Mexican site for K/T impact crater?

SIR — A decade ago Penfield and Camargo[1] interpreted gravity and magnetic anomalies from northwestern Yucatan, Mexico, as evidence for a large, buried extraterrestrial impact crater. Research throughout the Caribbean[2–6] suggests that this crater, now named the Chicxulub crater[3], could be the site of the impact purported to have caused mass extinctions at the Cretaceous/Tertiary (K/T) boundary[7]. Using Landsat Thematic Mapper imagery of the Yucatan, we identified[8] a semicircular ring of sink holes, known locally as cenotes, which correlates with the geophysical anomalies noted by Penfield and others[1,3] (Fig. 1). We propose that the origin of the cenote ring is related to post-impact subsidence of the Chicxulub crater rim.

The cenote ring forms a nearly perfect semicircular boundary, 170 km in diameter between unfractured (within the ring) and fractured Tertiary limestones, truncated by the coast and centred 17 km east of Progreso (Fig. 1). This boundary forms a barrier to lateral groundwater migration, causing increased flows, dissolution and collapse along the boundary[9]. Large groundwater flows along the boundary are indicated by a valley-shaped depression in the groundwater surface centred on the ring, and by freshwater springs found where the coastline intersects the ring[8,9]. The cenotes formed by the collapse process are 50–500 m diameter water bodies with depths of 2–120 m. Cenote density and width of the ring vary from about three cenotes per km^2 along a 3-km-wide portion in the southwest (Fig. 2), to a chain of single cenotes 3 km apart in the southeast. This variability is apparently related to differences in the flow of groundwater and fracturing outside the ring.

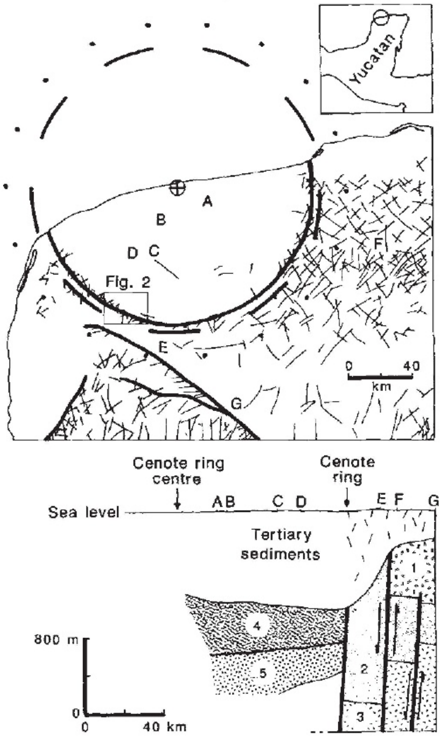

FIG. 1 Structural (upper) and subsurface (lower) geology of the cenote ring, northwestern Yucatan, Mexico (inset). Map fracture traces (thin lines) and faults (thick lines) from ref. 10. Semicircle, cenote ring; dashed circle, approximate location of negative gravity anomaly; dotted circle, approximate outer limit of concentric positive magnetic anomaly. Anomalies from Penfield and others[1,3]. Subsurface data from drill holes are described by Weidie[11] and Lopez Ramos[12], and plotted as a function of the radial distance from the cenote ring centre (hole locations lettered on the map and across the top of the cross-section). Thick lines with arrows show subsidence along possible ring faults; thin lines show fracturing in Tertiary rocks. Key: (1) breccia (ejecta?); (2) Upper Cretaceous marine sediments; (3) Lower Cretaceous marine sediments; (4) breccia (impact?) and crater fill; (5) volcanic rock (impact melt?).

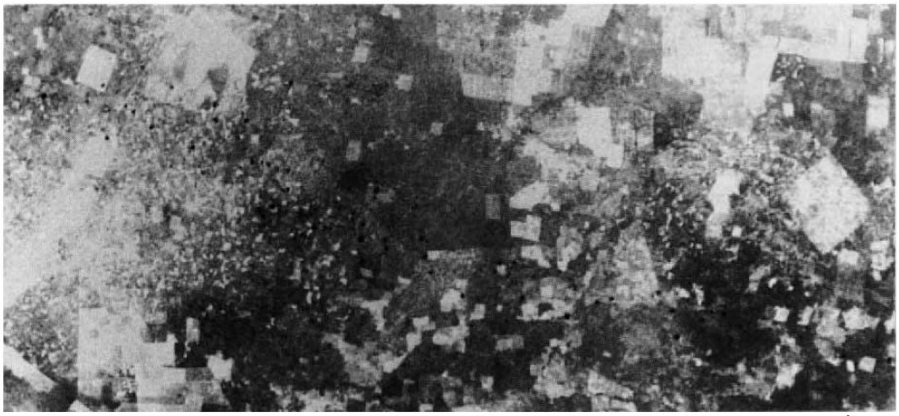

FIG. 2 Landsat Thematic Mapper band 5 (infrared) image of a portion of the cenote ring (location shown in Fig. 1). Note chain of cenotes (black dots) across the centre of the image. Width of image, about 31 km. Landsat data from EOSAT Co., Lanham, Maryland, USA.

The fracturing that created the cenote ring was almost certainly caused by a circular structure, because no combination of linear stresses would be likely to produce such a nearly perfect circular feature. Except for the fractures, the Tertiary limestones are undeformed, suggesting that the fractures are related to a buried pre-Tertiary structure. A buried impact crater or volcanic caldera could produce a circular structure of this size. We discount the latter possibility because collapse of a caldera would cause fracturing within the ring, and volcanic rocks are found beneath the centre of the ring, not outside as would be expected for a caldera (Fig. 1).

On the other hand, post-impact subsidence induced by slumping and viscous relaxation in the rim of the proposed Chicxulub crater could well have caused the fracturing outside the cenote ring. The magnitude of this subsidence need not have been great to fracture the Tertiary limestones. Viscous relaxation may have been by only metres or tens of metres over the millions of years since the crater was buried. Craters this size have wide or multiple rims, but the fracturing beyond 40 km east and south of the ring is probably related to stresses along adjacent fault systems.

Evidence of subsidence is found in the negative gravity anomaly[3] concentric with and just outside the ring (Fig. 1). Additional evidence of subsidence is the offset of Upper Cretaceous and earlier strata beneath the ring (Fig. 1), which may represent buried ring faults typical of impact crater rims.

If there is indeed a crater, the region within the cenote ring corresponds to its floor; the crater rim diameter would then probably be >200 km. If confirmed as a site of impact, the Chicxulub crater would be the largest terrestrial impact crater known, which is consistent with the uniqueness of the Cretaceous/Tertiary global catastrophe.

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