Remnants of a probable Tertiary impact crater in south Texas

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ABSTRACT

The remnants of a probable Tertiary impact crater have been discovered in south Texas. The post-Eocene, pre-Pleistocene impact site is structurally deformed in a generally circular pattern with a diameter of about 4,023 m. Thrust-faulted and strongly folded Eocene shales and sandstones and allochthonous blocks of related sedimentary material exist over the isolated circular area in otherwise gently dipping sediments of the Gulf Coastal Plain.

INTRODUCTION

Remnants of a probable post-Eocene, pre-Pleistocene impact crater have been located in south Texas. The center of the area of deformation is located 20.3 km southwest of the town of Uvalde in Zavala County, Texas, on the Nueces River (Fig. 1). The area of deformed Eocene clastic sediments has a diameter of about 4,023 m, but the preserved portion of the primary impact area has a diameter of about 2,438 m. The primary impact area may represent only the lower part of the originally deformed crater. Thrust faults in the soft Eocene shales extend out beyond the primary impact area. Strongly folded and faulted sediments have been discovered in outcrops coupled with large areas of probable allochthonous ejecta material. The area is littered with large blocks of well-cemented ferruginous sandstone that appear to be overturned in places. Regional deformation, sedimentary slumping, and gas explosion have been considered as interpretations of origin for this very structurally complex area, but none fits the field data as well as an impact hypothesis.

STRATIGRAPHY OF THE DEFORMED AREA

The impact site is located upon the Gulf Coastal Plain of south Texas. Gently dipping Eocene shales and sandstone surround the area of deformation. A relatively thin sequence (<10 m) of Carrizo sandstone overlies a sequence of shales and siltstones of the Indio Formation. The Indio has a thickness of about 100 m in the impact area. It is evident that the thin veneer of Carrizo sandstone was indurated and highly cemented with limonite at the time of deformation. Portions of this thin Carrizo sheet are now incorporated into the strongly folded and deformed thrust sheet on the northeast flank of the impact area. The original parts of the stratigraphic sequence and the different rock types were responsive in different ways to the impact energy. The indurated Carrizo broke on impact into ejecta pieces and large allochthonous blocks analogous to a brittle plate. Portions of the Carrizo were highly deformed and folded in the primary or central portion of the impact area. The underlying shales and siltstones of the Indio Formation were deformed in a more plastic manner. Ground water in the Indio siltstones and shales probably acted as a lubricant to deformation, and the Indio was deformed by thrust faulting and complex folding.

The area of deformation is largely covered by early Pleistocene fluviatile terrace and possible lake deposits, which now consist of caliche, gravel, and deep soil. An anomalous ferruginous breccia deposit overlies the large northeast thrust sheet. The clastic debris consists of limonite-cemented coarse-grained sandstone with large (2 to 3 cm) clasts of highly ferruginous shale. The limonitic shale clasts are subangular to subround. Even though large blocks of this material are concentrated in one area on the northeast side of the site, small pieces litter the entire impact area. Some of the pieces have been incorporated and reworked into the Pleistocene deposits. It is possible that a Pliocene and/or a Pleistocene lake existed within the impact crater and that some of these unusual ferruginous materials were reworked and incorporated in the lake sediment. It is uncertain how these breccia deposits are genetically related, either structurally or stratigraphically, to other rocks in the area.

STRUCTURE OF THE IMPACT SITE

The impact site is essentially circular in outline with rim uplifts preserved to the south and southwest. A major thrust sheet of the Indio is present on the northeast side of the area. This sheet was probably catastrophically flung out and away from the primary impact zone along a series of bedding planes. Splays and decollement folds are associated and incorporated into this large sheet. The thrust sheet, which had moved generally in a northwest direction, has been mapped as a discontinuous unit for about 2,125 m. Exposures along the banks of the Nueces River 1.4 km south of U.S. Highway 83 provide the best outcrops. Three additional thrust faults on the east and south flanks of the probable impact area are confined to the relatively soft Indio shales and siltstones.

The Bee Bluff area on the northeastern flank of the deformed area was originally described by Deussen (1924) and also by His (1967) as Indio in unconformable contact with the Carrizo. A photograph in the Deussen paper depicts the described unconformity (Fig. 2). We believe this to be a thrust fault within the Indio, and we further propose that two thrust faults can be seen on the face of the 27-m bluff (Figs. 1, 2). The fluvial Carrizo sandstone disconformably overlies the Indio Formation along the Nueces River south of Bee Bluff (Fig. 1).

The crater site in Texas might best be compared to Martian impact craters, where the emplacement of ejecta material was associated with water in the shallow subsurface (Carr and others, 1977). The plastic sedimentary material that underlies the impact area may have acted as a cushion that absorbed the enormous input of kinetic energy and released much of that energy through

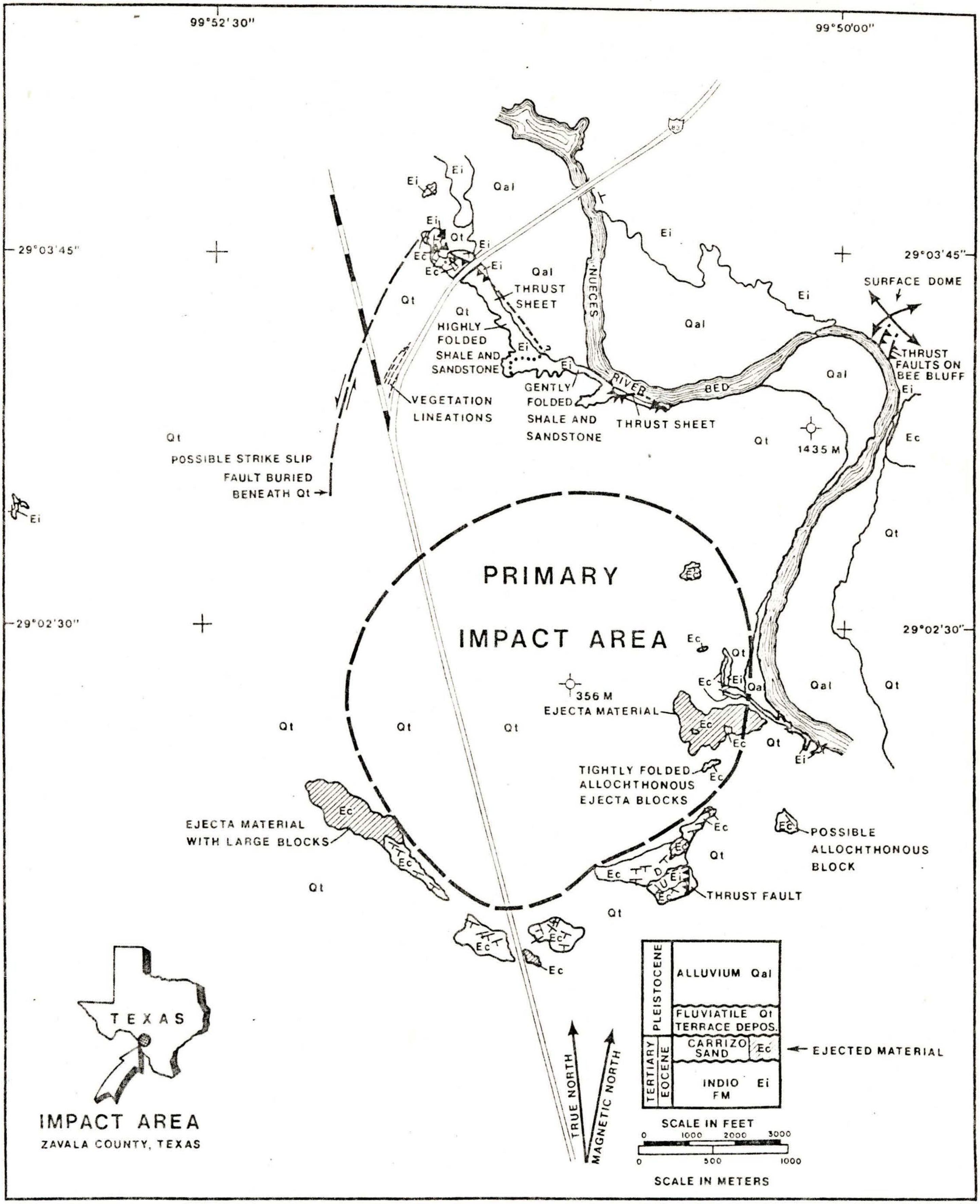

Figure 1. Detailed surface geology in area of deformation.

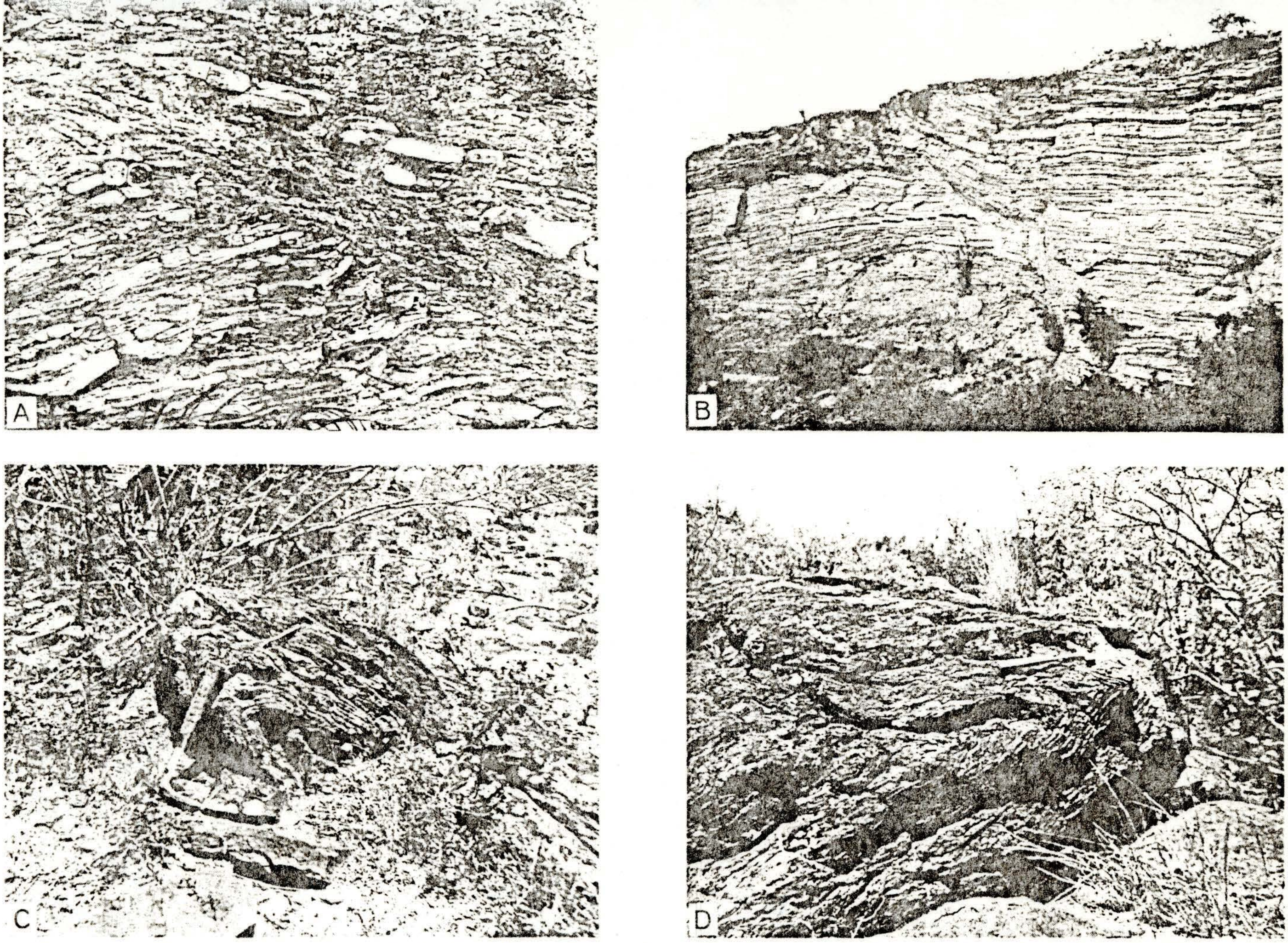

Figure 2. (A) Thrust fault on south rim, Indio Formation. (B) Thrust fault on Bee Bluff, Indio Formation. (C and D) Tightly folded Carrizo sandstone ejecta blocks within primary impact area (Fig. 1).

a splash effect of bedding plane thrusts and decollement folds. Thus, the depth of deformation may not have been as great as it would have been in more competent rocks. Beals and others (1963) have shown graphically that larger terrestrial and moon craters tend to be more shallow as diameters increase. The impact site described in this report is about 3,000 m in diameter and should have a depth of deformation of about 300 m. An oil test well was drilled in the center of the impact area to a depth of 356 m to test a strong gravity maximum that coincides with the impact area. A normal stratigraphic sequence was found from a depth of 121 m to total depth; the upper portion of the well was not logged. However, the stratigraphic sequence in the test well in the impact area was structurally 74 m high in relation to the sequence of another well drilled just east of the impact area (Fig. 1). This structural high may represent a central uplift or rebound decompression feature. It is estimated that at least one-third to one-half of the rocks in the original impact area have been removed by erosion. An erosional history of the Eocene rocks was well into an advanced stage at the time of deformation. Thus the best fit of all the data places the time of impact in the Oligocene or Miocene; the age of deformation is certainly post-Eocene and pre-Pleistocene. This spans a great deal of time. No melted materials have been found that could be used for radioactive dating. An indirect timing method might be found through a detailed geomorphic and geometric analysis.

King (1976) reported 55 known and probable terrestrial craters, 37 of which were 3,000 m or more in diameter. When an original crater diameter of about 3,000 m is assumed, the impact site represents a relatively small terrestrial crater.

CONCLUSIONS

Short (1975) has given categories of criteria for the recognition of impact craters. Evidence found at this probable impact site in south Texas includes layered rocks that have pronounced folds (some overturned) and extensive faults. The structural disturbance is confined to a circular pattern. Ejecta or allochthonous material is quite evident in the primary impact area. Breccia is common over the entire area but some of it may have been reworked in lake deposits of probable Pliocene-Pleistocene age. Melted material that could be used for radioactive isotope dating has not been identified.

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