Fire and ice: The Chicxulub asteroid impact and the K-Pg extinction

Rolando García,[1] Charles Bardeen,[1] Brian Toon[2] and Andrew Conley[1]

[1]National Center for Atmospheric Research, Boulder, CO, USA
[2]University of Colorado, Boulder, CO, USA

The extinction that marks the end of the Cretaceous period and the beginning of the Paleogene, 66 Ma, is one of the five great extinctions of the Phanerozoic eon. It is estimated that 75-80% of all species became extinct, including all marine dinosaurs and almost all terrestrial dinosaurs. In 1980, Luis Alvarez et al. proposed that the extinction was caused by the impact of a 10-km asteroid; in 1981, Glen Penfield and Antonio Camargo identified the impact crater in the vicinity of the town of Chicxulub, in the Yucatán Peninsula. We present the results of numerical simulations of the consequences of the impact, assuming as an initial condition that the impact produced global fires that injected as much as 70,000 Tg of carbon soot into the atmosphere. The results show that a small part of this soot is entrained into the circulation of the stratosphere and mesosphere, where it remains suspended for a prolonged period, absorbing solar radiation and blocking sunlight at the surface. As a consequence, the Earth's surface experiences a "global night" lasting 1-2 years, followed by a period of reduced illumination (5-50% of normal) for another 4-5 years. The suppression of sunlight at the surface causes global cooling of about 15°C (10-12° in the oceans and 25-30°C on land). At the same time, the soot in heats the stratosphere, which warms by as much as 100°C. Stratospheric heating affects the chemical composition and photochemistry, such that the ozone layer is reduced globally by 80% of normal, which allows high levels of UV radiation to reach the surface. The combination of darkness, cold, and enhanced UV flux appears to be able to account for the widespread pattern of extinction of Cretaceous flora and fauna.