

After the Chicxulub Impact: Control on depositional and diagenetic history of the Cenozoic carbonate formations of the northwestern Yucatan Peninsula, Mexico. M. Lefticariu¹, E. Perry¹, L. Lefticariu¹, W. Ward²

¹Northern Illinois University, Department of Geology and Environmental Geosciences, DeKalb, IL 60115

²26328 Autumn Glen, Boerne TX 78006

The Chicxulub bolide impact produced a crater structure that had a long-term influence on carbonate deposition and subsequent diagenesis in northwestern Yucatan Peninsula [1]. The Chicxulub Sedimentary Basin roughly occupies the impact crater and is circumscribed by the Ring of Cenotes (Fig. 1). The control of the Basin on sediment deposition and diagenesis was established by comparing lithologic, petrographic, and geochemical data of 11 cores from inside the Ring (depth ranges: 1,100 to 98 mbls<meters below the present land surface>) to those of 8 cores from outside the Ring (depth ranges: 671 to 21 mbls). The Ring of Cenotes and Ticul Fault are the main known structural features of northwestern Yucatan Peninsula.

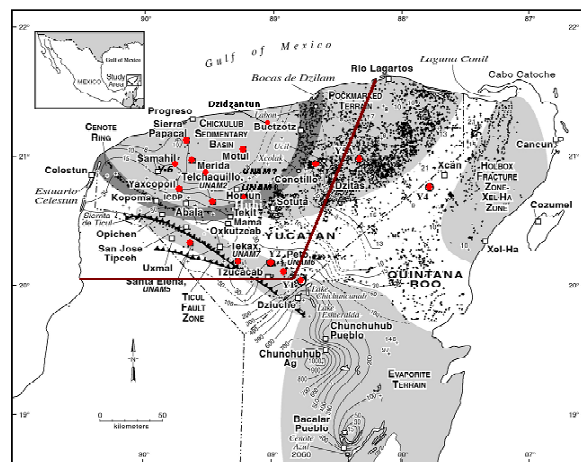
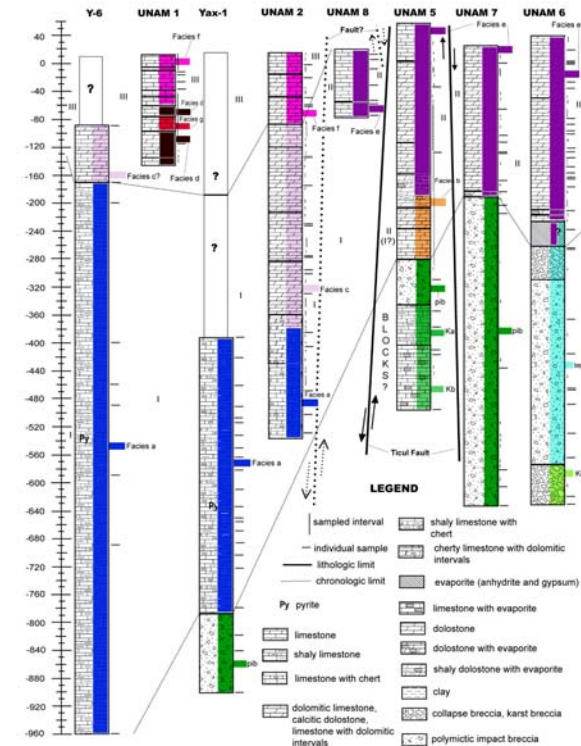


Fig.1. Location of sampled cores and main structural features on the hydrogeochemical map of northwestern Yucatan Peninsula, Mexico, of Perry *et al.* (2002); the contour lines are 100*SO₄/Cl equivalent ratio in groundwater. The study area is outlined.

A comparison of the depositional and diagenetic features from inside the Ring of Cenotes to those from outside shows that:

1) Lithofacies and biofacies succession inside the Ring show an upward shallowing trend, more gradual toward the center. Laminated pelagic limestone containing planktonic foraminifera, coccoliths, chert, and pyrite is abundant only inside the Ring (Fig. 2). Pelagic limestone with planktonic foraminifera is also present at the bottom of the Cenozoic deposits of UNAM 5 core.



Facies a: Laminated wackestone and mudstone with planktonic foraminifera and coccoliths; **Facies b:** Mudstone and wackestone with benthic foraminifera, echinoderms, ostracods, gastropods, and peloids, with intercalations of laminated mudstone with planktonic foraminifera; **Facies c:** Wackestone with large benthic foraminifera, echinoderms, red algae, and pelecypods, alternating with mudstone with planktonic foraminifera, sponge spicules, calcispheres, large benthic foraminifera, and echinoderms; **Facies d:** Wackestone and grainstone with large benthic foraminifera, echinoderms, and red algae; **Facies e:** Wackestone and mudstone with benthic foraminifera, pelecypods, gastropods, ostracods, peloids, and pellets, with intercalations of wackestone and grainstone with benthic foraminifera, red algae, and echinoderms; **Facies f:** Wackestone, grainstone, and mudstone with benthic foraminifera, red algae, echinoderms, gastropods, pelecypods, peloids, oysters, ostracods, and bryozoans; **Facies g:** Framestone with scleractinian corals, red algae, and benthic foraminifera; **pih:** polymictic impact breccia; **benib:** breccia with elements of polymictic impact breccia; **Ka:** Cretaceous limestone with planktonic foraminifera; **Kb:** Cretaceous limestone with gypsum, anhydrite, and halite; **Kc:** Cretaceous limestone and dolomite with benthic foraminifera, anhydrite and gypsum; **I:** Paleocene-Eocene, **II:** Eocene, **III:** Oligocene-Miocene

Fig. 2. Proposed facies succession in and stratigraphic correlation between the sampled cores. Depth is expressed in meters below the present mean sea level (mbsl).

- 2) The Basin filled by Middle Miocene.
- 3) Dolomitized shallow-water facies predominate outside the Ring.
- 4) Reef facies developed mainly above crater topographic highs.
- 5) The abundance of the possible features of subaerial exposure (subaerial crusts, vugs, karst, dedolomite) increases upward and outward from the center of the Chicxulub Basin.
- 6) The relative abundance of dolomite and number of generations of dolomite (including cement) are greater outside the Ring.
- 7) Dolomite is larger, more euhedral, and less stoichiometric inside the Ring.
- 8) The statistical and geostatistical trends of oxygen and carbon isotopes in whole-rock non-vug-filling calcite are better defined inside the Ring than outside. Together with stable isotope values they indicate less freshwater diagenesis inside the Ring.

The presence of smectite, zeolite, quartz, polyhedral dolomite, and potassium feldspar in UNAM 5 core between -224 and -140 mbsl (meters below the present mean sea level) is attributed to the presence in the Middle-Late Eocene of a warm, saline alkaline lake, subjected to silicic volcanoclastic input. It is suggested that the formation of this particular depositional environment is associated with the development of the Ticul Fault. Cloudy, replacive dolomite is the most abundant dolomite type present in core samples. Fine polyhedral dolomite is common in UNAM 5 core especially between -212 and -140 mbsl. Most dolomite mole % CaCO_3 ranges between 51 and 56.

$\delta^{18}\text{O}$ of whole-rock, non-vug-filling calcite ranges from -7.14 ‰ to +0.85 ‰ PDB. $\delta^{13}\text{C}$ varies between -6.92 ‰ and +3.30 ‰ PDB (Fig. 3).

$\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ of whole-rock, non-vug-filling dolomite ranges from -5.54 ‰ to +0.87 ‰ PDB, and -4.63 ‰ to +3.38 ‰ PDB, respectively (Fig. 4). $\delta^{18}\text{O}$ values are unlike those of most Plio-Pleistocene dolomites from the Gulf of Mexico and Caribbean regions [2]. A mixed dolomitizing fluid dominated by freshwater and/or an anomalously high geothermal gradient can explain the oxygen isotope values of most dolomite samples.

Lithostratigraphic, petrographic, major and trace element, and stable isotope data indicate that formation of diagenetic low-magnesium calcite and dolomite has taken place more frequently outside the Chicxulub Basin than inside during the Cenozoic Era. Crater morphology also controlled deposition and diagenesis.

References: [1] E.C. Perry, G. Velazquez-Oliman, L. Marin (2002), *Int. Geol. Rev.*, 44, 191-221; [2] D. Budd (1997), *Earth. Sc. Rev.*, 42, 1-47.

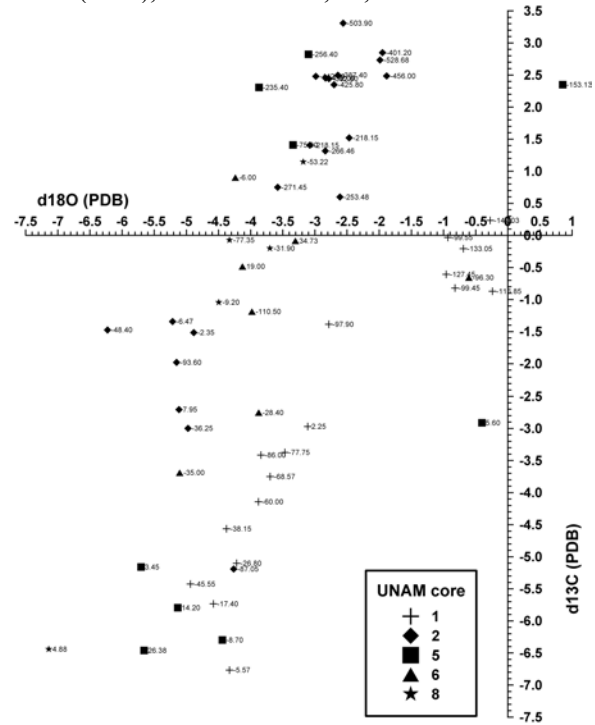


Fig. 3. $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ of whole-rock, non-vug-filling calcite. Sample depth (mbsl) appears next to each symbol

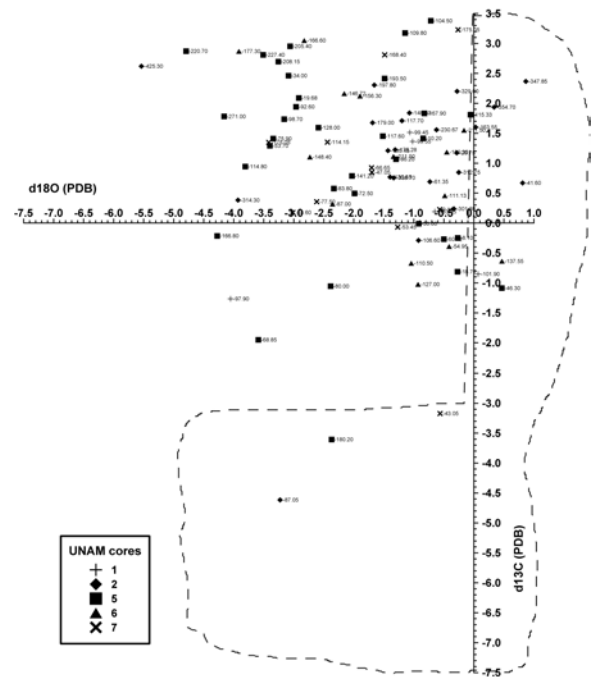


Fig. 4. $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ of whole-rock, non-vug-filling dolomite. The field of the Plio-Pleistocene dolomites from the Gulf of Mexico and Caribbean regions is outlined. Sample depth (mbsl) appears next to each symbol.