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The Chicxulub Multiring Impact Crater and the Cretaceous/Paleogene Boundary: Results From Geophysical Surveys and Drilling

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The Chicxulub crater has attracted considerable attention as one of the three largest terrestrial impact structures and its association with the Cretaceous/Paleogene boundary (K/Pg). Chicxulub is a 200 km-diameter multi-ring structure formed 65.5 Ma ago in the Yucatan carbonate platform in the southern Gulf of Mexico and which has since been buried by Paleogene and Neogene carbonates. Chicxulub is one of few large craters with preserved ejecta deposits, which include the world-wide K/Pg boundary clay layer. The impact has been related to the global major environmental and climatic effects and the organism mass extinction that mark the K/Pg boundary, which affected more than 70 % of organisms, including the dinosaurs, marine and flying reptiles, ammonites and a large part of the marine microorganisms.

The impact and crater formation occur instantaneously, with excavation of the crust down to 25 km depths in fractions of second and lower crust uplift and crater formation in a few hundreds of seconds. Energy released by impact and crustal deformation generates seismic waves traveling the whole Earth, and resulting in intense fracturing and deformation at the target site. Understanding of the physics of impacts on planetary surfaces and modeling of processes of crustal deformation, rheological behavior of materials at high temperatures and pressures remain a major challenge in geosciences.

Study of the Chicxulub crater and the global effects and mass extinction requires inter- and multidisciplinary approaches, with researchers from many diverse fields beyond the geosciences. With no surface exposures, geophysical surveys and drilling are required to study the crater. Differential compaction between the impact breccias and the surrounding carbonate rocks has produced a ring-fracture structure that at the surface reflects in a small topographic depression and the karstic cenote ring. The crater structure, located half offshore and half on-land, has been imaged by different geophysical aerial, land and marine methods including gravity, magnetics, electromagnetics and seismic refraction and reflection. The impact lithologies and carbonate sequence have been cored as part of several drilling projects.

Here we analyze the stratigraphy of Chicxulub from borehole logging data and core analyses, with particular reference to studies on CSDP Yaxcopoil-1 and UNAM Santa Elena boreholes. Analyses of core samples have examined the stratigraphy of the cover carbonate sequence, impact breccia contact and implications for impact age, K/Pg global correlations and paleoenvironmental conditions following impact. The K/Pg age for Chicxulub has been supported from different studies, including Ar/Ar dating, magnetic polarity stratigraphy, geochemistry and biostratigraphy. A Late Maastrichtian age has also been proposed for Chicxulub from studies in Yaxcopoil-1 basal Paleocene carbonates, with impact occurring 300 ka earlier predating the K/Pg boundary. This proposal calls attention to the temporal resolution of stratigraphic and chronological methods, and the need for further detailed analyses of the basal carbonate sections in existing boreholes and new drilling/coring projects. Stratigraphy of impact ejecta and basal sediments in Yaxcopoil-1 and UNAM boreholes indicates a hiatus in the basal sequence. Modeling of post- impact processes suggest erosion effects due to seawater back surge, block slumping and partial rim collapse of post-impact crater modification. Analyses of stable isotopes and magnetostratigraphic data for the Paleocene carbonate sequences in Yaxcopoil-1 and Santa Elena boreholes permit to investigate the post- impact processes, depositional conditions and age of basal sediments. Correlation of stable isotopes with the global pattern for marine carbonate sediments provides a stratigraphic framework for the basal Paleocene carbonates. The analyses confirm a K/Pg boundary age for the Chicxulub impact.

References:

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