03379. ***B***, Gravity-gradient map of the same area. Gravity measurements, processed to emphasize edges of dense rock bodies, reveal the multi-ring structure characteristic of large impact craters. Yellow to red colors indicate sharp boundaries between rock bodies of differing densities. White dots indicate surface sinkholes. Their locations reflect present-day ground-water flow along rock fractures influenced by Chicxulub's subsurface crater rim. Modified from Geological Survey of Canada, Natural Resources Canada, image on Web site http://miac.uqac.ca/