Tracing the Chicxulub ejecta blanket on the Southern Yucatán Peninsula: Implications for the mechanisms of ejecta deposition on Earth

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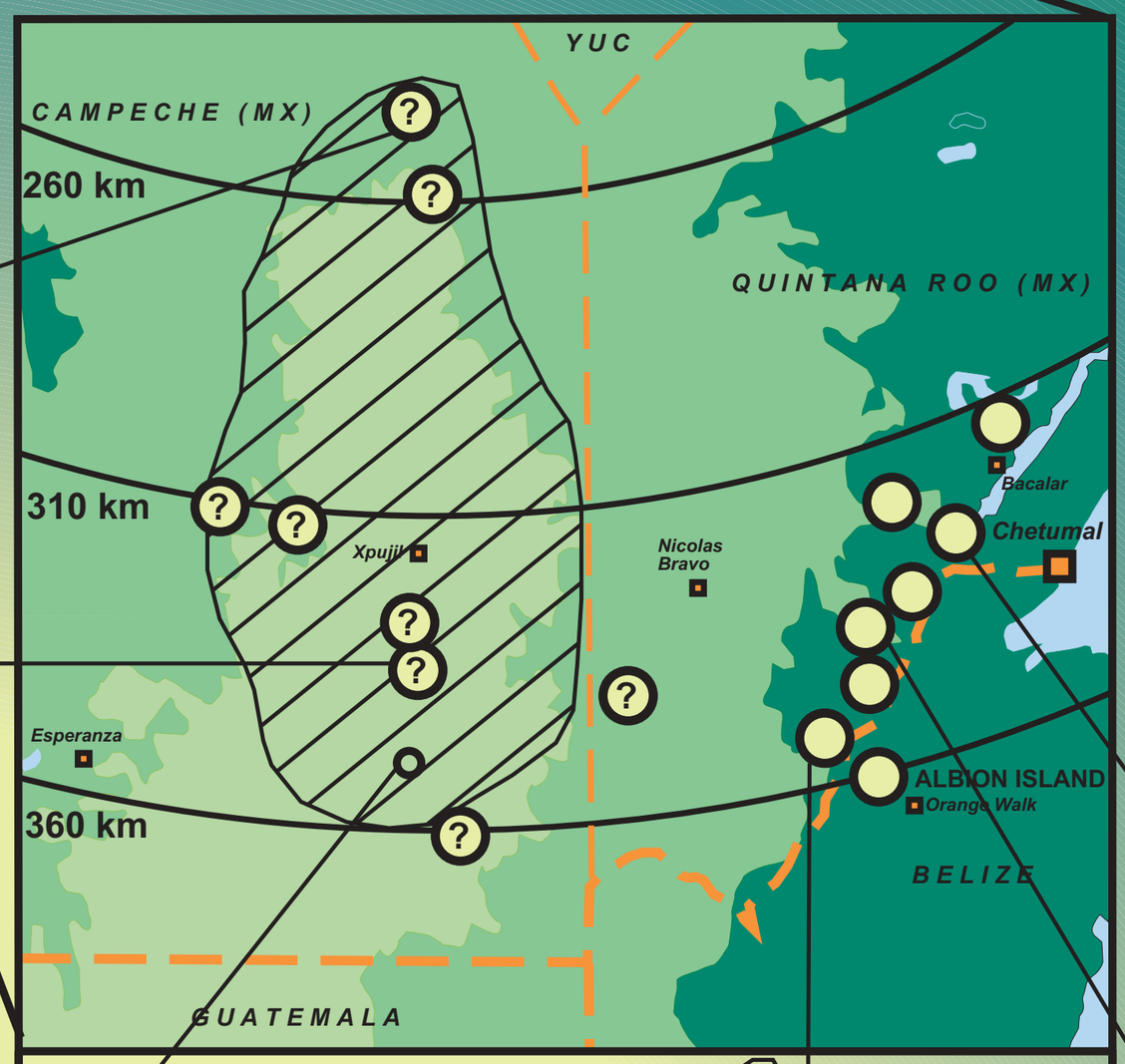
1. Introduction: Ejecta blankets display fundamental characteristics of impact processes an yield information on the target lithologies, theexcavation depth and the impact angle. However the mechanisms of ejecta deposition of large craters on Earth are still poorly constrained because of the lack of field data.
The Chicxulub structure (~180 km diameter) is the best preserved very large crater on Earth. It was quickly buried after the impact. Its continuous ejecta blanket is known from drill cores in the Gulf of Mexico and in the Northern Yucatán Peninsula. Here we present preliminary field results of a recently initiated project on ejecta occurrences on the Southern Yucatán peninsula. Intensive studies of outcrops of the continuous ejecta blanket of the Chicxulub crater will provide essential information on ejecta deposition on Earth and on other planets with atmospheres.

2. Southern Yucatán Peninsula - Geology, outcrop conditions & ejecta: The Southern Yucatán Peninsula is a more or less flat region with a smooth N-S-trending central ridge, built of mesozoic and cenozoic evaporites, limestones and dolomites. The geology of this region is poorly known. Occurrences of Cretaceous and K/T rocks are now known from the border between México and Belize. Reconnaissance geology is necessary in order to better constrain the general geology and to find Cretaceous rocks and occurrences of the K/T ejecta blanket. The limestones and evaporites exhibit a strong weathering leading to dissolution, in situ brecciation, recrystallization and the development of Caliche deposits. Since weathering breccias could be (and have been) mixed up with impact breccias, field criteria where developed to discriminate them from crater ejecta. Due to strong vegetation and limited surface drainage outcrops are restricted to quarries and road cuts.

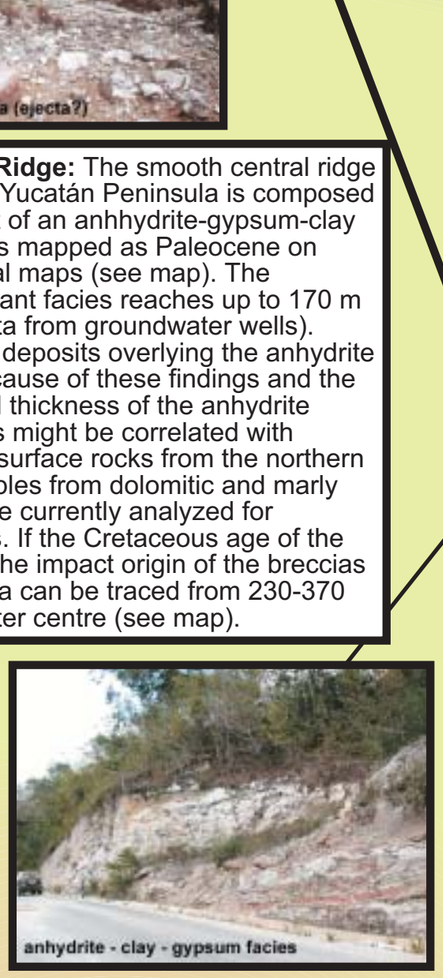
3. UNAM wells: The continuous ejecta blanket outside the crater is known from three wells from the Universidad Autonoma de México (UNAM 5, 7 and 6; 105, 126, and 151 km from crater center resp.; [1]). The ejecta succession resembles that of the Ries Crater with a lower Bunte Breccia deposit (evaporite rich polymict breccia, UNAM 7 and 6) and an upper suevitic breccia (melt rich polymict breccia, UNAM 7 and 5).

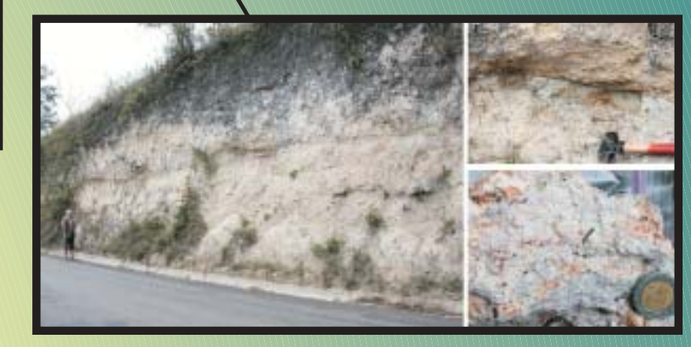
4. Albion Island: The only outcrop of the continuous ejecta blanket, described in detail, is located east of the Rio Hondo in Belize ([2], [3]). The lower contact of the ejecta blanket with the upper Cretaceous Barton Creek Fm. is well exposed. But only the lower 16 m of the ejecta blanket can be observed. The succession is composed of a lower ca. 1 m thick spheroid bed and an upper diamictite unit (>15 m). The striking differences from the ejecta close to the crater are:
- clasts are subangular to rounded and spheroids are present throughout the succession
- huge blocks of dolomite and limestone are present, often exhibiting matrix coatings
-evaporite clasts are rare or absent, but some rounded clasts show gipsum coatings
-clay spheroids (altered impact glasses) are present to varying amounts throughout the succession



5. Ejecta occurrences along the Rio Hondo: On the Mexican side of the Rio Hondo a lot of outcrops of the ejecta blanket similar to the Albion Fm. have been found between 320 and 360 km from the crater center (see map). Cretaceous rocks can also be observed within this area, but the direct contact is not exposed. The diamictites of the ejecta blanket, cropping out in a relatively large area display a clear variability and show some distinct features, different from the Albion Fm.:
- content of clasts and of clay spheroides (altered glasses) shows a strong variability
- in some outcrops the diamictite contains very abundant dolomite spheroids
- in some localities distinct sedimentary features are present, resembling shear planes, which might be interpreted in terms of sliding ejecta sheets.
But also features similar to Albion Island, like matrix coated boulders and clay spheroids, are present. The more distal ejecta is neither a breccia (rather a diamictite) nor shows the clear distinction between melt-free and melt-rich polymict breccias from the UNAM wells.

6. The Central Ridge: The smooth central ridge of the Southern Yucatán Peninsula is composed to a large extent of an anhhydrite-gypsum-clay facies which was mapped as Paleocene on recent geological maps (see map). The anhydrite dominant facies reaches up to 170 m in thickness (data from groundwater wells). Probable ejecta deposits overlying the anhydrite were found. Because of these findings and the great extent and thickness of the anhydrite these evaporites might be correlated with Cretaceous subsurface rocks from the northern peninsula. Samples from dolomitic and marly intercalations are currently analyzed for indicative fossils. If the Cretaceous age of the evaporites and the impact origin of the breccias is true, the ejecta can be traced from 230-370 km from the crater centre (see map).





7. Preliminary Field Results & Implications for Ejecta Deposition

Impact Angle: The presence of significant amounts of material from the continuous ejecta blanket along the Rio Hondo at a range of 3.5 to 4 crater radii from the impact center provides an argument against a low angle impact (20-30°) from the Southeast as proposed by SCHULTZ and D'HONDT ([4]). This ejecta would then occur within the forbidden zone of ejecta dispersal for oblique impacts.

Ejecta Emplacement: The localities identified so far will allow to trace the ejecta within a distance of (230?) 320 to 370 km from the crater center. The results of field and laboratory analysis will serve to evaluate existing models like the model of ballistic sedimentation ([5]), the ring vortex modell ([6], [7]) and numerical models ([8], [9]). A combined ballistic/ring-vortex modell could account as a preliminary working hypothesis: The lithologies of the UNAM wells could be explained by ballistic sedimentation with separated ejecta curtain material and a suevite resulting from vapor plume collapse. Farther outward vapor plume might have interacted with the ejecta curtain, disturbed by ring vortices, leading to an ejecta curtain collapse and the subsequent development of a highly mixed debris flow (cf. [10],[2]).

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References

[1] SALGE, T. et al. (2000), ICDP/KTB- SPP-Kolloquium, Abstracts, Bochum, 183-184.; **[2] POPE, K.O. et al. (1999),** EPSL, 170, 351-364.; **[3] FOUKE, B.W., et al. (2002),** Sedimentology, 49, 117-138.; **[4] SCHULTZ, P.H. and D'HONDT, S. (1996),** Geology, 24(11), 963-967.; **[5] HÖRZ, F., et al. (1983),** Rev. Geophys. Space Phys., 21, 1667-1725.; **[6] SCHULTZ, P.H. (1992),** J. Geophys. Res., 97(E7), 11, 623-11,662.; **[7] BARNOUIN-JHA, O.S. and SCHULTZ, P.H. (1996),** J. Geophys. Res., 101(E9), 21, 099-21,115.; **[8] O'KEEFE, J.D., et al. (2001),** LPSC XXXII, Abstracts, #2190.; **[9] STÖFFLER, D., et al. (2002),** LPSC XXXIII, Abstracts, #1871.; **[10] OCAMPO, A. et al. (1997),** GSA Annual Meeting, Salt Lake City, #51253.