

Oyster Mass Occurrence (OMO) of *Ceratostreon texana*, in the Early Cretaceous Walnut Formation, Central Texas.

Cali Lensmire¹ and Rex Hanger

Department of Geography, Geology and Environmental Science
University of Wisconsin-Whitewater

Abstract

The Cretaceous oyster, *Ceratostreon texana*, is a large (several cm length) oyster bivalved Mollusc found in rocks dated as Cretaceous: Albian (113 -1005 million) in Central Texas. An outcrop of the Keys Valley Marl Member of the Walnut Formation exposes a concentration of *C. texana* presenting as the dominant taxon in a paleo-community forming an Oyster Mass Occurrence (OMO), which are reefy deposits of oysters especially dominant in the Mesozoic. The *C. texana* OMO studied is characterized by a lack of juvenile individuals, extensive anterior fracturing and extensive macro-boring by other organisms. These indicators of extended time of dead shells on the seafloor pre-burial classify this OMO as an allobiostrome, formed largely of sedimentologic origin.

1. Introduction

Oyster Mass Occurrences (OMO's) are reefy accumulations of oyster, bivalved Molluscs forming the dominant taxon in the paleo-community (Toscano et al., 2018; Toscano & Lazo, 2020), where this is particularly true of the Mesozoic Era, with oysters of the Family Gryphaeidae (Stenzel, 1971). OMO's of the ancient oysters are useful within the relatively new science of conservation paleobiology (Lockwood & Mann, 2019), whereby they model the origination, expansion, decline and extirpation of faunas at long time scales not available to the biologist (e.g. Powell et al., 2006). *Ceratostreon texana*, is one of several OMO-forming, oyster species within the Cretaceous strata of Central Texas. A temporary exposure of this OMO was collected to form the basis of this study.

The Walnut Formation occurs in wide outcroppings throughout Central Texas (Moore, 1964) and is known as one of the most fossiliferous strata of the Cretaceous Period (Amsbury, 2002). Within the period, the formation is dated as part of the Albian Age (113 – 100.5 million years ago), and forms part of a second-order cycle of deposition (Mancini & Scott, 2006) dated more specifically as from about 108.2 to 104.0 million years ago (Scott et al., 2002). The Keys Valley Marl Member of the formation, in particular, is known for its dense concentrations of OMO's (Flatt, 1976) of the species, *Texigryphaea mucronata*, with 1000's km² of mapped beds in both outcrop and subsurface. *C. texana*, though less abundant, is an important index fossil for the Walnut Fm. (Adkins & Winton, 1919), and forms local buildups, separate from those of *T. mucronata* (Moore, 1964; Thompson, 1935).

2. Methods

UW-W Paleontology & Stratigraphy Location 1002 is a construction cut in the side of a small hillside in Killeen, Texas. The entire exposure is in the Walnut Formation, Keys Valley Marl Member. The 2.1 meters below the lowest *Texigryphaea mucronata* bed was sampled by 10

¹ Funding support through an Undergraduate Scholarship from the Wisconsin Space Grant Consortium. Current Address = Geological Sciences Dept., Ohio University, Athens, OH 45701

persons for a duration of 35 minutes, with instruction to recover everything that appeared to be organic in nature. The resulting collection was taken back to the UW-W labs where all fossil species were cleaned/prepped, sorted, identified and counted.

The large oyster bivalve Mollusc, *Ceratostreon texana*, was the numerical dominant of the collection (Figure 1) and so was chosen as proxy for paleoecological exemplar for the whole fauna. As the larger, left valves were more abundant, they were segregated for special study. All specimens were measured for length, width and height, and then a geometric mean was calculated from those three (McChesney, 2016). Concurrently, left valves were examined for fractures and noted which quadrant of the shell they occurred. Finally, the presence of the 3 most common macro-boring trace fossils were noted and counted. All subsequent statistical analyses were performed using PAST software (Hammer et al., 2001).

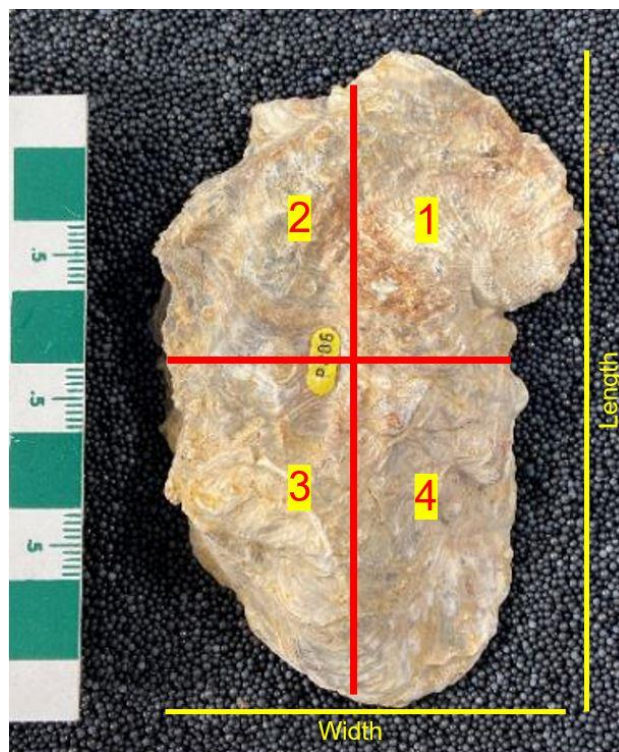


Figure 1: The oyster *C. texana* from UW-W Locality 1002, in the Keys Valley Marl Member of the Cretaceous Walnut Formation. Length and width measures shown as yellow bars (height measure not shown). Quadrants marked as 1, 2, 3 and 4 to record fracture locations.

3. Results

All measurement data for length, width and height of the left valves of *C. texana* are available in the Supplementary Data File. For the 341 specimens measured, all three measurements were positively correlated with each other (Table 1), and the mean of all geometric mean values was 37.31mm. Standard Deviation was 9.08mm, producing a size frequency histogram of the data (Figure 2) with a skewness = -0.57 plus kurtosis = -0.11. Testing for normality with the Shapiro-Wilk test, $p = 8.49 \times 10^{-7}$, or non-normal. The Grubbs test for significant outliers found none, so all data were used in the remaining analyses. Data were bootstrapped 10,000 times to generate

95% confidence intervals around the mean of 36.34mm to 38.27mm.

Table 1: Correlation metrics for all measurements.

	Length x Width	Length x Height	Width x Height
Pearson's r	0.86595	0.68479	0.67711
Spearman's r	0.82754	0.65398	0.65184

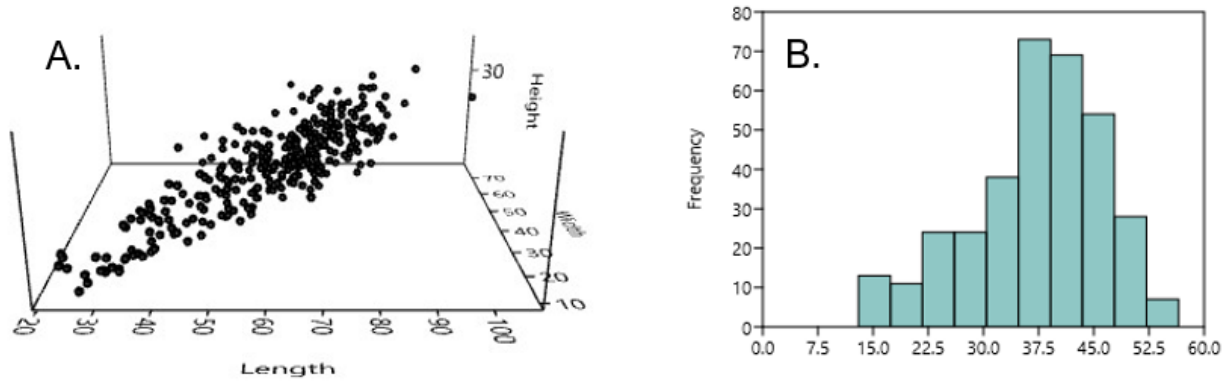


Figure 2: A) 3-d plot of length x width x height for *C. texana*, confirming species unity. B) Left skewed histogram of geometric means of *C. texana* showing absence of smallest size classes (juveniles).

Fractures on fossil shells have been shown to be useful evidence for determination of ancient paleo-environmental conditions (Zuchsin et al., 2003). As a general rule, the more fractured a specimen, the longer it has been sitting on the seafloor pre-burial. For the *C. texana* specimens in this study, fractures were not recorded for almost a quarter (23.65%) of all specimens. For those specimens that had fractures (Figure 3), the quadrant having the most fractures was Q4 at 38.17%. This is the quadrant at the growing, anterior edge of the shell which would be most exposed on the substrate. Breakage could then be caused by physical-environmental factors in a higher-energy environment of the OMO, but could also represent potential predation attempts by durophagous organisms (LaBarbera, 1981). Either possible hypothesis requires exposure of the shell above the substrate.

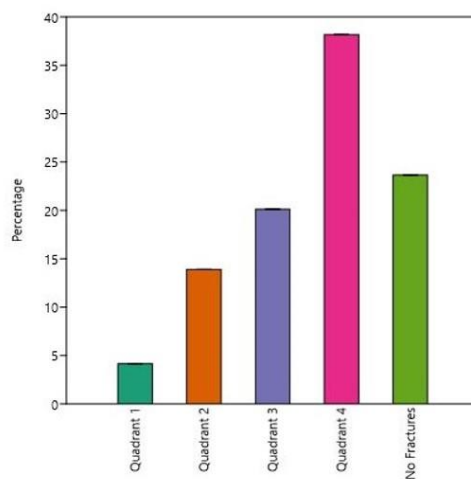


Figure 3: Relative abundance as percentage of fractures by shell quadrant. Among fractured shells, quadrants 3 and 4 show most fractures.

Patterson et al. (2020) present evidence for the ubiquity of macro-borings on modern to Pleistocene reef organisms that exist pre-burial on the seafloor, associated with the Great Barrier Reef of Australia. El-Hedeny et al. (2007) documented that this trend also holds true for Cretaceous oysters from Egypt. Macro-borings attributed to various organisms (Figure 4) were present on 199 of 341 *C. texana* shells of this study, or 58.4%. Three specific macro-borings were recognized: *Entobia* sp. (made by Clionid sponges), *Maeandropolydora* sp. (made by polychaete worms) and *Gastrochaenolites* sp. (made by pholad, bivalved Molluscs). Of this number, 63.8% of the *C. texana* shells had macro-borings of only one type, so 36.1% had evidence of multiples. *Entobia* sp. is dominant among single and multiple bored shells.

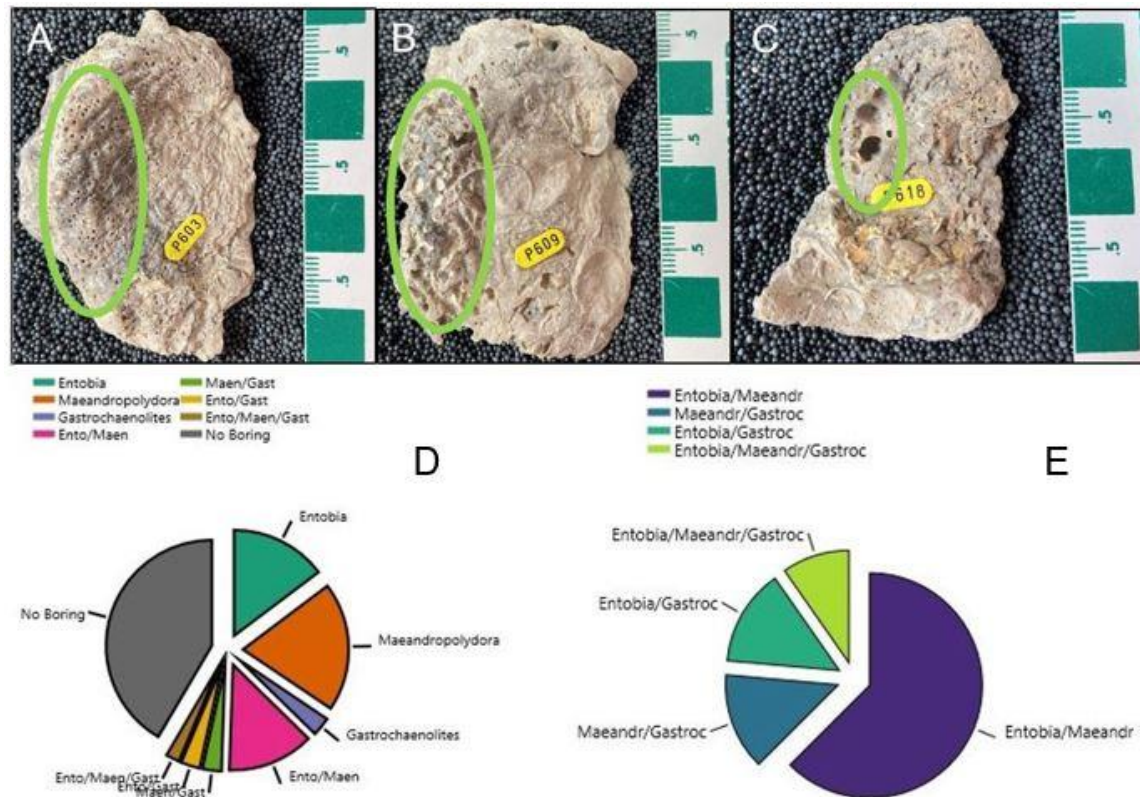


Figure 4: Analysis of macro-boring on *C. texana*. A) *Entobia* sp. encircled by green oval. B) *Maeandropolydora* sp. encircled by green oval. C) *Gastrochaenolites* sp. encircled by green oval. D) Relative abundance of macro-borings on shells. E) Relative abundance of macro-borings on shells that have multiple macro-borer species.

4. Discussion and Conclusion

Size-frequency data support the unity of all specimens as a single species, *C. texana*, but point to the absence of the smallest size classes (= the juveniles). This is strong evidence for the removal of the smallest individuals via some physical-environmental processes (Dodd et al., 1985). The combination of fractures plus extensive macro-boring is evidence of extended time on the seafloor substrate before burial. In summary, the data suggest that the paleo-population of *C. texana* at locality 1002 is biased taphonomically and thus inferences about paleoecology must be tentative.

The Cretaceous *C. texana* accumulations are consistent with OMO's of modern (Powell et al., 2006) and Pleistocene oysters (Lockwood & Mann, 2019). OMO's may be classified (Toscano et

al., 2018) as being produced due to accumulation by original, biologic gregariousness (=autobiostrome) or or via sedimentologic origin (=allobiostrome). Contrary to numerous cases of autobiostrome OMO elsewhere in the Walnut Formation (Flatt, 1976) for a different oyster species, *Texigryphaea mucronata*, the *C. texana* buildup at locality 1002 would suggest an allobiostrome OMO. Whether this is a diagnostic separation for the two species throughout the Walnut Formation, or just a local occurrence requires further field work on *C. texana* OMO accumulations throughout Central Texas.

In summary, *Ceratostreon texana* formed a type of ancient reef termed an Oyster Mass Occurrence (OMO) in the Keys Valley Marl Member of the Cretaceous Walnut Formation in central Texas. Three data sources – size-frequency, fractures and macro-borings were collected and then analyzed statistically. The absence (loss) of juveniles, plus extensive anterior fracturing and borings by multiple taxa confirm the relatively long time on the seafloor and the taphonomic loss of information about the original paleo-community. This evidence supports a conclusion that this *C. texana* OMO was an allobiostrome formed by mostly sedimentologic processes.

5. Acknowledgment

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References

- Adkins, W. S. & Winton, W. M. (1919). Paleontological correlation of the Fredericksburg and Washita Formations in North Texas. *University of Texas Bulletin*, No. 1945, 1-127.
- Amsbury, D. L. (2002). Stratigraphy of Fredericksburg Group (Middle – Upper Albian Cretaceous), North-Central Texas. In Scott, R. W. (Ed.), *Perkins Memorial Volume: U. S. Gulf Coast Stratigraphy and Paleocology*. (pp. 227-276). *Gulf Coast Section of the Society of Economic Paleontologists and Mineralogists Foundation, Special Publications in Geology 1*.
- Dodd, J. R., Alexander, R. and Stanton, R. J., Jr. (1985) Population dynamics in *Dendraster*, *Merriamaster*, and *Anadara* from the Kettleman Hills, California. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 52, 61-78.
- El-Hedeny, Ma. M. & El-Sabbagh, A. M. (2007). Macro-borings on Late Cretaceous oysters of Egypt. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, 244(3), 273-286.
- Flatt, C. D. (1976). Origin and significance of the oyster banks in the Walnut Clay Formation, Central Texas. *Baylor Geological Studies, Bulletin*, 30, 1-47.
- Hammer, O., Harper, D. A. T. & Ryan, P. D. (2001). PAST: paleontological statistics software package for education and data analysis. *Palaeontologica Electronica*, 4(1), 1-9.
- LaBarbera, M. (1981). The ecology of Mesozoic *Gryphaea*, *Exogyra*, and *Ilymatogyra* (Bivalvia: Mollusca) in a modern ocean. *Paleobiology*, 7(4), 510-526.

Lockwood, R. & Mann, R. (2019). A conservation palaeobiological perspective on Chesapeake Bay oysters. *Philosophical Transactions of the Royal Society B*, 374, 20190209.

Mancini, E. A. & Scott, R. W. (2006). Sequence stratigraphy of Comanchean Cretaceous outcrop strata of Northeast and South-Central Texas: Implications for enhanced petroleum exploration. *Gulf Coast Association of Geological Societies Transactions*, 56, 539-550.

McChesney, J. (2016). You should summarize data with the geometric mean. <https://jlmc.medium.com/understanding-three-simple-statistics-for-data-visualizations-2619dbb3677a>

Moore, C. H., Jr. (1964). Stratigraphy of the Fredericksburg Division, South-Central Texas. *Bureau of Economic Geology, Report of Investigation*, No. 52, 1-48.

Patterson, M. A., Webster, J. M., Hutchings, P., Braga, J.-C., Humblet, M. & Yokoyama, Y. (2020). Bioerosion traces in the Great Barrier Reef over the past 10 to 30kyr. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 542, 1-18.

Powell, E. N., Kraeuter, J. N. & Ashton-Alcox, K. A. (2006). How long does oyster shell last on an oyster reef? *Estuarine, Coastal and Shelf Science*, 69, 531-542.

Scott, R. W., Benson, D.G., Morin, R. W., Shaffer, B. L. & Oboh-Ikuenobe, F. E. (2002). Integrated Albian-Lower Cenomanian chronostratigraphy standard, Trinity River section, Texas. In Scott, R. W. (Ed.), *Perkins Memorial Volume: U. S. Gulf Coast Stratigraphy and Paleocology*. (pp. 277-334). *Gulf Coast Section of the Society of Economic Paleontologists and Mineralogists Foundation, Special Publications in Geology*, 1.

Stenzel, H. B. (1971). Oysters, *Treatise on Invertebrate Paleontology*, Part N, Volume 3, Mollusca (6) (Bivalvia). Kansas University Press, Lawrence, Kansas, 276 pp.

Talbert, S. J. & Atchley, S. C. (2000). Sequence stratigraphy of the Lower Cretaceous (Albian) Fredericksburg Group, Central and North Texas. *Gulf Coast Association of Geological Societies Transactions*, 50, 369-378.

Toscano, A. G. & Lazo, D. G. (2020). Taxonomic revision and palaeobiogeographic affinities of Berriasian – Valanginian oysters from the Vaca Muerta and Mulichinco formations, southern Mendoza, Neuquen Basin. *Cretaceous Research*, 109, 1-24.

Toscano, A. G., Lazo, D. G. & Luci, L. (2018). Taphonomy and Paleocology of Lower Cretaceous oyster mass occurrences from West-Central Argentina and evolutionary paleoecology of gregariousness in oysters. *PALAIOS*, 33, 237-255.

Zuschin, M., Stachowitsch, M. & Stanton, R. J. Jr. (2003). Patterns and processes of shell fragmentation in modern and ancient marine environments. *Earth-Science Reviews*, 63, 33-82.

