J. Paleont., 68(4), 1994, pp. 846–851

0022-3360/94/0068-0846$03.00

A NEW SPECIES OF THE OLIGOPYGOID ECHINOID *HAIMEA* FROM THE LOWER EOCENE OF BAJA CALIFORNIA SUR, MEXICO

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ABSTRACT—The oligopygoid echinoid *Haimea bajasurensis* n. sp. is described from middle lower Eocene ("Capay Stage") shallow-marine sandstones in the middle part of the Bateque Formation and shallow-marine limestones in the upper part of the Tepetate Formation, Baja California Sur, Mexico. The new species is both the earliest and the westernmost oligopygoid, and the first occurrence of *Haimea* in North America.

INTRODUCTION

OLIGOPYGOIDS ARE an extinct group of Eocene irregular echinoids that early workers classified as either cassiduloids or holectypoids. Wagner and Durham (1966) assigned them to the holectypoids, a group that is regarded by most workers as transitional between regular and irregular echinoids. Kier (1967) erected the order Oligopygoida because oligopygoids differ from cassiduloids by lacking phyllodes, by having demiplates at the ambitus, and by having a well-developed lantern in adults. Oligopygoids differ from holectypoids by having petaloids and by lacking phyllodes. Kier (1967, 1970, 1974) also recognized that oligopygoids are closely related to clypeasteroids (sand dollars) and that the most striking similarity between the two groups is the lantern. Mooi (1990) showed that oligopygoids are the sister group to the clade containing both the order Clypeasteroida A. Agassiz, 1872, and the enigmatic Paleocene genus *Togocyamus* Oppenheim, 1915.

In the order Oligopygoida Kier, 1967, there is only one family, the Oligopygidae Duncan, 1889, and two genera *Haimea* Michelin, 1851 [=*Pauropgyus* of Arnold and Clark, 1927] and *Oligopygus* de Loriol, 1888. *Haimea* is similar in all its characters to *Oligopygus* except that in *Oligopygus* the opening of the peristome is circular to irregular in shape, is usually situated in a deep transverse trough, and is not surrounded by bourrelets. Furthermore, the sutures are corrugated in *Oligopygus,* whereas they are smooth in *Haimea.* Previously, *Haimea* was known from middle to upper Eocene rocks in Trinidad, Bonaire, St. Bartholomew, Anguilla, Jamaica, Cuba, Senegal (northwest Africa), and Peru (Kier, 1967). Recent field work by the authors resulted in the discovery of *Haimea* in lower Eocene rocks of two formations in Baja California Sur, Mexico. One is the Bateque Formation of Mina (1956, 1957), southeast of San Ignacio Lagoon on the Pacific coast of Baja California Sur (Figure 1). McLean et al. (1985) mapped the Bateque Formation in this area, and the only macropaleontologic work on the formation was by Squires and Demetrion (1989, 1990a, 1990b, 1992) and Squires (1990a, 1990b, 1990c, 1992). Squires and Demetrion (1992) also included an analysis of the depositional environments of the formations, which ranges in age from middle early Eocene ("Capay Stage") to late middle Eocene ("Tejon Stage"), on the basis of calcareous nannofossils, planktonic foraminifers, and mollusks, and consists of shallow-marine deposits locally rich in macroinvertebrates. *Haimea bajasurensis* n. sp. specimens were found in the middle part ("Capay Stage") of the formation at CSUN locs. 1470, 1546, 1547, 1549, and 1550 (Figure 1A). Specimens were recovered from lenses of channel-lag, short-distance storm accumulations at all of these localities. The lenses are about 50 cm thick, usually consist of concentrations of various bivalves in yellow, very fine grained sandstone, and are surrounded by bioturbated and barren very fine grained sandstone. Only a few specimens of *Haimea bajasurensis* were found in these lenses, except at locality 1547 where 10 specimens (that represent a partial size series) were collected.

The other *Haimea*-bearing formation in Baja California Sur is the Tepetate Formation of Heim (1922) in Arroyo Conejo, northwest of the city of La Paz (Figure 1). Knappe (1974) mapped the Tepetate Formation in this area and reported the age of the deposits to range from early Eocene to earliest middle Eocene, on the basis of planktonic and benthic foraminifers. *Haimea bajasurensis* n. sp. specimens were found in the uppermost part ("Capay Stage") of the formation at CSUN loc. 1492 (Figure 1B). This part of the formation is temporally correlative to the middle part ("Capay Stage") of the Bateque Formation, on the basis of shallow-marine macrofossil species (Squires and Demetrion, 1991; Squires, 1992). Microfossil samples from locality 1492 were analyzed for calcareous nannofossils but proved to be barren (M. V. Filewicz, personal commun.). At locality 1492, there is only a 25-m-thick, cliff-face exposure of the Tepetate Formation consisting of pseudophragminid foraminifer-rich, white limestone with scattered specimens of shallow-marine mollusks and *Haimea bajasurensis.* The limestone beds are several meters thick, channelized, bioturbated (including vertical *Ophiomorpha* burrows in places), and locally high-angle crossbedded and laminated. The beds are interpreted as having been deposited by storm processes in a shallow-water environment with bioturbation taking place during fair-weather times. Many of the pseudophragminids and shallow-marine mollusks are broken but not abraded. Both types of fossils are interpreted as having been transported only a short distance during the storms. According to Vaughan (1945), pseudophragminids (=discocyclinids) lived in very shallow, tropical waters below tide level to perhaps 100 m. The abundance of pseudophragminids in the deposits at locality 1492 is similar to that found by Squires and Demetrion (1992) in shallow-marine deposits of the Bateque Formation and that found by Squires (1984) in shallow-marine deposits of the Llajas Formation, Simi Valley, southern California. In both of these formations, the pseudophragminid-bearing beds were deposited by storm-influenced and fair-weather-influenced sedimentary processes.

Nearly all the specimens of *Haimea bajasurensis* at locality 1492 are complete and form a fairly complete size series (ranging from 8 to 28.7 mm in length), indicating that post-mortem transport was minimal. Oligopygoids were probably epibenthic to shallow burrowing (Carter et al., 1989) and used their lantern to break up ingested substrate particles much as clypeasterines today (Mooi, 1990). The specimens of *H. bajasurensis* at locality

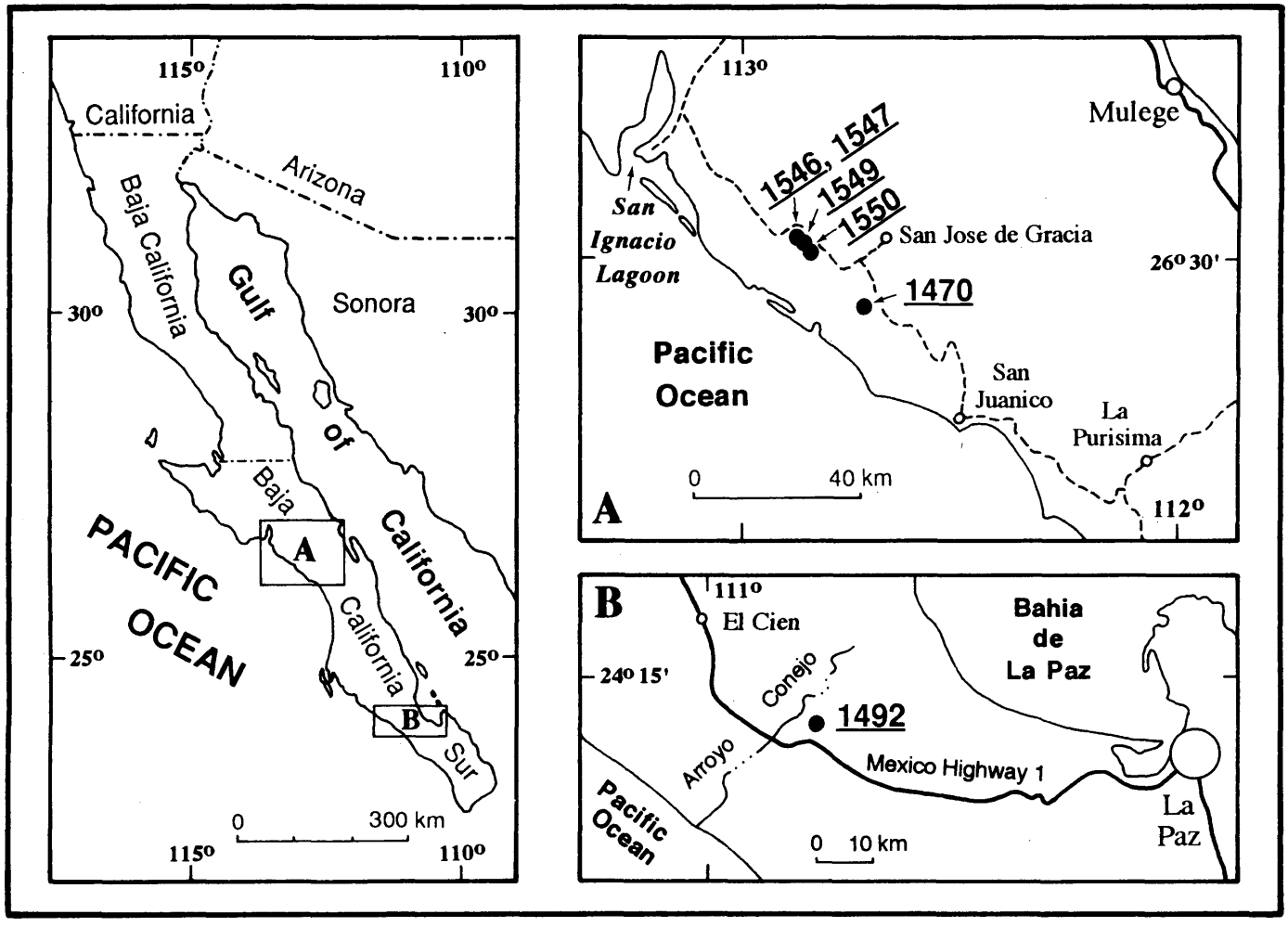

FIGURE 1—Index map to California State University, Northridge collecting localities, Baja California Sur, Mexico. A, Bateque Formation; B, Tepetate Formation.

1492 most likely lived among the pseudophragminid debris during fair-weather times. Many of the specimens of *H. bajasurensis* were found in talus along the base of the cliff as individuals free of any rock matrix. Rare specimens are hollow and cutting them open revealed their lantern supports. No lantern fragments were found, and this suggests that some post-mortem transport must have moved the tests around enough to shake the disarticulated lanterns out through the peristome and periproct.

Abbreviations used for catalog and/or locality numbers are: CSUN, California State University, Northridge; IGM, Instituto de Geología, Universidad Nacional Autónoma de México, Mexico City; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section. The type specimens are housed at IGM; plaster casts of the types are housed at LACMIP.

SYSTEMATIC PALEONTOLOGY

Order OLIGOPYGOIDA Kier, 1967
Family OLIGOPYGIDAE Duncan, 1889
Genus HAIMEA Michelin, 1851

Type species.—By original designation, *Haimea caillaudi* Michelin, 1851; fide Kier (1967) from upper Eocene of Jamaica.

HAIMEA BAJASURENSIS n. sp.
Figure 2.1–2.9

Echinolampas? sp. A SQUIRES AND DEMETRION, 1992, p. 45, figs. 135–136.

Diagnosis.—A *Haimea* with a moderately high test, petaloids I, II, IV, and V extending 60 percent of distance from apical margin to ambitus, petaloids with a narrow interporiferous zone, and ambulacra beyond petaloids with pores in single series along adradial sutures.

Description.—Small to medium sized (smallest specimen 8 mm long, 7.2 mm wide, 6 mm high; largest specimen, slightly crushed, 28.7 mm long, 25.9 mm wide, 16.1 mm high); test slightly ovate, greatest width at apical system, width varying from 80 to 89 percent (average 86 percent) of length; aboral surface very slightly convex to almost flat; test moderately high, greatest height at apical system, height varying from 62 to 78 percent (average 69 percent) of length; sides very steep, oral surface flat with peristome slightly depressed; apical system central, four genital pores, anterior pair closer than posterior, pores located within madreporite, pores not present in smallest specimens, pores first appear in specimens 10.8 mm long, pores large and ovate on some specimens, small and circular in others, probably indicating sexual difference; petaloids well developed, flush with test to very slightly elevated; petaloid III longest,

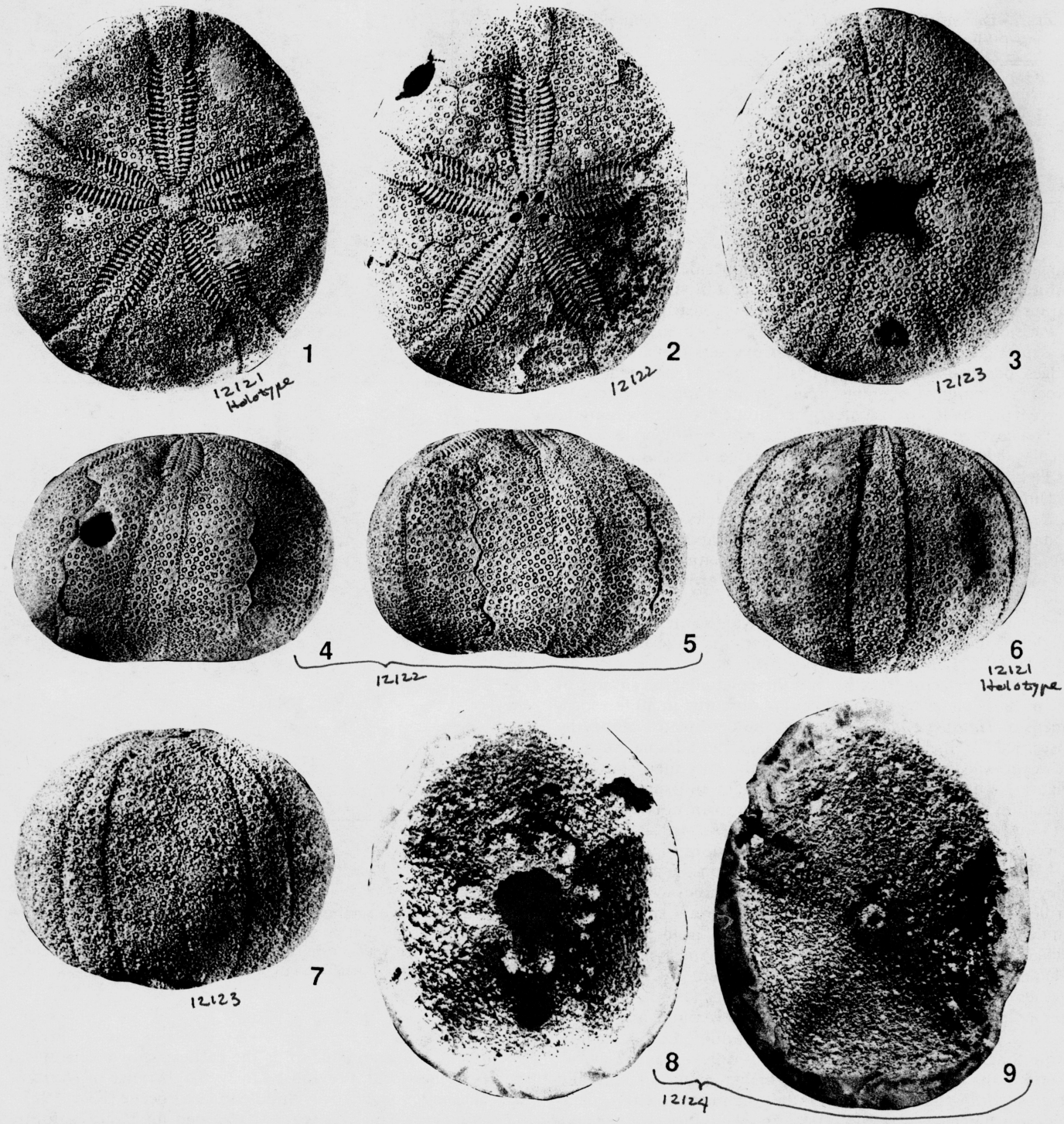

FIGURE 2—*1–9, Haimea bajasurensis* n. sp., CSUN loc. 1492. *1,* holotype, IGM 5934, aboral view, ×3.5; *2,* paratype, IGM 5935, aboral view, ×3.2; *3,* paratype, IGM 5936, oral view, ×4.5; *4, 5,* paratype, IGM 5935, ×2.7; *4,* left side; *5,* right side; *6,* holotype, IGM 5934, anterior view, ×3.5; *7,* paratype, IGM 5936, posterior view, ×4.5; *8, 9,* paratype, IGM 5937, ×3.5; *8,* lower interior showing lantern supports; *9,* upper interior.

extending approximately two-thirds of distance from apical margin to ambitus, other petaloids extending only 60 percent of this distance; straight, open, pore pairs conjugate, interporiferous zone at greatest width at extremity of petaloid, slightly narrower than poriferous zone on specimens with large and ovate genital pores, slightly wider than poriferous zone on specimens with small and circular genital pores; petaloid III with two to three more pore-pairs in poriferous zone than petaloids II and IV; interambulacra two columns in each area, wider than ambulacra; plate sutures smooth; interambulacra at the peristome slightly externally inflated and form bourrelets.

Beyond petals and extending to peristome, ambulacra with

TABLE 1—Dimensions (in mm) of the type specimens of *Haimea bajasurensis* n. sp.

IGM specimen	Length	Width	Height
5918	*	17.5	10.9
5934	18.0	15.7	11.6
5935	19.7	16.8	13.8
5936	13.7	12.0	9.5
5937	19.5	15.6	13.6

* Incomplete specimen.

single series of closely spaced, pores alongside each adradial suture; area between adradial sutures widest in vicinity of maximum curvature of ambitus and converging near peristome.

Peristome central, pentagonal, slightly wider than long, slightly depressed; perignathic girdle with five sets of paired small ridges, posterior support (apophyses) the most elevated; periproct inframarginal, opening circular, located approximately 75 percent of distance from center of peristome to posterior margin.

Test covered with small, irregularly arranged tubercles; scrobicules deep with vertical sides; boss large, extending upward as high as surrounding surface of test.

Dimensions of type specimens in Table 1.

Remarks.—Out of 137 collected specimens, 49 are totally complete, show no indications of crushing, and are free of matrix. The length-width and length-height relationships of these 49 specimens, which are from the Tepetate Formation at locality 1492, are plotted in Figure 3. There is little variation in the length-width ratio, but there is a fairly wide scatter of points in the length-height ratio. These same patterns have been noted by Kier (1967) for other species of *Haimea*.

In the ambulacral areas beyond the petaloids, the sutures of the primary plates and demiplates are obscured in all the specimens of *Haimea bajasurensis*, and the demiplates cannot be discerned. A single series of pores along the adradial sutures, however, can be readily seen, as on the specimen shown in Figure 2.4 and 2.5. The plate arrangement and sutures of the structures that form the lantern supports also are not discernible.

Approximately half of the specimens of *Haimea bajasurensis* have holes in them like the specimen shown in Figure 2.2 and 2.4. The holes are on the dorsal surface or on the ambitus, but they are never on the ventral surface. These holes were probably drilled by predatory naticid gastropods. Several specimens of unidentifiable naticid gastropods were found at locality 1492.

The new species was compared to all previously known and adequately defined species of *Haimea*. There are 13 of these species, and they are monographed in Kier (1967). The new species is most like *Haimea parvipetala* (Arnold and Clark, 1927, p. 38, Pl. 5, figs. 13–15) from the middle Eocene Yellow Limestone in Jamaica. The new species differs from *H. parvipetala* in the following features: test higher, greatest height and greatest width at apical system rather than anterior to it, petaloids much narrower, petaloid III with two to three (rather than four to seven) more pore-pairs than petaloids II and I, and periproct inframarginal rather than submarginal.

Haimea bajasurensis n. sp. is the westernmost and northernmost *Haimea* in the world. Previously, the western limit of this genus was in Cuba and Peru along the 80th parallel west of Greenwich, and its northern limit was in Cuba (Kier, 1967). The presence of *Haimea* in Baja California Sur, Mexico, extends its western limit by 925 km and the northern limit by 100 km. *Haimea bajasurensis* is also the westernmost oligopygoid anywhere in the world. Previously, the only other oligopygoid genus, *Oligopygus*, was reported as far west as southeastern Mexico (Kier, 1967).

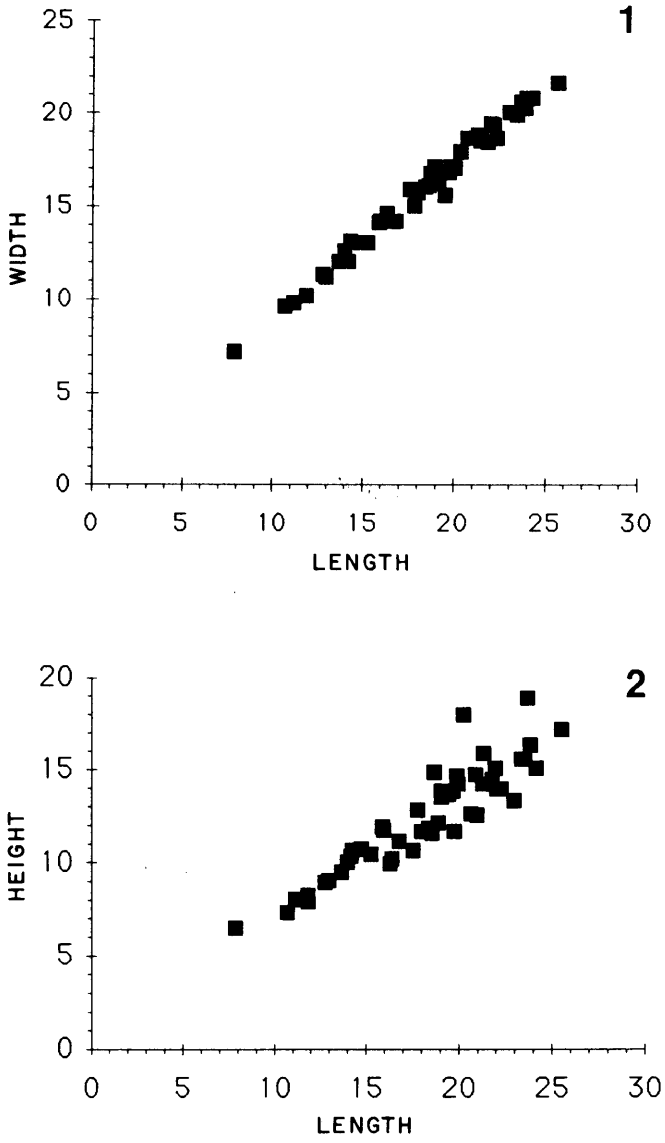

FIGURE 3—Scatter diagrams showing relationships of test dimensions (in mm) of the 49 best preserved specimens of *Haimea bajasurensis* n. sp. from the Tepetate Formation at CSUN loc. 1492. *1*, length relative to width; *2*, length relative to height.

Haimea bajasurensis n. sp. is the earliest known oligopygid species in the world. Previously, the geologic range of *Haimea*, like that of *Oligopygus*, was middle to late Eocene (Kier, 1967).

Etymology.—The new species is named for Baja California Sur.

Material.—One hundred twenty specimens from the Tepetate Formation; 17 specimens from the Bateque Formation. Paratype, IGM 5918 (formerly hypotype, IGM 5918 in Squires and Demetrion, 1992, figs. 135, 136) = plastoparatype, LACMIP 12120; holotype, IGM 5934 = plastoholotype, LACMIP 12121; paratypes, IGM 5935 through 5937 = plastoparatypes, LACMIP 12122 through 12124.

Occurrence.—Baja California Sur, Mexico, middle lower Eocene ("Capay Stage"): Bateque Formation, CSUN locs. 1470, 1546, 1547, 1549, and 1550; Tepetate Formation, CSUN loc. 1492 = type locality.

ACKNOWLEDGMENTS

Maria del Carmen Perrilliat (Instituto de Geología, Universidad Nacional Autónoma de México) arranged for paleontologic collecting in Baja California Sur and graciously provided type-specimen numbers. LouElla R. Saul (Natural History Museum of Los Angeles County, Invertebrate Paleontology Section) allowed access to the collections for studying comparative specimens of *Haimea* from Cuba. Sherman Suter (Natural History Museum of Los Angeles County, Echinoderm Section) provided taxonomic insights and important references. Jann Thompson (Smithsonian Institute) provided a key reference. Rich Mooi (California Academy of Sciences, San Francisco) critically reviewed an early draft of the manuscript. Burchard D. Carter (Georgia Southwestern University) and Louis G. Zachos (Austin, Texas) gave very useful reviews, and their suggestions greatly improved the manuscript. Mark V. Filewicz and Roy Fulwider (Unocal Corporation, Ventura, California) processed and analyzed microfossil samples. George E. Davis (California State University, Northridge) shared his knowledge of computer software.

REFERENCES

AGASSIZ, A. 1872 [1872–1874]. Revision of the Echini. Memoirs of the Museum of Comparative Zoology, 3:383–762.

ARNOLD, B. W., AND H. L. CLARK. 1927. Jamaican fossil Echini; with descriptions of new species of Cainozoic Echinoidea by Herbert L. Hawkins. Memoirs of the Museum of Comparative Zoology at Harvard College, 50:1–84.

CARTER, B. D., T. H. BEISEL, W. B. BRANCH, AND C. M. MASHBURN. 1989. Substrate preferences of late Eocene (Priabonian/Jacksonian) echinoids of the eastern Gulf Coast. Journal of Paleontology, 63:495–503.

DUNCAN, P. M. 1889. A revision of the genera and great groups of the Echinoidea. Journal of the Linnean Society of London, Zoology, 23:1–311.

HEIM, A. 1922. Notes on the Tertiary of southern Lower California (Mexico). Geological Magazine, 59:529–547.

KIER, P. M. 1967. Revision of the oligopygoid echinoids. Smithsonian Miscellaneous Collections, 152:1–149.

——. 1970. Lantern support structures in the clypeasteroid echinoids. Journal of Paleontology, 44:98–109.

——. 1974. Evolutionary trends and their functional significance in the post-Paleozoic echinoids. Journal of Paleontology, 48 (supplement 5):1–95.

KNAPPE, R., JR. 1974. The micropaleontology of a section of the Tepetate Formation and a paleobiogeographic comparison with equivalent foraminifera along the west coast of the United States. Unpubl. M.S. thesis, Ohio University, Athens, 114 p.

LORIOL, P. DE. 1888. Notes pour servir a l'étude des échinodermes. Recueil Zoologique Suisse, Genève, série 1, 4:365–407.

MCLEAN, H., B. P. HAUSBACK, AND J. H. KNAPP. 1985. Reconnaissance geologic map of part of he San Isidro quadrangle, Baja California Sur, Mexico. U.S. Geological Survey, Miscellaneous Field Studies Map MF-1799, scale 1:125,000.

MICHELIN, H. 1851. Description de quelques nouvelles espéces d'Echinides. Revue de Magasin de Zoologie Pure et Appliquee, Paris, série 2, 3:92–93.

MINA, F. 1956. Bosquejo geológico de la part sur de la peninsula de Baja California. Twentieth International Geological Congress, Excursion A-7:1–77.

——. 1957. Bosquejo geológico del Territorio Sur de la Baja California. Asociacíon Mexicana de Geólogos Petroleros, Boletín 9:139–269.

MOOI, R. 1990. Paedomorphosis, Aristotle's lantern, and the origin of the sand dollars (Echinodermata: Clypeasteroida). Paleobiology, 16:25–48.

OPPENHEIM, P. 1915. Die eocäne Invertebraten-Fauna des Kalksteins in Togo. Beiträge zur geologischen Erforschung der Deutschen Schutzgebiete, 12:1–126.

SQUIRES, R. L. 1984. Megapaleontology of the Eocene Llajas Formation, Simi Valley, California. Natural History Museum of Los Angeles County, Contributions in Science, Number 350, 76 p.

——. 1990a. New Paleogene siliquariid and vermetid gastropods from the Pacific coast of southwestern North America. The Veliger, 33: 286–292.

——. 1990b. First occurrence of the Tethyan bivalve *Nayadina* (*Exputens*) in Mexico, and a review of all species of this North American subgenus. The Veliger, 33:305–316.

——. 1990c. New Paleogene *Fimbria* (Mollusca: Bivalvia) from the Pacific coast of southwestern North America. Journal of Paleontology, 64:552–556.

——. 1992. New occurrences of the malleid bivalve *Nayadina* (*Exputens*) from the Eocene of Jamaica, Mexico, and Washington. The Veliger, 35:133–136.

SQUIRES, R. L., AND R. A. DEMETRION. 1989. An early Eocene pharetronid sponge from the Bateque Formation, Baja California Sur, Mexico. Journal of Paleontology, 63:440–442.

——. 1990a. New early Eocene marine gastropods from Baja California Sur, Mexico. Journal of Paleontology, 64:99–103.

——. 1990b. New Eocene marine bivalves from Baja California Sur, Mexico. Journal of Paleontology, 64:382–391.

——. 1991. Early Eocene macrofaunal comparisons between the Tepetate and Bateque Formations, Baja California Sur, Mexico. Geological Society of America, Program with Abstracts, Annual Meeting, 23:A194.

——. 1992. Paleontology of the Eocene Bateque Formation, Baja California Sur, Mexico. Natural History Museum of Los Angeles County, Contributions in Science, Number 434, 55 p.

VAUGHAN, T. W. 1945. American Paleocene and Eocene larger foraminifera. Geological Society of America, Memoir 9:1–175.

WAGNER, C. D., AND J. W. DURHAM. 1966. Holectypoids, p. U440–U450. *In* R. C. Moore (ed.), Treatise on Invertebrate Paleontology, Part U, Echinodermata 3, Volume 2. Geological Society of America and University of Kansas Press, Lawrence.

ACCEPTED 22 JUNE 1993

APPENDIX

LOCALITIES

CSUN loc. 1470. 40-m elevation, at base of east-facing canyon wall, southeastern end of Mesa La Azufrera, along west side of Arroyo San Juan de Abajo, about 0.75 km west of dirt road from San José de Gracia to El Datilon, at 112°44′W and 26°29.5′N, coordinates 27.35 and 31.20 of Mexican government topographic quadrangle map (scale 1:50,000), Punta Santo Domingo (number G12A74), Baja California Sur, Mexico, 1982. Bateque Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: R. L. Squires and R. A. Demetrion, 1990.

CSUN loc. 1492. Approximately 1.25 km east of Mexico Highway 1 and just north of a dirt road that intersects Mexico Highway 1 at kilometer 74, 140-m elevation on a south-facing cliff face along the north side of a tributary to Arroyo Conejo, at 110°53′50″W and 24°10′N, coordinates 10.75 and 72.55 of Mexican government 1:50,000 topographic quadrangle map, El Conejo (number G12D81), Baja California Sur, Mexico, 1983. Tepetate Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: R. L. Squires and R. A. Demetrion, 1991.

CSUN loc. 1546. 120-m elevation, near middle of east-facing cliff along canyon wall, near north end of Mesa La Azufrera, west side of Arroyo La Tortuga in vicinity of abandoned rancho El Cuarenta, 112°53′13″W, 26°38′55″N, coordinates 12.45 and 48.80 of Mexican government 1:50,000 topographic quadrangle map, San Jose de Gracia (number G12A64), Baja California Sur, Mexico, 1983. Bateque Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: R. L. Squires and R. A. Demetrion, 1992.

CSUN loc. 1547. Immediate vicinity of CSUN loc. 1546 and approximately 5 m stratigraphically upsection.

CSUN loc. 1549. 90-m elevation, just west of dirt road, near base of east-facing cliff along canyon wall, northeast side of Mesa La Azufrera, west side of Arroyo La Tortuga, 112°51′45″W, 26°38′30″N, coordinates 14.75 and 48.10 of Mexican government 1:50,000 topographic quadrangle map, San Jose de Gracia (number G12A64), Baja California Sur,

Mexico, 1983. Bateque Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: R. L. Squires and R. A. Demetrion, 1992.

CSUN loc. 1550. 140-m elevation, just west of dirt road, lower part of east-facing cliff along canyon wall, northeast side of Mesa La Azufrera, west side of Arroyo La Tortuga, 112°51'00"W, 26°37'55"N, coordinates 15.95 and 47.05 of Mexican government 1:50,000 topographic quadrangle map, San Jose de Gracia (number G12A64), Baja California Sur, Mexico, 1983. Bateque Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: R. L. Squires and R. A. Demetrion, 1992.

J. Paleont., 68(4), 1994, pp. 851–860

0022-3360/94/0068-0851$03.00

UPPERMOST WENLOCK AND LOWER LUDLOW PLECTOGRAPTINE GRAPTOLITES, ARCTIC ISLANDS, CANADA: NEW ISOLATED MATERIAL

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ABSTRACT—Beautifully preserved, isolated and uncompressed plectograptine graptolites from the uppermost Wenlock "*Pristiograptus*" *ludensis* Biozone and the lower Ludlow *Lobograptus progenitor* Biozone are described from the Arctic Islands. Described species comprise *Agastograptus robustus* Obut and Zaslavskaya from the *ludensis* and *progenitor* zones; *Agastograptus* sp., *Gothograptus chainos* Lenz, and *Plectograptus* (*Sokolovograptus*?) sp., from the *ludensis* Zone; and *Holoretiolites* (*Balticograptus*) *erraticus* (Eisenack) from the *progenitor* Zone. The dozens of specimens of *A. robustus* from one locality are covered with almost continuous periderm and interthecal tissue, a feature rarely seen in plectograptines.

INTRODUCTION

PLECTOGRAPTINE AND retiolitine (retiolitid) graptolites are particularly well represented and uncommonly well preserved in uncompressed form in graptolite-bearing nodules that occur throughout the Cape Phillips Formation of the central part of the Canadian Arctic Islands (Lenz and Melchin, 1987a, 1987b; Lenz, 1993), and isolated specimens are readily recovered following acid digestion of the nodules. The superb preservation of the retiolitid graptolites, in conjunction with very good stratigraphic control, presents an unparalleled opportunity to better understand these graptolites. A recently completed study of upper Wenlock (Homerian) and lower Ludlow (Gorstian) plectograptines (Lenz, 1993) was a first step in monographing these rich and superbly preserved faunas. Collections subsequently made during the summer of 1991 yielded four species of plectograptines not recovered in the earlier study (Lenz, 1993) and one previously illustrated species that was better preserved. The description of these five species is the purpose of this paper.

The recovery of isolated, uncompressed graptolites is a relatively rare event, but such material contributes much to the understanding of their astogenetic development and morphology. This is especially true in the case of retiolitid graptolites, which can be morphologically very complex. The relationships between the sicula (if present) and thecal development, the relationship of inner and outer rhabdosomal lists, the nature of the thecae, the distribution of primary and secondary skeletal lists, and whether or not the virgula is part of the skeletal anatomy or is free or attached distally can only be determined in isolated specimens. The great advantage of isolated, uncompressed specimens is that they may be readily viewed and studied in three dimensions, and hence the need for the production and use of scanning electron micrograph stereopairs.

LOCATION

Two localities were sampled; these are a southern tributary of Abbott River, northwestern Cornwallis Island, and southernmost Baillie Hamilton Island (localities 1 and 2, respectively, of index map, Figure 1). Locality 1 (75°13.6'N, 95°43'W) comprises two sections, the stratigraphically lower section on the east side of the creek and the higher on the west side, the two being separated by an estimated 2–3 m of covered interval. At locality 2 rocks are well exposed along a single, continuous shore section (75°46'N, 94°22'W), only the upper half of which yielded uncompressed graptolites.

STRATIGRAPHY, BIOSTRATIGRAPHY, AND FAUNAL DISTRIBUTION

The Cape Phillips Formation (Thorsteinsson, 1958) is a graptolite-bearing, basinal-facies unit that is widespread throughout the Arctic Islands. It is well known for the presence of calcarous nodules that yield isolated, uncompressed graptolites, particularly retiolitids (retiolitines and plectograptines) (Lenz and Melchin, 1987a, 1987b; Lenz, 1993). The plectograptines occur in strata ranging in age from late Llandovery through to about mid Ludlow.

Wenlock and Ludlow graptolite biostratigraphy for the Arctic Islands has recently been discussed in Lenz and Melchin (1990, 1991) and Lenz (1990), respectively. Zones relevant to this study are the *Monograptus testis–Cyrtograptus lundgreni* Biozone of late Wenlock (early Homerian), the "*Pristiograptus*" *ludensis* Biozone of latest Wenlock (late Homerian), and the *Lobograptus progenitor* Biozone of early Ludlow (Gorstian) age.

Two sections, section 1 (stratigraphically underlying section 2 by about a 2–3-m interval) and section 2, both from locality 1, Abbott River tributary, expose a nearly complete sequence of upper Wenlock to lower Ludlow rocks, only the Wenlock portion of which has yielded uncompressed graptolites.

The faunas of the two localities and their zonal assignments, from younger to older, are as follows (species with asterisks are those described in this study):

Locality 1, section 2 (Abbott River, south tributary)

30 m—"*Pristiograptus*" *ludensis* (Murchison), "*Pr.*" *sherrardae* (Sherwin) (both species flattened and common)