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MIDDLE EOCENE TEREBRATULIDE BRACHIOPODS FROM THE BATEQUE FORMATION, BAJA CALIFORNIA SUR, MEXICO

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ABSTRACT—Two species of terebratulide brachiopods are described from the upper part of the Bateque Formation (middle Eocene) on the Pacific coast of Baja California Sur, Mexico, *Terebratulina* cf. *Terebratulina louisianae* Stenzel, 1940, and *Terebratalia batequia* n. sp. *Terebratalia batequia* n. sp. is the earliest confirmed record of the genus *Terebratalia* Beecher, 1893, which has been an important component of Pacific brachiopod faunas through to the present day. The occurrence of *Terebratulina* cf. *Terebratulina louisianae* Stenzel is one of the earliest records of the genus from the west coast of North America. These brachiopods, like other elements of the Bateque invertebrate fauna, may record Eocene migration from the Atlantic to Pacific Ocean via the Central American seaway.

INTRODUCTION

EOCENE BRACHIOPODS have been described from the western margin of North America by a number of authors including Stanton (1896), Arnold (1908), Weaver (1942), Hertlein and Grant (1944), Squires (1984), and Squires et al. (1992). This paper includes the first description of brachiopods from the Bateque Formation, Baja California Sur, Mexico. Recently, other aspects of the paleontology of the Bateque Formation have been described by Squires and Demetrion (1989, 1990a, 1990b, 1992). The brachiopods were discovered and collected during the summer of 1991 by Demetrion, and additional specimens were collected by Demetrion and Squires in 1992. Consequently, they had not been described in the previous works of Squires and Demetrion.

The faunas described by Squires and Demetrion (1989, 1990a, 1990b, 1992) from the Bateque Formation have increased knowledge of stratigraphic and paleobiogeographic occurrences for a number of taxa. The pharetronid calcareous sponge *Elasmostoma bajaensis* Squires and Demetrion, 1989, is the first Tertiary record of the genus from the Western Hemisphere, having previously been recorded from the Jurassic and Cretaceous of Western Europe. Additional Mesozoic relicts were subsequently identified by Squires and Demetrion (1992). The earliest records (Squires and Demetrion, 1990a, 1990b, 1992) of a number of taxa are in the Bateque Formation: the strombid gastropod *Platyoptera*; the bivalve *Nayadina* (*Exputens*); and the crab *Ranina*. In addition, the Bateque Formation includes first occurrences on the west coast of North America of the bivalves *Pycnodonte* (*Phygraea*), *Cubitostrea*, and *Cypraedia*. Of the two species of terebratulid brachiopods described herein, *Terebratalia batequia* n. sp. provides the earliest confirmed record of the genus *Terebratalia* Beecher, 1893, although Squires

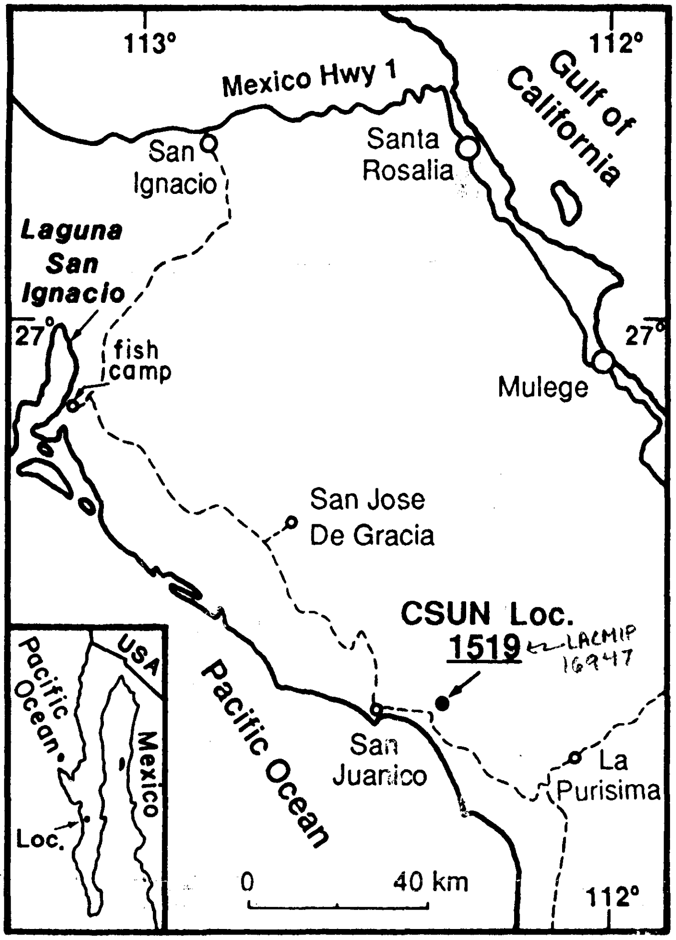

FIGURE 1—Index map to California State University, Northridge collecting locality 1519, Baja California Sur, Mexico. Dashed lines represent unpaved roads.

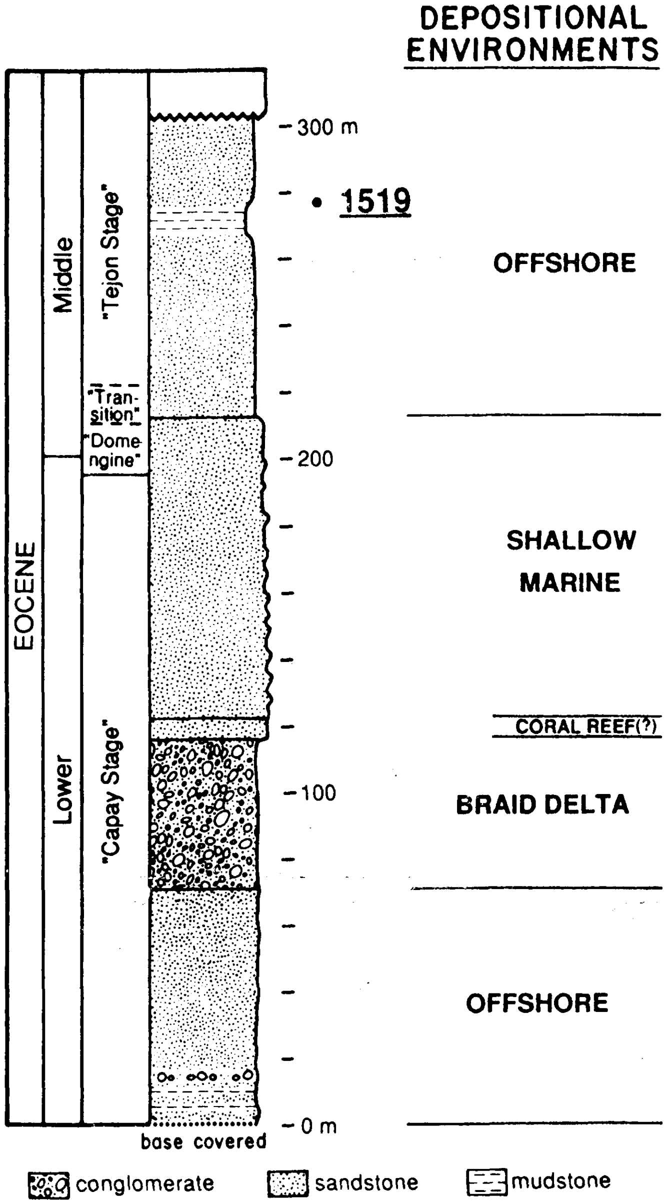

FIGURE 2—Composite columnar section of the Bateque Formation showing Pacific coast of North America provincial stages (from Squires 1987), stratigraphic position of locality CSUN 1519, and depositional environments. Adapted with permission, Contributions in Science, Natural History Museum of Los Angeles County (from Squires and Demetrion, 1992).

et al. (1992) figured a probable representative, *Terebratalia* n. sp.?, from the late early Eocene of Washington State; the occurrence of *Terebratulina* cf. *Terebratulina louisianae* Stenzel, 1940, is one of the earliest for the genus from the west coast of North America. The latter appears close to an Atlantic species described from the southern United States and may have migrated via the Central American seaway to the west coast of North America. It is interesting to speculate that *Terebratalia* an important component of the Tertiary–Recent Pacific brachiopod fauna (e.g., Hatai, 1940), may be one of a number of Eocene immigrants, originating in the Atlantic Ocean.

BRACHIOPOD LOCALITY AND ITS STRATIGRAPHIC SETTING

The brachiopods described in this paper were collected from locality CSUN 1519 (Figure 1) in the upper part of the Bateque Formation (Figure 2) on the Pacific coast of Baja California Sur, Mexico, near the mouth of and on the south side of Arroyo Mezquital, at coordinates 3.6 and 67.4, 1.5 km south and 0.45 km east of the northwest corner of Mexican government 1:50,000 San Isidro (number G12A86) topographic map, 1983. There is a 40-m-high bluff at the locality, which is 0.5 km north of a secondary road that joins about 3 km to the west with the main road between the villages of San Juanico and La Purisima. There is a prominent eastward bend in the main road (near the mouth of Arroyo Mezquital) where these two roads join. The locality is approximately 3 km northeast of where several new taxa of Eocene bivalves were found by Squires and Demetrion (1990b) in the upper part of the Bateque Formation.

Only an 18-m-thick portion of the Bateque Formation is exposed in the immediate vicinity of locality CSUN 1519, and the formation is unconformably overlain by the middle Miocene Isidro Formation, which yielded a new species of clypeasteroid echinoid (Squires and Demetrion, 1993). (For a generalized geologic map of the area, see McLean et al., 1985.) Locality 1519 is near the middle of the 18-m-thick exposure in a 1.5-m-thick interval of very fine grained sandstone that contains scattered lenses of fossiliferous conglomeratic sandstone. Most of the lens-

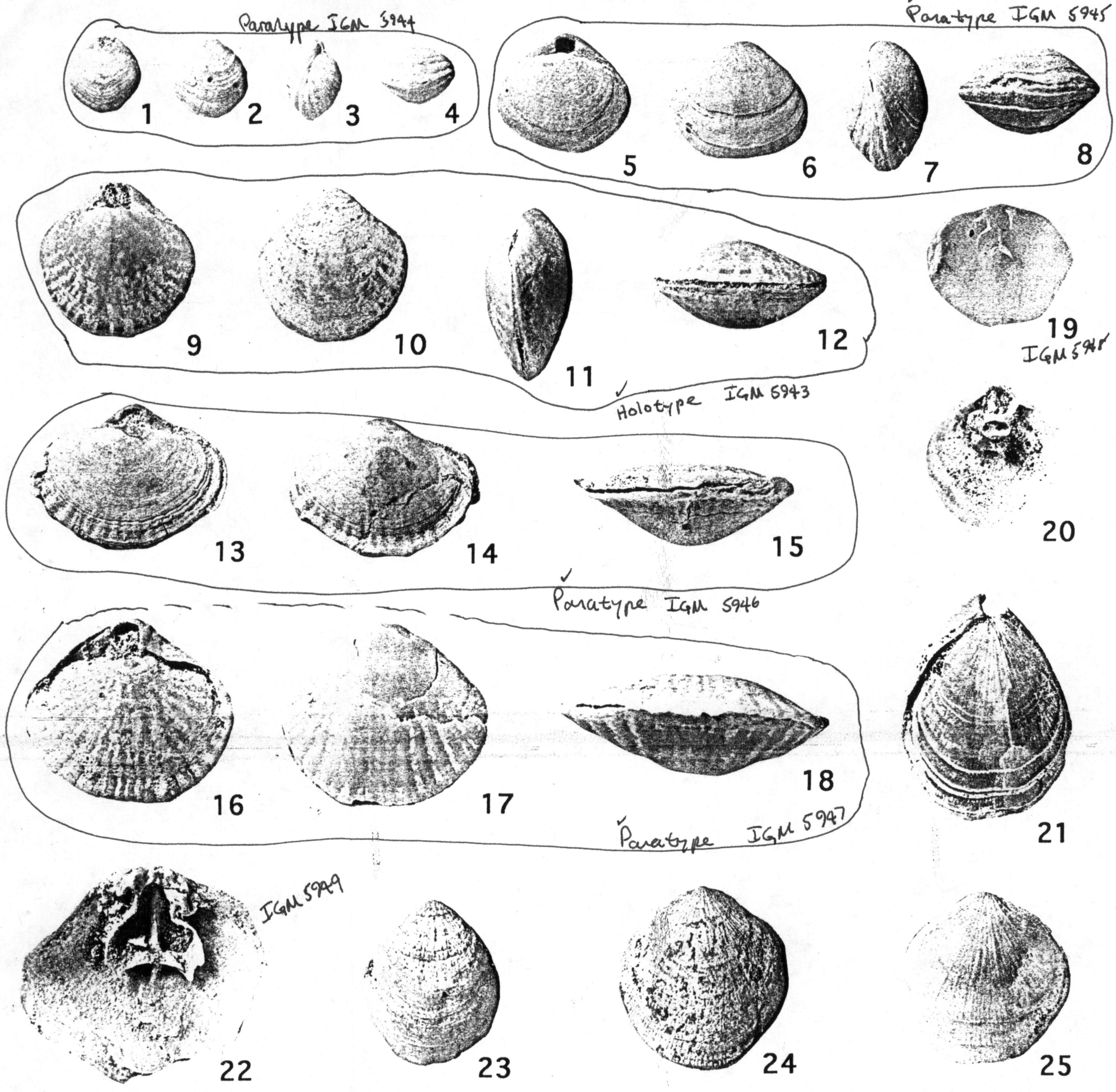

FIGURE *3*—Middle Eocene brachiopods *Terebratalia batequia* n. sp. and *Terebratulina* cf. *Terebratulina louisianae* Stenzel, 1940, from the upper part of the Bateque Formation, near the mouth of Arroyo Mezquital, Baja California Sur, Mexico (Figure 1), locality CSUN 1519. *1–19, 22, Terebratalia batequia* n. sp. *1–4,* paratype, juvenile specimen, brachial, pedicle, lateral, and anterior views, IGM 5944, ×2.5, *2,* pedicle view shows two small borings referable to *Oichnus paraboloides* Bromley, 1981; *5–8,* paratype, immature specimen, brachial, pedicle, lateral, and anterior views, IGM 5945, ×2.5; *9–12,* holotype, specimen with rounded outline, brachial, pedicle, lateral, and anterior views, IGM 5943, ×2.5; *13–15,* paratype, wide specimen, brachial, pedicle, and anterior views, IGM 5946, *13, 14,* ×2.5, *15,* ×2.7; *16–18,* paratype, large, wide specimen, brachial, pedicle, and anterior views, IGM 5947, *16, 17,* ×2.5, *18,* ×3; *19,* brachial valve interior showing partly complete brachidium, IGM 5948, ×2; *22,* brachial valve interior showing partly complete brachidium, IGM 5949, ×3.3. *20, 21, 23–25, Terebratulina* cf. *Terebratulina louisianae* Stenzel, 1940. *20,* brachial valve interior showing partially damaged brachidium, IGM 5938, ×2; *21,* external brachial view, IGM 5939, ×2.2; *23–25,* brachial valve exteriors, *23,* specimen showing signs of nonlethal predation attack just to the right of center of the valve, IGM 5940; *24,* IGM 5941; *25,* IGM 5942, ×2.5.

es are directly above an erosional surface that truncates underlying beds with a slight angular discordance. The conglomerate clasts are very well rounded, up to 10 cm in length, and consist of a dark porphyritic igneous rock. Fossils are most common in the upper parts of the lenses and locally form coquinas. In addition to the brachiopods, there are large benthic foraminifers (*Operculina* sp. aff. *O. cookie* Cushman, 1921a, *Pseudophragmina advena* (Cushman, 1921b), *Lepidocyclina* sp.), bryozoans, bivalves (*Batequeus mezquitalensis* Squires and Demetrion, 1990b, *Pycnodonte* (*Pegma*) *bajaensis* Squires and Demetrion, 1990b, *Cubitostrea mezquitalensis* Squires and Demetrion, 1990b), gastropod molds, and cidaroid echinoid spines. All of these other species are illustrated in the monographic work on the Bateque Formation by Squires and Demetrion (1992). Approximately 50 percent of the specimens of *Terebratalia batequia* n. sp. are articulated. A few of the specimens of the pectinid bivalve *Batequeus mezquitalensis* possess their delicate auricles, and one large (10-cm-long) specimen of the gryphaeid oyster *Pycnodonte* (*Pegma*) *bajaensis* was found articulated.

Underlying the brachiopod-bearing interval is a 10-m-thick section of silty, very fine grained sandstone that is micaceous and bioturbated but contains no macrofossils. At the top of this 10-m-thick section, just below the erosional surface at the base of the brachiopod-bearing interval, there are parallel-laminated beds and locally, abundant vertical or near-vertical burrows. Overlying the brachiopod-bearing interval is a 7-m-thick section of gray mudstone to silty mudstone and macrofossils are rarely present.

Squires and Demetrion (1990a, 1990b, 1992) interpreted that the upper part of the Bateque Formation in the Arroyo Mezquital area was deposited offshore below normal storm wave base and maximum storm wave base, with a large benthic foraminiferal-*Batequeus-Cubiostrea* community living in adjacent waters no deeper than 100 m. The paleoenvironment of the Bateque Formation in the vicinity of locality 1519 is similarly interpreted with one major exception. The community itself is not present, but transported faunal elements of the community make up most of the fossils in the brachiopod-bearing interval. The overall good condition and size-range of these unabraded, complete shells indicates that there was a short distance of post-mortem transport most likely by means of waves and/or currents associated with a large storm. Igneous rock clasts were also transported along with the shells. The articulated brachiopods may have lived among the shell and gravel rubble at locality 1519 whereas the broken specimens underwent post-mortem transport along with the rest of the macrofauna.

Calcareous nannofossils from the upper part of the Bateque Formation in the Arroyo Mezquital area (Squires and Demetrion, 1990a, 1990b, 1992) indicate the middle Eocene *Discoaster bifax* (CP14a) Subzone of Okada and Bukry (1980), which correlates with the Eocene part of the provincial molluscan "Tejon Stage" near the CP13–CP14 boundary (Squires and Demetrion, 1992).

Abbreviations are as follows: IGM = Instituto de Geologiá, Universidad Nacional Autónoma Museum de México, Mexico City; USNM = United States National Museum of Natural History, Washington, D.C.; L = length; W = width; T = thickness.

SYSTEMATIC PALEONTOLOGY

Phylum Brachiopoda Duméril, 1806
Class Articulata Huxley, 1869
Order Terebratulida Waagen, 1883
Suborder Terebratulidina Waagen, 1883
Superfamily Cancellothyridacea Cooper, 1973
Family Cancellothyridae Thomson, 1926
Subfamily Cancellothyridinae Thomson, 1926
Genus Terebratulina d'Orbigny, 1847

Type species.—*Anomia caputserpentis* Linneaus, 1767, p. 1153.

Terebratulina cf. terebratulina louisianae Stenzel, 1940
Figures 3.20, 3.21, 3.23–3.25, 4.3, 4.4

cf. *Terebratulina louisianae* Stenzel, 1940, p. 722, Pl. 34, figs. 10–16.
?*Terebratulina tejonensis waringi* Hertlein and Grant, 1944, p. 77, Pl. 5, figs. 12–16, 21.

Description.—Elongate overall outline, brachial valves circular to elongate outline; brachial valve gently convex to inflated profile; large, rounded pedicle foramen, disjunct deltidial plates; anterior commissure incipiently to broadly uniplicate; ornament of numerous fine, bifurcating ribs; simple ring-like brachidium.

Discussion.—Specimens are all incomplete but exhibit typical characteristics of the genus *Terebratulina,* which are internally a simple calcareous loop and externally an ornament of fine ribbing.

The Mexican specimens are very similar in outline and style of ribbing to *Terebratulina louisianae* Stenzel, described from near the base of the Cane River Formation of Louisiana, and therefore tentatively assigned to this species. Dockery (1986, fig. 1) reported the chronostratigraphic position of the Cane River Formation straddles the lower Eocene–middle Eocene boundary.

In size and outline, the specimens are comparable with other species of *Terebratulina* recorded from Paleogene strata of California. *Terebratulina tejonensis* Stanton, 1896, from the upper Paleocene through middle Eocene, appears to be more coarsely ribbed (Hertlein and Grant, 1944, p. 75–77, Pl. 5, figs. 5, 6, and text-fig. 19) than *Terebratulina* cf. *Terebratulina louisianae.* The pedicle valve of *Terebratulina tejonensis* is sulcate (Hertlein and Grant, 1944, p. 76), as in the few Mexican specimens, which show a corresponding deflection of the anterior commissure of the brachial valves. One of the brachial valves of *Terebratulina* cf. *Terebratulina louisianae* is inflated. It shows signs of a non-lethal predation attack (Figure 3.23). *Terebratulina honsyuensis* Nomora and Hatai, 1936 (in Hatai, 1940, p. 243, Pl. 2, figs. 29, 30) from the Miocene of Japan is very similar to *Terebratulina tejonensis* Stanton, 1896 (Hatai, 1940, p. 244). *Terebratulina tejonensis waringi* Hertlein and Grant (1944, p. 77–79, Pl. 5, figs. 12–16, 21) from the middle Eocene of California appears to be very similar to the material from Baja California Sur, Mexico, having a rounded brachial valve, with fine ribbing. Further investigation of Eocene representatives of described species of *Terebratulina* is necessary to determine if *Terebratulina louisianae* and *Terebratulina tejonensis waringi* are synonymous. *Terebratulina washingtoniana* Weaver, 1942 (and in Hertlein and Grant, 1944, p. 83–84, Pl. 5, figs. 11, 17, 18), recorded from the middle Eocene of Washington State, U.S.A., appears very similar to *Terebratulina tejonensis waringi,* having a finely ribbed ornament and circular brachial valve. Hertlein and Grant (1944, p. 83) indicated that Weaver's species may be synonymous with forms previously described from California. Also relevant here are the forms recently figured by Squires et al. (1992, Pl. 1, figs. 6–8, Pl. 2, figs. 1–6) of *Terebratulina ungulica weaveri* Hertlein and Grant, 1944, from the late early Eocene of Washington State.

The rounded outline of the brachial valve and fine ribbing distinguish *Terebratulina* cf. *Terebratulina louisianae* from the Eocene–Miocene forms described by Cooper (1979) from Cuba. Cooper (1979) indicated that the brachidium of *Terebratulina*? *palmeri* Cooper from the Miocene of Cuba differed significantly from that in *Terebratulina.* The relatively coarse ornament and small size of *Terebratulina*? (Cooper, 1971) from the Eocene of Tonga makes a direct relationship with the Mexican specimens unlikely.

More recently Cooper (1988) revised and described a number of species of *Terebratulina* from the Paleocene of the East Coast of the United States. *Terebratulina alabamensis* Cooper (1988,

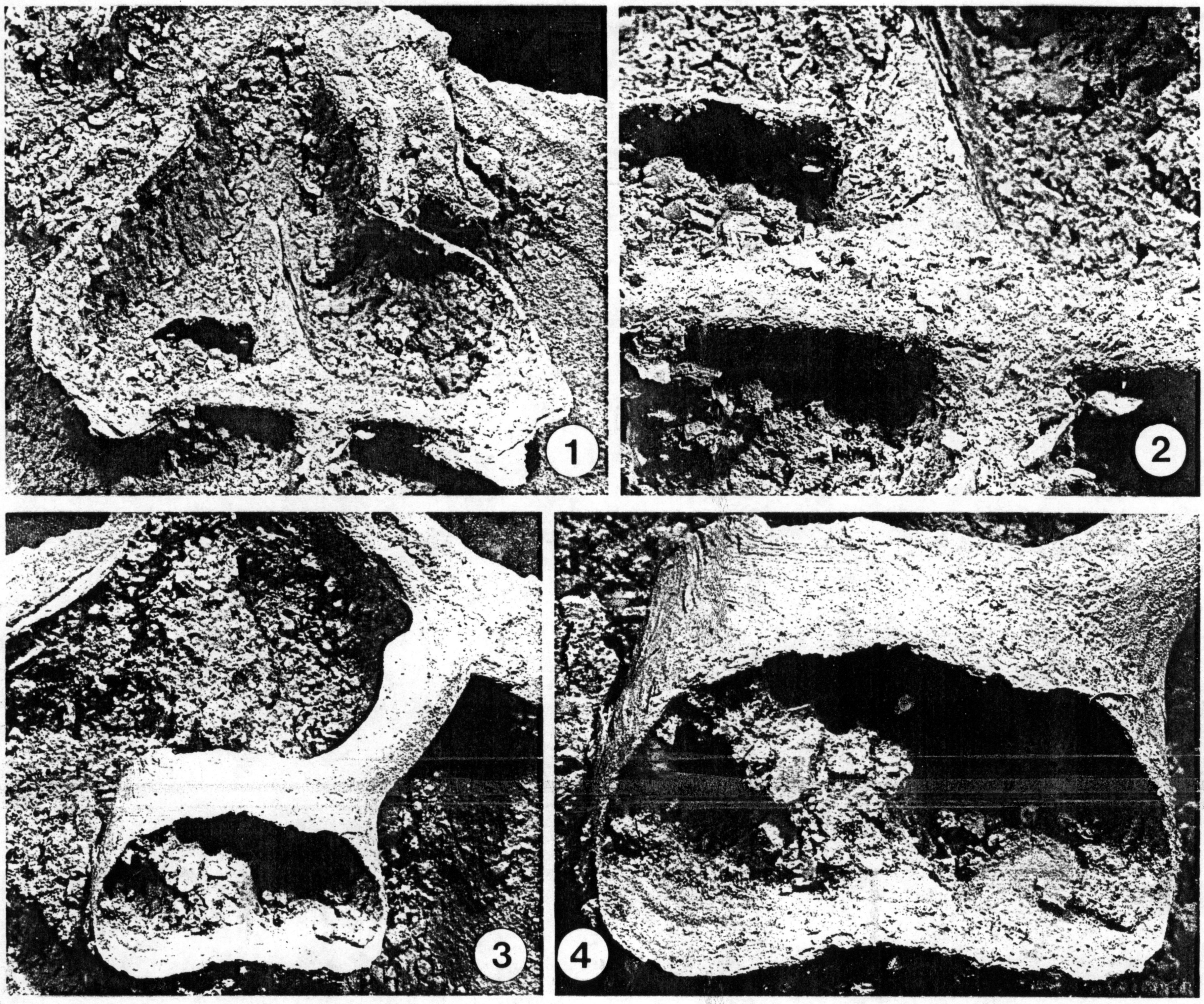

FIGURE 4—Scanning electron micrographs of brachidia of Bateque Formation brachiopods, from the upper part of the Bateque Formation, near the mouth of Arroyo Mezquital, Baja California Sur, Mexico (Figure 1), locality CSUN 1519. *1, 2, Terebratalia batequia* n. sp., IGM 5949. *1,* general view of damaged brachidium, specimen tilted, ×17; *2,* close up of junction between median septum and lateral branches, ×45. *3, 4, Terebratulina* cf. *T. louisianae* Stenzel, 1940, IGM 5938. *3,* general view of damaged brachidium, with left crus broken off, ×20; *4,* close up of loop, with growth lamellae visible, ×40. Specimens were gold coated for photography.

p. 7, Pl. 6, figs. 5–13) from the Oligocene of Alabama is very similar to *Terebratulina* cf. *Terebratulina louisianae,* but is rectimarginate. *Terebratulina brundidgensis* Aldrich, 1907 (in Cooper, 1988, p. 8, Pl. 1, figs. 9–14, Pl. 3, figs 1–4, 16–19), from the Paleocene of Alabama is more elongate and with coarser ribbing than *Terebratulina* cf. *Terebratulina louisianae.* Both *Terebratulina capillata* Cooper (1988, p. 8, Pl. 3, figs. 37–41, Pl. 5, figs. 7–11, 29–40) from the Eocene of North Carolina and *Terebratulina lachryma* (Morton, 1833) (in Cooper, 1988, p. 9, Pl. 1, fig. 16, Pl. 3, figs. 11–15, Pl. 5, figs. 26–28, Pl. 6, figs. 14–28) from the Eocene of South Carolina possess a more oval outline than the Bateque specimens. The brachial valve of *Terebratulina wilsoni* Cooper (1988, p. 10, Pl. 1, fig. 15, Pl. 6, figs. 29–36) from the Eocene of South Carolina has an oval outline, although the species appears very similar to *Terebratulina* cf. *Terebratulina louisianae.* Most of the species of *Terebratulina* for which Cooper (1988) was able to illustrate the brachidium show delicate crura supporting the loop, unlike the stout crura of *Terebratulina* cf. *Terebratulina louisianae* (Figures 3.20, 4.3), although *Terebratulina brundidgensis* Aldrich (Cooper, 1988, Pl. 1, fig. 14) is an exception. Owing to the juvenile status of the material described by Toulmin (1940) as *Terebratulina* sp. from the Salt Mountain limestone, early Eocene, Alabama, it is difficult to make a detailed comparison with the material from Mexico.

Material.—Five specimens: four brachial valve fragments and one pedicle valve fragment, IGM 5938–5942. Maximum brachial valve length approximately 17 mm.

Occurrence.—Locality CSUN 1519, Baja California Sur, Mexico, upper part of Bateque Formation, middle Eocene.

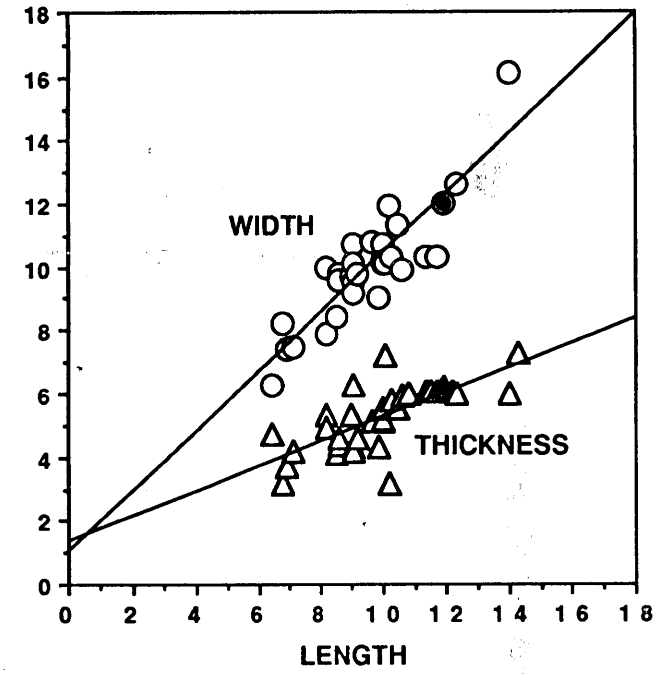

FIGURE 5—Graph showing length vs. thickness (triangles), and length vs. width (circles) for *Terebratalia batequia* n. sp. Black triangle and circle represent holotype. 38 specimens measured: IGM 5943–5947, 5950, USNM 476730. Dimensions in mm. Correlation coefficient for length vs. thickness = 0.512, for length vs. width = 0.779.

Suborder TEREBRATELLIDINA Muir-Wood, 1955
Superfamily TEREBRATELLACEA King, 1850
Family LAQUEIDAE Thomson, 1927,
emended Richardson, 1975
Subfamily TEREBRATALIINAE Richardson, 1975
Genus TEREBRATALIA Beecher, 1893

Type species.—*Terebratula transversa* Sowerby, 1846, p. 94.

TEREBRATALIA BATEQUIA n. sp.
Figures 3.1–3.19, 3.22, 4.1, 4.2, 5

v ?*Terebratalia* n. sp.? SQUIRES, GOEDERT, AND KALER, 1992, Pl. 1, figs. 9–11.

Diagnosis.—Biconvex profile, rounded to elliptical outline; wide hinge line; erect beak, large pedicle foramen, disjunct deltidial plates; ornament of broad, non-bifurcating ribs; crenulate commissure, anterior commissure weakly sulcate.

Description.—Biconvex profile, outline rounded to elliptical, ranging from length and width approximately equal to width greater than length; hinge line wide; beak erect, beak ridges subangular, large pedicle foramen, disjunct deltidial plates; point of maximum width in posterior half of valve length; ornament of broad, non-bifurcating ribs, developed over anterior of valves (half to three-quarters of valve surface), neanic stage generally smooth; ribbing not significantly raised above valve surface; crenulate commissure, anterior commissure weakly sulcate; a very weak, broad sulcation present on pedicle valve, defined by two slightly prominent ribs; growth lines well marked; punctate; internal structures of brachial valve include cardinal process and brachidium with lateral connecting bands joining with median septum; rudimentary dental lamellae in pedicle valve.

Discussion.—A review of the literature has not revealed a named species of *Terebratalia* with an ornament of broad, non-bifurcating ribs comparable to that of *Terebratalia batequia* n. sp. Therefore the material from Baja California Sur, Mexico, is referred to a new species. The extant species *Terebratalia transversa* has bifurcating and more strongly developed ribs than in *Terebratalia batequia* n. sp. There is considerable variation in outline and development of ribbing in *Terebratalia batequia* n. sp. This is interpreted as intraspecific variation. Schumann (1991) recently indicated a broad range of morphotypes, from ribbed to smooth forms, for Recent specimens of *Terebratalia transversa* from the San Juan Islands, U.S.A. *Terebratalia* n. sp.? (Squires et al., 1992, Pl. 1, figs. 9–11) from the early Eocene of Washington State appears to possess non-bifurcating ribs. The apparently smooth "fold" in the brachial valve of the figured specimen from Washington State may be a matter of preservation. This form is very likely closely related to *Terebratalia batequia* n. sp.

Specimens of the new species range from forms in which length and width are approximately equal to forms in which width is greater than length (Figure 5). Some asymmetry of outline is shown, indicating crowding during growth. Small rotund juvenile(?) forms are also present (Figure 3.1–3.4). The size-range of complete (two-valved), measured specimens indicates that they may be close to representing a biocoenosis. A number of specimens show shell repair from nonlethal predatory attacks. In addition, borings referable to *Oichnus paraboloides* Bromley, 1981 (e.g., Figure 3.2), and possible *Podichnus* sp. Bromley and Surlyk, 1973, were seen. Epifauna observed on two specimens includes *Serpula batequensis* Squires and Demetrion, 1992.

In a few specimens of *Terebratalia batequia* n. sp. the median septum and attached lateral branches of the trabecular loop (Richardson, 1975 = terebrataliform) are preserved (Figures 3.19, 3.22, 4.1, 4.2). The ascending branches and transverse band of the brachidium have not been seen.

Material.—Holotype, IGM 5943 (Figure 3.9–3.12), dimensions: L 11.9; W 12.0; T 6.2 mm; paratypes, IGM 5944–5950; comparative non-type, non-figured material, USNM 476730; locality and horizon as for holotype. In total, 178 specimens comprising: 85 articulated specimens; separate valves, some fragmentary, 33 brachial valves, and 61 pedicle valves; additional fragmentary material; locality and horizon as for holotype.

5 specimens retained for LACMIP coll = LACMIP 12324

Etymology.—Named after the Bateque Formation from which the specimens were collected.

Occurrence.—Locality CSUN 1519, Baja California Sur, Mexico, upper part of Bateque Formation, middle Eocene = type locality.

= LACMIP loc 16947 (Non figured paratypes)

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