CRETACEOUS INVERTEBRATES OF THE AURORA LIMESTONE

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THIS study of Cretaceous invertebrates is based on fossils collected during the summer of 1953 from the Aurora limestone in the Sierra de Tlahualilo, Coahuila, Mexico. Fossils were obtained at forty-nine localities scattered for fifteen miles along the western front of the range, which is situated on the boundary line between the states of Coahuila and Durango, about fifty-six miles northeast of the city of Torreón. The purpose of the study was to determine the age of the Aurora limestone in this area and to correlate it with sediments laid down elsewhere in Mexico and in Texas.

Large collections were obtained from a very persistent layer about four hundred feet below the top of the Aurora limestone. The distribution and elevation of the outcrop of this layer were mapped with plane table and alidade. Its geographic distribution in three separate areas is shown in Figure 1. In the Ojo de Agua and Guayule embayments at the south it crops out along canyons within the range. In the central part of the area it is present along the western flank of the Villareal uplift. Farther north it is widely distributed in the Gonzalez Basin, which is a synclinal depression between the Villareal uplift on the south and the Barro uplift on the north. These three areas of outcrop are separated by faults along the western margin of the range, north and south of the Villareal uplift.

All specimens are deposited in the Museum of Paleontology of the University of Michigan and bear catalogue numbers of the Museum. Both the field and the laboratory work were conducted under the auspices of the Museum of Paleontology.

PRESERVATION OF FOSSILS

The fossils, though abundant, are for the most part in a poor state of preservation, and the more fragile shells are badly weathered or incomplete. The poor condition of the specimens has limited the degree to which they could be identified.

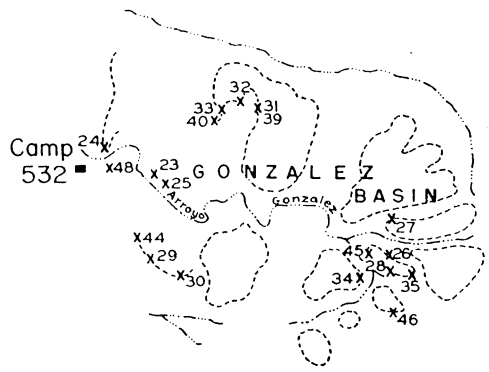
The fossils were collected both in place and from the float, where they had weathered out and were loose on the surface. Those in place were better preserved, but more difficult to collect. The larger number—notably the brachiapods, gryphaeas, and pectens, as well as the echinoids—have retained their original shell material; the gastropods, cephalopods, and most of the pelecypod genera are preserved as casts. In some specimens there has been a calcite replacement of the shell.

Fossil Localities

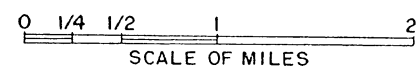
All the localities listed below (see Fig. 1) are in the *Gryphaea mucronata* zone except numbers 21 and 50, which are in the *Lima wacoensis quadrangularis* zone. The directions "right" and "left" refer to the observer's right and left as he faces downstream.

1. On left side of tributary of Arroyo Guayule, about 1,200 feet southeast of Camp 531.
2. On right side of tributary of Arroyo Guayule, about ¼ mile upstream from Locality 1.
3. In saddle on divide between two tributaries of Arroyo Guayule, about 2,300 feet east of Camp 531.
4. On top of ridge on right side of tributary of Arroyo Guayule, upstream from and about 2,100 feet northeast of Camp 531.
5. Near top of ridge on left side of tributary of Arroyo Guayule, about 1,400 feet northeast of Camp 531.
6. On right side of canyon tributary to Arroyo Guayule and about 225 feet west of Locality 5.
7. On crest of ridge on south side of tributary to Arroyo Guayule, about 2,000 feet northeast of Camp 531.
8. On crest of ridge on south side of tributary to Arroyo Guayule, about ½ mile northeast of Camp 531.
9. About 100 feet east of Locality 8, on crest of same ridge on south side of tributary of Arroyo Guayule.
10. Near crest of ridge on left side of tributary of Arroyo Guayule, about 3,600 feet northeast of Camp 531.
11. Near crest of ridge overlooking canyons to the east which are tributary to Arroyo Guayule, about 4,600 feet northeast of Camp 531.
12. On side of next knob west of Locality 11, between tributaries of Arroyo Guayule, about 4,600 feet northeast of Camp 531.
13. On side of small outlying knob between tributaries of Arroyo Guayule, about 5,100 feet northeast of Camp 531.
14. On top of ridge between tributaries of Arroyo Guayule, about ¾ mile northeast of Camp 531.
15. On top of ridge between tributaries of Arroyo Guayule, about 800 feet west of Locality 14 and about ¾ mile northeast of Camp 531.

BARRO UPLIFT



DISTRIBUTION OF FOSSIL LOCALITIES ALONG PART OF THE WESTERN FLANK OF THE SIERRA DE TLAHUALILO COAHUILA, MEXICO



-----Gryphaea mucronata bed

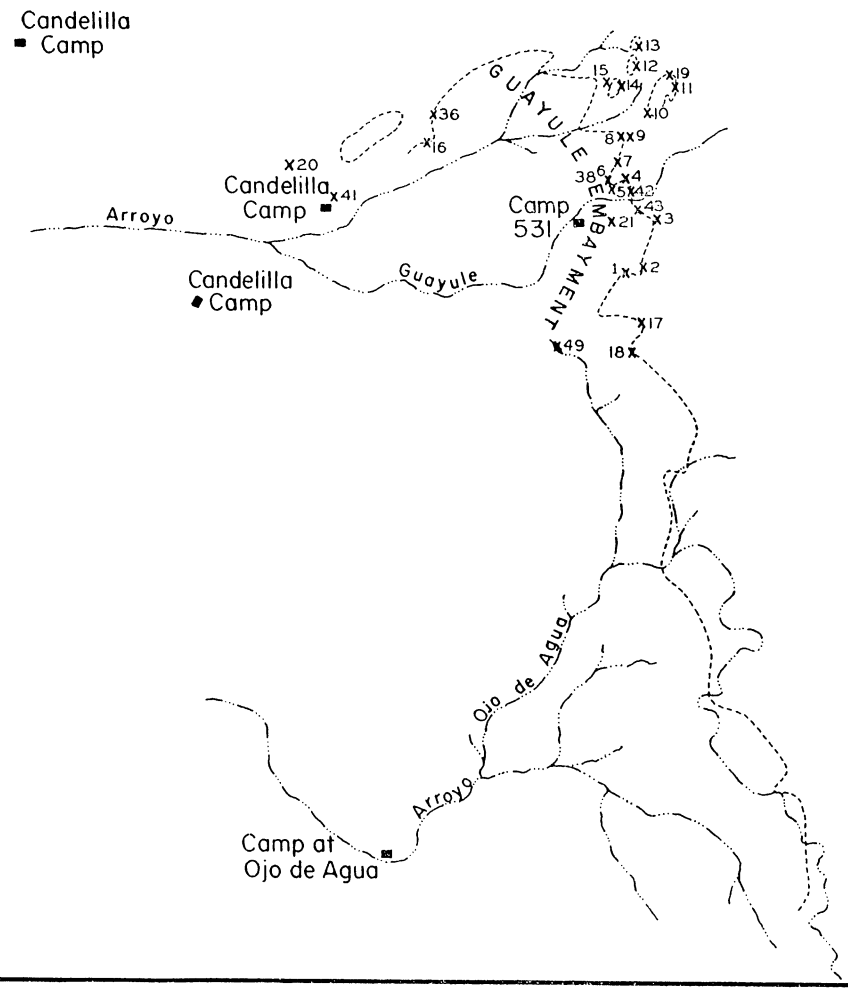


FIG. 1

16. On right side of tributary of Arroyo Guayule, about 4,600 feet northwest of Camp 531.
17. On rim of hill on tributary of Arroyo Ojo de Agua, about 3,200 feet southeast of Camp 531.
18. On left side of canyon tributary to Arroyo Ojo de Agua, opposite Locality 17, about 3,800 feet south-southeast of Camp 531.
19. In the Guayule embayment on side of knoll carved by stream erosion, about 4,785 feet northeast of Camp 531.
20. At southeast corner of outlying hill of limestone, west of principal mountain front, about 1½ miles west-northwest of Camp 531. (The fauna, mostly ostreidae, is not diagnostic of age.)
21. On crest of hill on left side of canyon of Arroyo Guayule, about 900 feet east of Camp 531. (Zone of *Lima wacoensis quadrangularis.*)
22. On west flank of Villareal uplift, on right side of westward draining canyon, 3½ miles and about 130 feet northwest of Camp 531.
23. Outcrop along right side of bed of Arroyo Gonzalez, about 2,000 feet east of Camp 532.
24. On nose of hill on right side of mouth of Arroyo Gonzalez, about 760 feet northeast of Camp 532.
25. Outcrop along left side of bed of Arroyo Gonzalez, about 400 feet upstream from Locality 23 and about 2,350 feet southeast of Camp 532.
26. Outcrop bench along left side of tributary of Arroyo Gonzalez, 1½ miles and about 100 feet southeast of Camp 532.
27. On hillside on left of canyon tributary to Arroyo Gonzalez, about 100 feet above stream bed, 1½ miles and about 625 feet east-southeast of Camp 532.
28. Outcrop bench along right side of tributary of Arroyo Gonzalez, 1½ miles and about 925 feet southeast of Camp 532.
29. On crest of ridge, at western front of Sierra de Tlahualilo, west of Tlahualilo fault scarp, about 3,000 feet southeast of Camp 532.
30. On nose of ridge, at western front of Sierra de Tlahualilo, about 950 feet southeast of Locality 29 and about 3,960 feet southeast of Camp 532.
31. In northern part of Gonzalez Basin, on hillside at left of draw which drains about S. 45° W., approximately 5,100 feet northeast of Camp 532.
32. In saddle on top of ridge, on opposite side of draw from Locality 31, about 4,700 feet northeast of Camp 532.
33. About 530 feet southwest of Locality 32, on same ridge.
34. On left side of tributary of Arroyo Gonzalez, about 860 feet southwest of Locality 28, on opposite side of stream bed.
35. On right side of tributary of Arroyo Gonzalez, about 600 feet upstream from Locality 28.
36. On north side of Guayule embayment, on left side of canyon draining southwestward, about 5,000 feet northwest of Camp 531.
37. On west flank of Villareal uplift, on right side of stream bed of arroyo which drains westward, 2½ miles and about 1,900 feet northwest of Camp 531.
38. About 1,450 feet northeast of Camp 531, opposite Locality 6.
39. Same location as Locality 31, but fossils collected from float at somewhat lower stratigraphic position.

40. In northern part of Gonzalez Basin, about 400 feet southwest of Locality 33.
41. One mile and about 1,385 feet west-northwest of Camp 531, on limestone hill, 400 feet northeast of site of Candelilla camp.
42. Top of limestone ridge, about 1,650 feet northeast of Camp 531.
43. On left side of canyon of Arroyo Guayule, about 1,650 feet northeast of Camp 531.
44. On western front of Sierra de Tlahualilo, about 2,500 feet southeast of Camp 532.
45. On top of limestone hill, 1½ miles and about 230 feet southeast of Camp 532.
46. On south side of Gonzalez Basin, on top of ridge, 1½ miles and about 1,400 feet southeast of Camp 532.
47. On west side of Villareal uplift, 3 miles and about 400 feet northwest of Camp 531.
48. On nose of ridge at left side of mouth of canyon of Arroyo Gonzalez, about 800 feet east of Camp 532.
49. On right side of canyon tributary to Arroyo Ojo de Agua, about 3,430 feet south-southwest of Camp 531. (Zone of *Lima wacoensis quadrangularis.*)

The Fauna

The fauna of the Aurora limestone (see Table I) studied during the present investigation comprises sixty-nine species belonging to four phyla. The Mollusca constitute more than 75 per cent. The dominant element is the Pelecypoda, consisting of twenty-nine species. Gastropoda have the next largest representation, with nineteen species. Brachiopoda are abundant in number of individuals, but only one species is recognized. Echinoidea are represented by only a few individuals, but fifteen species have been identified. The remaining biologic groups, Cephalopoda and Anthozoa, are poorly represented, both in individuals and in species. The number of species in the fauna, their distribution in biologic groups, and the extent to which they have been identified are summarized in Table II.

The fauna belongs to three distinct zones and to one locality, the stratigraphic position of which with reference to the others is not known. For convenience, the zones are designated by the name of the dominant fossil present. In descending order, stratigraphically, they are: (1) the *Lima wacoensis quadrangularis* zone; (2) the *Gryphaea mucronata* zone; and (3) the miliolid zone. The zones are of local significance only, but the fauna of each is distinct, and they are analyzed separately here.

Lima wacoensis quadrangularis zone

The *Lima wacoensis quadrangularis* zone is in the upper part of the Aurora limestone, about four hundred feet above the *Gryphaea mucronata* zone. It was found only at localities 21 and 49 in the Guayule

TABLE I

Distribution of Fauna of the Aurora Limestone

Fossils	Localities 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Coelenterata																																																	
Coral ?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	?	..	..	..	..	..	..	..	..	..	..	..	?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Brachiopoda																																																	
Kingena wacoensis (Roemer)	×	×	×	×	×	..	×	×	×	×	×	×	×	..	×	×	×	×	×	×	..	×	×	×	×	×	..	..	×	..	×	×	..	×	×	..	×	×	..	..	..	×	..	..	×	..	×	..	..
Pelecypoda																																																
Alectryonia carinata (Lamarck)	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Alectryonia (?) sp. cf. A. diluviana Linnaeus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gryphaea mucronata Gabb	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	..	..	..	×	×	×	×	×	×	×	×	×	×	×	×	×	..	×	×	..	×	..	×	×	×	×	×	..	..	..
Pteria pedernalis (Böse)	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Trigonia sp. cf. T. guadalupae Böse	..	..	..	..	×	×	..	..	..	×	..	..	..	×	..	..	×	..	×	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Trigonia spp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..	×	..	..	..
Pecten indiduraensis Jones	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pecten texanus Roemer	×	×	×	×	×	×	×	×	..	×	×	×	×	..	×	×	×	×	×	..	×	×	×	×	×	×	..	..	×	..	×	×	..	..	×	×	×	..	×	..	×	..	..	×	×	..	..	..
Pecten spp.	..	×	..	×	..	..	..	..	..	..	×	×	..	×	×	..	×	×	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Lima sp. cf. L. elpasensis Stanton	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lima wacoensis quadrangularis Stanton	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lima sp. aff. L. semilaevis Cragin	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Lima spp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×
Pholadomya spp.	..	..	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pholadomya ? spp.	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Homomya sp. cf. H. alta Roemer	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Homomya sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cypricardia ? sp. aff. C. texanum Roemer	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Veniella coahuilaensis Jones	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Veniella sp. A	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
Veniella sp. B	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Eoradiolites sp. aff. E. davidsoni Hill	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Phacoides acute-lineolatus (Roemer)	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cardium sp. A	×	×	..	×	..	..	..	..	..	×	×	..	×	..	..	..	×	..	..	..	..	×	×	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Cardium sp. B	..	..	..	×	..	..	..	..	..	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cardium sp. C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Protocardia texana (Conrad)	×	×	..	×	×	×	..	..	..	×	×	×	..	×	×	..	×	×	×	..	..	×	..	..	..	×	..	..	..	..	×	×	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..
Protocardia sp. aff. P. multistriata Conrad	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyprimeria texana (Roemer) ?	..	?	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	?	..	?	?	..	?	..	..	..	?	..	..	?	..	..	..	..	..	..	..	..	..	?	..	..	..	..
Gastropoda																																																
Pleurotomaria austinensis Shumard	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pleurotomaria sp. A	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pleurotomaria sp. B	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Turbo ? sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Pseudomelania ? spp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Natica sp.	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Amauropsis sp. cf. A. bulbiformis Sowerby	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Lunatia ? sp.	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tylostoma kentense Stanton	..	..	..	×	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	×	×	?	..	..
Tylostoma ? sp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Turritella sp. aff. leonensis Conrad	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Turritella spp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	?
Nerinea ? sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Anchura ? spp.	..	..	..	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Aporrhais ? sp. aff. subfusiformis Stanton	..	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..
Aporrhais sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Aporrhais ? spp.	..	..	..	×	×	..	..	..	..	×	..	..	..	..	..	..	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cephalopoda																																																
Cymatoceras hilli (Shattuck)	..	..	×	×	..	..	..	..	..	..	×	..	..	×	..	..	..	..	..	..	..	..	×	..	×	×	..	..	..	×	×	..	×	..	×	×	..	×	..	..	..	..	..	..	..	×	×	..	..	..
Turrilites brazoensis Roemer	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Turrilites spp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Budaiceras mexicanum Böse	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Echinoidea																																																
Holectypus sp. A	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Holectypus sp. B	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..
Holectypus sp. C	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..
Holectypus sp. D	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Holectypus sp. E	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..
Holectypus spp.	..	×	×	×	..	×	..	×	..	..	×	×	..	..	..	..	×	×	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	×	×	..	×	×	..	..	..	..	×	..	×	×	×	×	..	..
Enallaster sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Hemiaster calvani Clark	..	..	×	?	..	..	..	..	?	..	?	..	..	..	..	..	×	×	..	?	?	..	×	..	×	..	..	..	..	×	..	..	..	..	?	..	..	..	..	..	..	..	..	..	?	..	..	..	..	..
Hemiaster whitei (Clark)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	?	..	..	?	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..
Hemiaster sp.	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Enallaster texanus (Roemer)	..	..	..	×	×	..	..	..	..	?	..	..	..	..	?	..	?	..	?	?	?	..	..	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	?	..
Holaster ? spp.	..	..	..	×	..	..	×	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..

embayment. Eighteen species are recognized, ten of which are either identical with or similar to known species. Table III shows the geologic range of these related species as reported elsewhere in Mexico and Texas. Five of them are confined to the Washita group and two to the Fredericksburg group. The other three are long-ranging forms occurring in both the Washita and the Fredericksburg and, in one instance, extending downward into the Trinity group. The predomi-

TABLE II

NUMBER OF FOSSIL SPECIES IDENTIFIED IN THE AURORA LIMESTONE AND DEGREE OF IDENTIFICATION

Degree of identification	Number of species identified						
	Anthozoa	Brachiopoda	Pelecypoda	Gastropoda	Cephalopoda	Echinoidea	Total
Identified with known species	..	1	9	2	3	3	18
Questionably identified with known species	..	..	1	1	..	3	5
Related to known species	..	..	4	2	..	..	6
Compared with known species	..	..	4	1	..	..	5
Generic identification only	..	..	11	13	1	9	34
Class identification only	1	..	..	..	..	..	1
Total	1	1	29	19	4	15	69

nance of the five allied species confined to the Washita group indicates rather strongly that the *Lima wacoensis quadrangularis* zone is to be correlated with some part of the Washita group of the Comanchean series.

The distinctive character of the *Lima wacoensis quadrangularis* assemblage is shown by the fact that only four of its eighteen species occur also in the *Gryphaea mucronata* zone. *Lima wacoensis quadrangularis* itself (Pl. I, Fig. 3) is found only in the higher zone and is fairly common there. In Texas it is limited to the Washita group. The large gastropod *Pleurotomaria austinensis* Shumard (Pl. II), so common and widespread in the Washita of Texas, appears only in the *Lima wacoensis quadrangularis* zone in the small area of Coahuila covered by this investigation. A genus that appears to be of some stratigraphic value is *Pholadomya* (Pl. III, Fig. 5). *Pholadomya* and the closely re-

lated genus *Homomya* comprise an important element of the fauna at the top of the Aurora limestone. Although some species of these genera occur below, in the *Gryphaea mucronata* zone, they form a minor element there. Perhaps the most diagnostic fossil in this zone, so far as correlation goes, is *Budaiceras mexicanum* Böse (Pl. III, Figs. 1–2), whose known occurrence is in the Buda limestone. A single specimen of *Eoradiolites* sp. aff. *E. davidsoni* Hill (Pl. IV, Fig. 1), col-

TABLE III

GEOLOGIC RANGE OF FOSSILS RELATED TO SPECIES IN THE LIMA WACOENSIS QUADRANGULARIS ZONE OF THE AURORA LIMESTONE

Species	*Nearest allied species*	*Occurrence of allied species in Texas and Mexico*
Pecten texanus Roemer	P. texanus Roemer	Washita, Fredericksburg
Lima sp. cf. L. elpasensis Stanton	L. elpasensis Stanton	Duck Creek, Comanche Peak
Lima wacoensis quadrangularis Stanton	L. wacoensis quadrangularis Stanton	Washita
Cypricardia ? sp. aff. C. texanum Roemer	C. texanum Roemer	Fredericksburg
Eoradiolites sp. aff. E. davidsoni Hill	E. davidsoni Hill	Edwards
Pleurotomaria austinensis Shumard	P. austinensis Shumard	Georgetown, Duck Creek, Fort Worth
Turritella sp. aff. leonensis Conrad	T. leonensis Conrad	Washita
Budaiceras mexicanum Böse ..	B. mexicanum Böse	Buda
Hemiaster calvani Clark ?	H. calvani Clark	Washita
Enallaster texanus (Roemer) ?	E. texanus (Roemer)	Washita, Fredericksburg, Trinity

lected at Locality 21 in the Guayule embayment, although related to a form that occurs in the Edwards limestone of Texas, serves locally to tie this fauna to an assemblage found at the top of the Aurora limestone a few miles to the south, in the Ojo de Agua embayment. The fauna of this embayment is being studied in connection with stratigraphic investigations in that area.

GRYPHAEA MUCRONATA ZONE

The *Gryphaea mucronata* zone is the most dependable stratigraphic marker in the Sierra de Tlahualilo. Its distribution is shown in Figure 1. It was traced for more than fifteen miles along the western side of the range, being associated with a characteristic lithologic sequence

that facilitated its recognition along the canyons and flanks of the mountains. This sequence is illustrated in Plate V.

The *Gryphaea mucronata* zone is the most fossiliferous horizon in the Sierra de Tlahualilo, both in number of megascopic specimens and in number of species. Along its outcrop there is usually a coquina one or two feet thick made up almost entirely of *Gryphaea mucronata*. Beneath it is a bench of yellowish-gray, granular limestone about four feet thick that is underlain by from three to five feet of rubbly, nodular limestone. Below this is a unit six or eight feet thick of thin, platy beds of limestone that characteristically weather into brownish slabs on the surface. This distinctive sequence is about fifty feet above a cliff-forming unit of thick benches of limestone that we mapped as the top of the middle Aurora limestone. Identification of the contact between the middle and the upper Aurora was everywhere confirmed by the presence of the coquina above the contact. The coquina appears to mark the base of the fossiliferous zone. In most places no fossils were found above or below the coquina, but occasionally the limestones above were sparsely fossiliferous through an interval of from ten to fifty feet. Specimens of *Cymatoceras hilli* (Shattuck) were present in a number of localities five to ten feet above the coquina, and specimens of *Turrilites brazoensis* were found at one place in the coquina and at several spots in the limestone above it.

Fifty-seven species have been recognized in the *Gryphaea mucronata* zone. Twenty-six of these were identified as identical with or similar to known species. These are shown in Table IV, together with the stratigraphic range of allied species in Texas or elsewhere in Mexico. Two are compared with species from the Upper Cretaceous (Eagle Ford or Austin Chalk). One is reported to occur in both the Eagle Ford formation and in the Washita group. Nine are allied to Washita species, six to Fredericksburg species, and five to species that are known to range through both the Washita and the Fredericksburg groups. Two are allied to species extending from the Eagle Ford to the Fredericksburg group and one to a species extending from the Washita to the Trinity group. The fact that more species of the *Gryphaea mucronata* zone are allied to those of the Washita group than to those of the Fredericksburg, that more allied species are known from strata higher than from strata lower than the Washita, and, finally, that the number that occur in both the Washita and the Fredericks-

burg groups is greater than the number restricted to the Fredericksburg but less than the number restricted to the Washita indicates a somewhat greater affinity with the Washita group than with the Fredericksburg group.

TABLE IV

GEOLOGIC RANGE OF FOSSILS RELATED TO SPECIES IN THE GRYPHAEA MUCRONATA ZONE OF THE AURORA LIMESTONE

Species	*Nearest allied species*	*Occurrence of allied species in Texas and Mexico*
Kingena wacoensis (Roemer)	K. wacoensis (Roemer)	Washita, Fredericksburg, Trinity
Alectryonia carinata (Lamarck)	A. carinata (Lamarck)	Washita, Fredericksburg
Alectryonia (?) sp. cf. A. diluviana Linnaeus	A. diluviana Linnaeus	Austin Chalk
Gryphaea mucronata Gabb	G. mucronata Gabb	Fredericksburg
Pteria pedernalis (Böse)	P. pedernalis (Böse)	Fredericksburg, Indidura (members 2 and 3)
Trigonia sp. cf. T. guadalupae Böse	T. guadalupae (Böse)	Fredericksburg, Waco
Pecten indiduraensis Jones	P. indiduraensis Jones	Indidura (members 1, 2, and 3)
Pecten texanus Roemer	P. texanus Roemer	Washita, Fredericksburg
Lima sp. aff. L. semilaevis Cragin	L. semilaevis Cragin	Denton, Fort Worth
Homomya sp. cf. H. alta Roemer	H. alta Roemer	Fredericksburg
Cypricardia ? sp. aff. C. texanum Roemer	C. texanum Roemer	Fredericksburg
Veniella coahuilaensis Jones	V. coahuilaensis Jones	Indidura (members 2 and 3)
Phacoides acute-lineolatus (Roemer)	P. acute-lineolatus (Roemer)	Edwards
Protocardia texana (Conrad)	P. texana (Conrad)	Washita, Fredericksburg
Protocardia sp. aff. P. multistriata Conrad	P. multistriata Conrad	Weno, Pawpaw
Cyprimeria texana (Roemer) ?	C. texana (Roemer)	Fredericksburg
Amauropsis sp. cf. A. bulbiformis Sowerby	A. bulbiformis Sowerby	Benton
Tylostoma kentense Stanton	T. kentense Stanton	Washita
Aporrhais ? sp. aff. subfusiformis (Shumard)	A. subfusiformis (Shumard)	Washita, Comanche Peak
Cymatoceras hilli (Shattuck)	C. hilli (Shattuck)	Washita
Turrilites brazoensis Roemer	T. brazoensis Roemer	Main Street, Grayson
Holectypus sp. A	H. castilloi Cotteau	Washita
Holectypus sp. B	H. transpecosensis Cragin	Washita
Hemiaster calvani Clark	H. calvani Clark	Washita
Hemiaster whitei (Clark)	H. whitei (Clark)	Fredericksburg
Enallaster texanus (Roemer)	E. texanus (Roemer)	Washita, Fredericksburg, Trinity

The type locality of *Gryphaea mucronata* Gabb (Pl. VI, Figs. 1–3) is near Arivechi, Sonora, Mexico, where the species is associated with fossils definitely of Fredericksburg age. Stanton (1947, p. 28) evidently considered *G. mucronata* to be restricted to the Fredericksburg. Correlation Chart 10a prepared by Imlay (1944b) under the auspices of the Committee on Stratigraphy of the National Research Council

indicates the range of *G. mucronata* to be middle Fredericksburg and upper Trinity. It is a widely variable species, which has often been confused with *G. graysonana* Stanton, from the upper Washita. Our species shows the same range of variation as specimens of *G. mucronata* from Arivechi and from the Goodland limestone of Tarrant County, Texas. It is a smaller, thinner, and narrower form than the figured specimens of *G. graysonana.*

The next most common species at this horizon is *Pecten texanus* Roemer. Although in Texas it ranges downward into the Fredericksburg, it is a characteristic Washita species. Stanton (1947, p. 46) states that it is "common at almost all exposures of the Washita throughout Texas. At Denison in Grayson County it is especially abundant in the Duck Creek limestone, Denton Clay, Fort Worth limestone and Grayson Marl. In the Austin section in Travis County it has a similar range, occurring in the Georgetown, Del Rio and Buda formations."

Cymatoceras hilli (Shattuck) (Pl. I, Fig. 4; Pl. III, Figs. 3–4; Pl. IV, Fig. 2; Pl. VI, Fig. 4) and *Turrilites brazoensis* Roemer (Pl. VII) are probably the best indicators of age because of their limited range elsewhere in Mexico and Texas. In regard to the distribution of *C. hilli,* Miller and Harris (1945, p. 6) say: ". . . insofar as we have been able to ascertain, this species is not known to occur outside of the Washita of central Texas; stratigraphically it ranges throughout all but the extremities of that group." They go on to mention its occurrence in the Buda, Fort Worth, Weno, and Main Street formations, and in the transition zone between the Main Street and Grayson formations.

Turrilites brazoensis is one of the most distinctive and widely distributed ammonites in the Washita group. Adkins (1928, p. 214) gives its range in Texas as Main Street and Grayson. Böse and Cavins (1927, p. 90) say: "A characteristic for the base of the Cenomanian is the occurrence of the large *Turrilites brazoensis* Roemer in the Main Street Beds."

Another group of invertebrates that is present nearly everywhere in the *Gryphaea mucronata* zone in the Sierra de Tlahualilo is the Echinoidea. Specimens of the large *Holectypus* (Pl. I, Figs. 1, 3) have been tentatively grouped by me into five species, based on the size, shape, and position of the periproct. These are almost certainly the forms that Böse (1910, p. 159) included in his *H. limites.* Cooke (1946) does

not recognize *H. limites*, but places it in synonomy partly with *H. castilloi* Cotteau and partly with *H. transpecosensis* Cragin, both of which are confined to the Washita group. *Hemiaster calvani* Clark is another well-known Washita species that occurs at a number of localities in the *Gryphaea mucronata* zone.

One of the most abundant fossils associated with *Holectypus* and *Turrilites brazoensis* in this zone is the brachiopod *Kingena wacoensis* (Roemer). In Texas it is abundant in the Washita and rare in the Fredericksburg. With regard to the association of these forms Böse and Cavins (1927, p. 25) say: ". . . the base of the Cenomanian in Texas and northern Mexico is to be found in the uppermost Georgetown beds . . . . The limestones contain a great number of *Acanthoceras cunningtoni* Sharpe, a characteristic Cenomanian group, and *Turrilites brazoensis* Roemer. They are accompanied by a great number of *Holectypus limitis* Böse. A little lower there is a bed with numerous *Kingena wacoensis* Roemer. We consider these beds as the lower Cenomanian." At another place Böse (1927, p. 153) says: "In the Mexican region *Holectypus limitis* Böse, *Acanthoceras cunningtoni* Sharpe and *Turrilites brazoensis* Roemer occur in the same bed, and with them rather rare specimens of *Kingena wacoensis* Roemer, but the main layer of the latter species is below the bed with ammonites, which is not over three meters thick; the *Kingena* bed is a calcareous marl, and the ammonite bed above it is a blue gray soft shale. It may be well to include the *Kingena* bed in the Cenomanian but no characteristic ammonite so far has been found in it which would decide the question." Böse and Cavins (1927, p. 16) correlated the strata in northern Mexico containing this association of species with the Upper Georgetown beds of Texas and placed the Albian-Cenomanian boundary in the middle of the Georgetown formation.

MILIOLID ZONE

About one hundred feet stratigraphically below the *Gryphaea mucronata* zone is the top of a foraminiferal limestone unit that has a thickness of sixty-five feet along Cañon Guayule. This appears to be the miliolid limestone that is widely distributed over western Texas and Mexico. Although not every bed of the unit is composed of the tests of foraminifera, layers of miliolid limestone are well distributed through the entire thickness. This unit was observed elsewhere in the Sierra de Tlahualilo at several places on top of the range and on the west flank of the Villareal uplift.

In regard to the age and distribution of miliolid limestone, Imlay (1944a, p. 1095) says: "Miliolid-bearing limestone containing some rudistids and apparently of upper Albian to lower Cenomanian age occurs in the upper part of the El Abra limestone of the southern oil fields near Tuxpan, Veracruz and in the front ranges west of Tampico between Gomez Farias and Tamazunchale."

Adkins (1932, p. 347) has noted that miliolid limestone is a common Edwards facies in Texas. Concerning its stratigraphic position and distribution he says: "Miliolid limestone is practically confined to reefy Fredericksburg in southern Coahuila, southwards in the El Abra limestone of the Front Ranges, underground in the South Fields, along the mountain front west of Orizaba, to the Isthmus of Tehuantepec."

Conclusions

This survey of the fossils collected from the Aurora limestone in a small area along the western flank of the Sierra de Tlahualilo indicates that the upper part of the formation is correlated with part of the Washita and Fredericksburg groups. In the Ojo de Agua embayment to the south, in the Sierra de Tlahualilo, I have collected *Exogyra arietina* Roemer from strata resting on top of the Aurora limestone. Since *E. arietina* is characteristic of the Del Rio clay (upper Washita) in Texas, its presence supports a correlation of the top of the Aurora with the upper part of the Georgetown limestone. The zone of *Gryphaea mucronata*, which is also Washita, would likewise be correlated with part of the Georgetown limestone of Texas, since that is the lowest formation of the group in the western part of the state. The middle of the Aurora, which contains the miliolid member, is certainly to be correlated with the upper part of the Fredericksburg group.

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PLATES I–VII

EXPLANATION OF PLATE I

(All figures natural size.)

Holectypus sp.

FIG. 1. Aboral view, showing ambulacral and interambulacral plates. Specimen No. 32387, Locality No. 28 (*Gryphaea mucronata* zone)

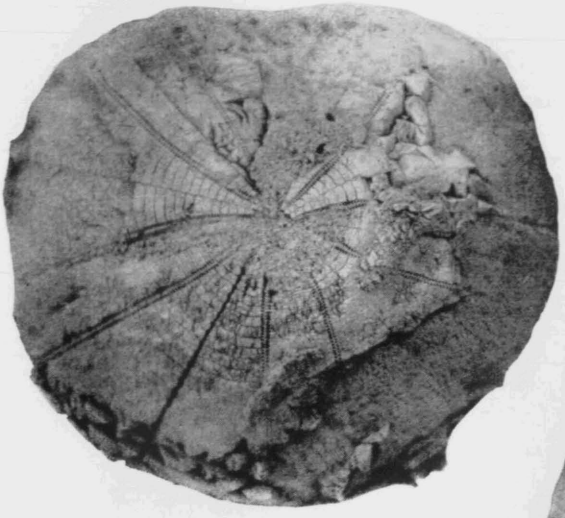
FIG. 2. Side view of same specimen as in Figure 1, showing elevation of aboral surface

Lima wacoensis quadrangularis Stanton

FIG. 3. Right valve of cast, showing the characteristic ribbing, prominent beak, and nearly 90° angle between the dorsal and the anterior margins. Specimen No. 32388, Locality No. 21 (*Lima wacoensis quadrangularis* zone)

Cymatoceras hilli (Shattuck)

FIG. 4. Ventral view, showing rounded venter and sculpture of impressed lines. Specimen No. 32389, Locality No. 35 (*Gryphaea mucronata* zone)



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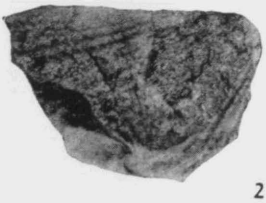

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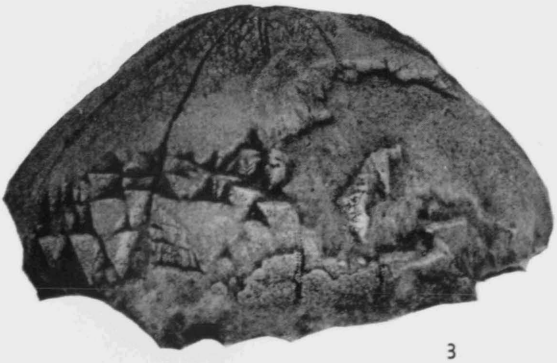

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4

EXPLANATION OF PLATE II

(All figures natural size.)

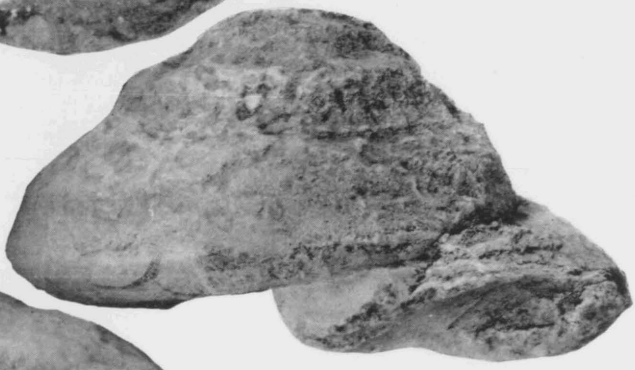
Pleurotomaria austinensis Shumard

FIG. 1. Umbilical view, showing sculpture of revolving lines. Specimen No. 32390 Locality No. 21 (*Lima wacoensis quadrangularis* zone)

FIG. 2. Apertural view of same specimen as in Figure 1, showing elevation and profile of oral surface

FIG. 3. Top view of same specimen as in Figure 1, showing coiling

1



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3

EXPLANATION OF PLATE III

(All figures natural size.)

Budaiceras mexicanum Böse

FIG. 1. Ventral view, showing breadth of the test and profile of the venter. Specimen No. 32392, Locality No. 21 (*Lima wacoensis quadrangularis* zone)

FIG. 2. Umbilical view of same specimen as in Figure 1, showing broad, low, curved ribs on the flank

Cymatoceras hilli (Shattuck)

FIG. 3. Apertural view, showing breadth of the test and profile of the venter on inner and outer whorls. Specimen No. 32391, Locality No. 35 (*Gryphaea mucronata* zone)

FIG. 4. Ventral view of same specimen as in Figure 1, showing sutures crossing the venter

Pholadomya sp.

FIG. 5. Side view of outer surface of left valve of cast, showing low beaks, marginal contour, and sculpture of concentric elevated lines. Specimen No. 32393, Locality No. 21 (*Lima wacoensis quadrangularis* zone)


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EXPLANATION OF PLATE IV

(All figures natural size.)

Eoradiolites sp. aff. *E. davidsoni* Hill

FIG. 1. Side view of fragment of right valve of cast, showing laminations. Specimen No. 32394, Locality No. 21 (*Lima wacoensis quadrangularis* zone)

Cymatoceras hilli (Shattuck)

FIG. 2. Umbilical view, showing sutures. Specimen No. 32391, Locality No. 35 (*Gryphaea mucronata* zone)

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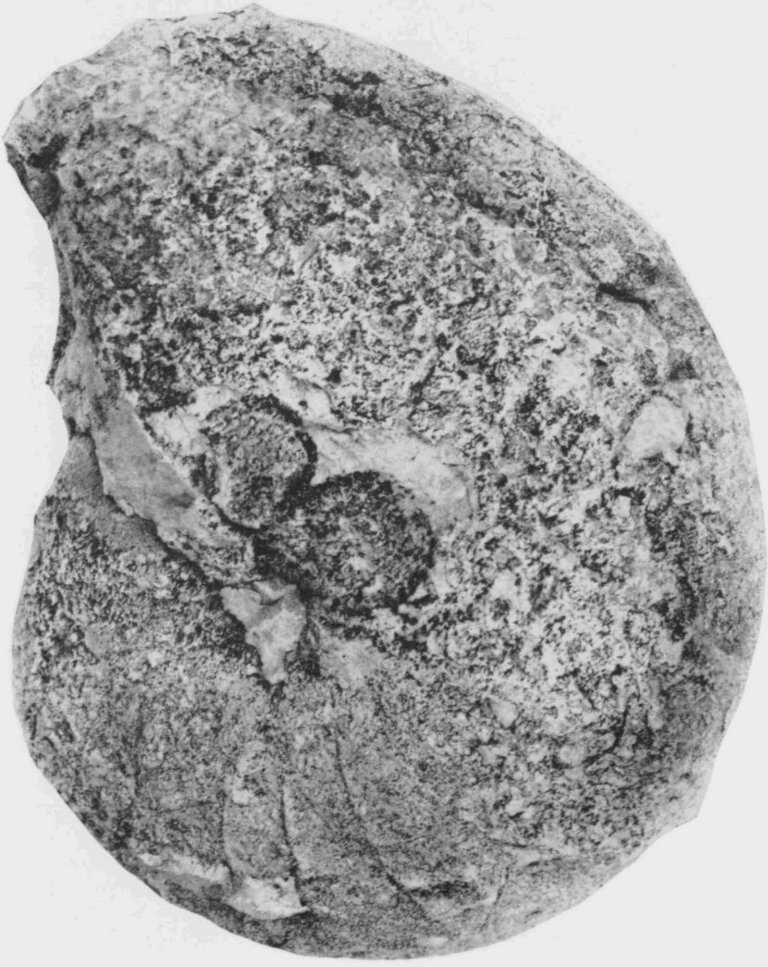

2

Outcrop of *Gryphaea mucronata* zone at Locality 23, showing characteristic lithologic succession below the coquina at the top of the bench

EXPLANATION OF PLATE VI

(All figures natural size.)

Gryphaea mucronata Gabb

FIG. 1. Anterior view of left valve, showing curvature of beak and depth of valve. Specimen No. 32395, Locality No. 25 (*Gryphaea mucronata* zone)

FIG. 2. Inner side view of left valve of same specimen as in Figure 1, showing curvature of beak

FIG. 3. Outer side view of left valve of same specimen as in Figure 1, showing radial groove and width of valve

Cymatoceras hilli (Shattuck)

FIG. 4. Umbilical view, showing sculpture of radiating impressed lines. Specimen No. 32389, Locality No. 35 (*Gryphaea mucronata* zone)

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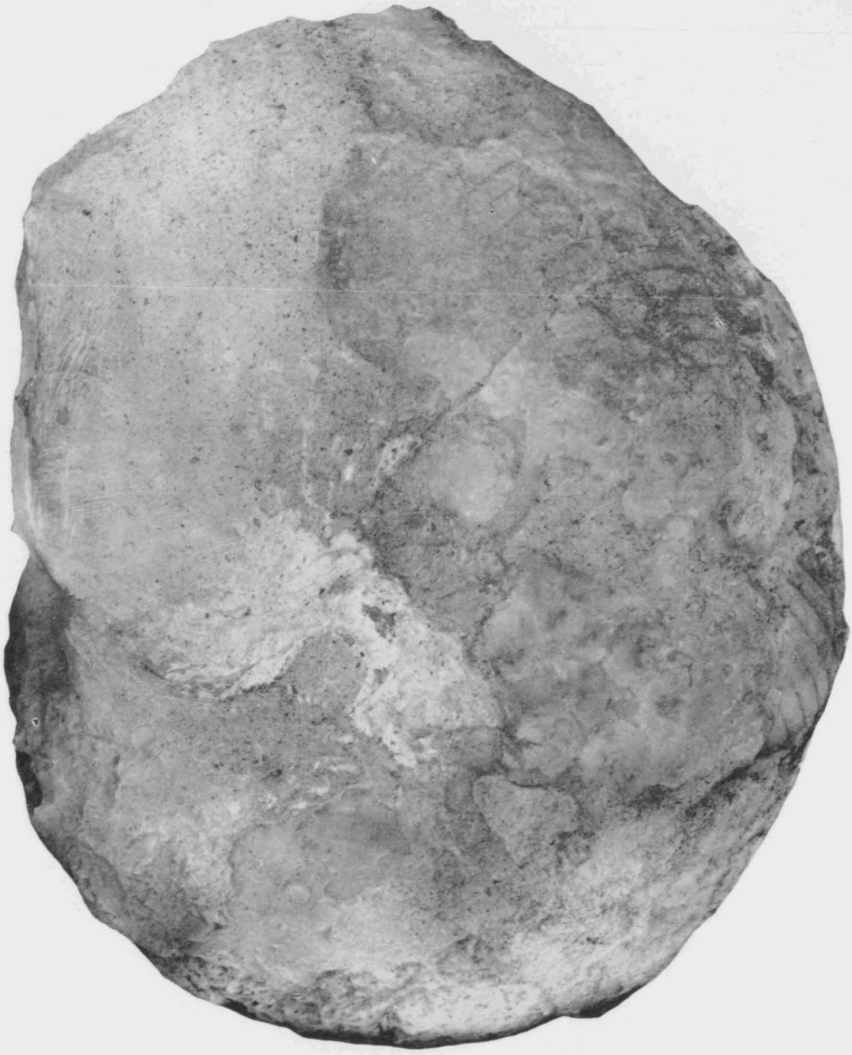

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EXPLANATION OF PLATE VII

(Figure natural size.)

Turrilites brazoensis Roemer

Ventral view, showing spiral coiling and arrangement of nodes near the shoulders. Specimen No. 32396, Locality No. 35 (*Gryphaea mucronata* zone)