

Eocene Megafossils from Ishigaki-shima Ryūkyū-rettō

GEOLOGICAL SURVEY PROFESSIONAL PAPER 399-B



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By F. STEARNS MacNEIL

GEOLOGY AND PALEONTOLOGY OF ISHIGAKI-SHIMA, RYŪKYŪ-RETTŌ

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Mollusks and a new subfamily of clypeasteroid echinoids are recorded from the Miyara Formation of Ishigaki-shima, a formation which previously has yielded only Foraminifera



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EOCENE MEGAFOSSILS FROM ISHIGAKI-SHIMA, RYŪKYŪ-RETTŌ

By F. STEARNS MACNEIL

ABSTRACT

A collection of mollusks was obtained from the Miyara Formation (middle Eocene) of Ishigaki-shima in the southern Ryūkyū Islands. Previously only Foraminifera have been reported from the Miyara Formation. The mollusks and the only identified foraminifer suggest an age no older than late early Eocene and probably not as young as latest Eocene.

Eleven species of gastropods, six pelecypods, and one echinoid are recognized in the collection.

Six new species are described: *Lunella miyarensis*, *Turritella kotakai*, *Vicarya ibarumensis*, *Caricella fosteri*, *Terebra miyarensis*, and *Cardium ishigakensis*. *Orthaulax japonicus* Nagao is reassigned to the genus *Ancillopsis* Conrad, and *Hahazimania hahazimensis* Yabe and Hatai is reassigned to the genus *Ampullinopsis* Conrad. *Corbula* (*Corbula*) *subtumida* Nagao is reassigned to the genus *Caryocorbula* Gardner. Unidentified species of *?Mazzalina*, *?Bulla*, *?Scaphander*, *Ostrea*, *?Anomia*, *?Cardita*, *?Myrtea*, and an undescribed family of scutellinid echinoid are recorded.

INTRODUCTION

The discovery of Eocene mollusks on Ishigaki-shima was made in 1948 by Mr. D. E. Flint, of the U.S. Geological Survey, at a locality described as "a conglomerate bed in bedded volcanics just west of the town of Ibaruma." Ibaruma lies in a narrow isthmus connecting two larger parts of a long peninsula at the northeast end of Ishigaki-shima. Only three species were collected by Flint—a *Turritella* (21 specimens), a large *Melanatria* (1 specimen), and a *?Terebra* (1 specimen). A much larger collection was made by Miss H. L. Foster in 1955 during the course of geologic mapping. Most of the additional species came from Flint's discovery locality on the coast, but a hillside inland from the coastal outcrop yielded fossils at six different levels.

Yabe (1920) and Hanzawa (1935) both reported the occurrence of Eocene deposits on Ishigaki-shima and designated them the Miyara Group. The only fossils known to Yabe and Hanzawa were the Foraminifera "*Pellatispira madareszi* (Hantken)," *Camerina* sp., and *Discocyclina* sp. *Pellatispira madareszi* is a European species that has been tentatively identified along with

named subspecies from Indonesia. Umbgrove (1931, p. 83) in commenting on the geologic range of *Pellatispira* said, "The seven species now described from the Eocene of the East Indian Archipelago have all been found in Tert. *b* [upper Eocene]. One species only: *Pellatispira madareszi* var. *provaleae*, was at the same time found in Tert. *a* [lower Eocene]."

Otuka (1939, p. 482) remarked on the probable age of the Miyara Group as follows:

The Miyara group, which is exposed on Isigaki Is., and at Kobama Is. [Obama-jima?], rests on the erosional surface of an intensely folded Paleozoic formation, and is overlain by the Miocene Yaeyama coal-bearing group. This foraminiferous group in the Ryūkyū islands may be upper Eocene, but so far no trace of lower Eocene has ever been reported from there.

Whipple (1932, p. 80) in commenting on the association of *Pellatispira*, *Camerina*, and *Discocyclina* said, "These associations would appear to be rather characteristic of the Tertiary *b* in the Pacific region."

Mollusks from the Miyara Formation, from the degree of evolution and the similarity to things known in formations elsewhere, seem to be of middle or late Eocene age. In the Indonesian twofold division of the Eocene they fall in the Tertiary *b* zone and probably in the lower part of it.

Only one species in the Miyara fauna is identified with a species of restricted occurrence in the Eocene deposits of Kyushu; *Melanatria kahoensis* (Nagao) is known from the Takeya Formation of supposed middle Eocene age. Another species is identified tentatively as *Orthaulax japonicus* Nagao, a species found in the early, middle, and late Eocene of Kyushu. This species is reassigned tentatively to the genus *Ancillopsis*. A large naticid in the collection is referred to the genus *Ampullinopsis*. It may be the form that Yabe and Hatai described as a new genus and species, *Hahazimania hahazimensis*, from the *Camerina*-bearing tuff of Haha-jima in the Bonin Islands. Their material consisted of internal molds. The exact position of the Bonin Island deposits within the Eocene is not known,

but a middle or late Eocene age is probable. The only previously described Eocene pelecypod species identified is *Corbula* (*Corbula*) *subtumida* Nagao; it is transferred to the genus *Caryocorbula*. It is reported from the lower and upper Eocene of Kyushu.

A gastropod here described as *Terebra miyarensis* may be closely related to a species described by Nagao (1928) as ?*Melania miikensis*. This relationship, if correct, would record in the Miyara Formation the same species stocks that Hatai and Nisiyama (1952, p. 6) listed as the diagnostic forms of the Miroku Group, the lowest Eocene of Kyushu. These species are: *Orthaulax? japonicus* Nagao, *Favus japonicus* Nagao (? a *lapsus calami* for *Favus nipponicus*), and *Melania miikensis* Nagao. The related species in the Miyara Formation are: *Ancillopsis japonicus*, *Melanatria ka-hoensis*, and *Terebra miyarensis*.

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA

Family TURBINIDAE

Genus LUNELLA Roeding 1798

Lunella miyarensis MacNeil, n. sp.

Plate 1, figures 1-3

Shell of medium size, low turbiniform; whorls made tricarinate by three rows of large nodes at the periphery; subsutural slope broad with a nearly central row of closely set rounded beads and two to three raised plain or beaded spiral threads above and below it; successive positions of the anal sinus indicated by a row of strong blunt hollow spines just below the suture; suture overlapping the peripheral nodes on the spire whorls, except that an occasional node in the upper row may be partly exposed; protoconch unknown; aperture subrounded with a pronounced anal notch that projects as a blunt hollow spine; shell not umbilicate but with a moderately strong siphonal fasciole; details of parietal wall and callus not well shown on type but apparently smooth and appressed.

The holotype (USNM 638646) measures 11.9 mm in height and 14.5 mm in diameter.

This species seems to be more closely related to some Recent and Pleistocene shells now referred to the genus *Lunella* than to any known species from Tertiary deposits of the Far East. Although the Recent species such as *Lunella coronatus granulatus* (Gmelin) (see Taki, 1951, pl. 74, fig. 2) and *Lunella coronatus coreensis* (Reeve) (see Taki, 1951, pl. 74, fig. 1; and Kira, 1955, pl. 11, fig. 9) have much weaker spirally arranged peripheral nodes, the plan of ornamentation is similar. The Eocene species is less rounded and the suture is higher, leaving less of the spire whorls exposed. Prob-

ably the shape of this species is more like that of *Bolma girgyllus* (Reeve) than *Lunella coronatus*, but *B. girgyllus* has neither the hollow subsutural spines nor the basal row of nodes.

Lunella cinerea (Born), a less ornate Recent species, is reported from Miocene and Pliocene rocks of Indonesia (Altena, 1938, p. 289). The present species has stronger sculpture than any other known species of the genus and is much older than any species previously reported.

Type locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Family TURRITELLIDAE

Genus TURRITELLA Lamarck 1799, s. 1.

Turritella kotakai MacNeil, n. sp.

Plate 1, figures 5-8, 12-18

Shell of medium size for the genus; apical angle ranging from 15° to 20°; whorls of adult singly or doubly carinate; sutures generally well defined and slightly incised; basal angle weak to moderately sharp; base rounded; anal sinus very deep; protoconch unknown; earliest whorls bicarinate, with the pair of carinae located slightly nearer the lower suture, the upper carina slightly stronger; juvenile whorls with the lower carina persisting to form the lower and weaker of two prominent carinae, or becoming obsolete with the upper carina persisting as a sharp central keel; carinae in adults ranging from two of nearly equal size, to a stronger upper carina and a weaker lower carina, to a single strong carina; spacing of carinae in bicarinate forms ranging from well separated to closely spaced, and even in shells with a single strong carina there may be a weak thread at greater or lesser distance below it; base rounded and indistinct or set off by a moderately sharp angle (the former more apt to be a gerontic condition); a third and weaker spiral carina marking the base of the body whorl; sutures well defined, weakly incised, and falling at about the middle of a spiral concavity; profile of outer lip as shown by growth lines recurving sharply to a deep moderately broad anal sinus, the apex of which occupies about the lower two-thirds of the subsutural slope, and thence curving less abruptly to a broadly rounded convexity at or just above the basal angle, again recurving below the basal angle; aperture subrounded.

The holotype (USNM 638647), a bicarinate form, measures 39 mm in height and 17 mm in diameter. The paratype (USNM 638648), a monocarinate form, measures 47.5 mm in height, and 20 mm in diameter. The largest figured specimen (USNM 638655), which

consists of only four whorls, has a height of 48 mm and a diameter of 26.8 mm. Other figured specimens are numbered 638649–638654, 638656, and 638657.

At first glance it might seem that at least two or more species are represented, but among more than 200 specimens in the collection every possible intergradation can be found. The monocarinate form is more common, although even among them there are many with a weak second carina. Less than a fifth of the specimens have two strong carinae in adults. The evidence that only one species is represented because of complete intergradation is supported by the fact that the only two tips found, both of them recovered as rubber casts from molds in the rock, are identical in the youngest stages, one of them retaining both carinae whereas the other loses the lower carina on about the ninth or tenth whorl.

The deep, almost turridlike, anal sinus of this species is one of its most striking features. The sinus on the specimen figured on plate 1, figure 18, falls higher on the whorl than it does on some Japanese Eocene *Turritella* with similar strong spiral carinae (Nagao, 1928, pl. 19, fig. 11a; Kotaka, 1959, pl. 12, figs. 2, 3, 5).

Two species of *Turritella* were described by Nagao (1928) from the lower Eocene of Kyushu. One, *T. okadai* (Kotaka, 1950, pl. 5, figs. 1–4), has a strong subsutural carina unlike the present species. The other, *T. miikensis* (Kotaka, 1950, pl. 5, figs. 5–6), has two carinae on the lower part of the whorl like the present species, but the figured specimens are juveniles and very poorly preserved so that an exact comparison cannot be made. The juvenile shown on plate 1, figure 6, certainly bears some resemblance to *T. miikensis*.

Photographs of this species were sent to Dr. Tamio Kotaka of Tōhoku University, and he has commented on them as follows (written communication, 1960):

Your specimens belong to the genus *Colpospira* Donald 1900, according to the morphology of the protoconch and the shape of the growth lines, which have a deep siphonal notch (the lateral sinus of Marwick, 1957). They belong to the group of *Acutospira* proposed by me in my monograph and based on *Turritella okadai* Nagao, 1928. This group has sharp edged spirals and a low growth line angle. In *Acutospira* I have included the Eocene *C. (A.) okadai* (Nagao), *C. (A.) tashiroi* Kotaka, and *C. (A.) yabei* Kotaka.

Your species shows close relationship with my *yabei*, but *yabei* is more advanced judging from the appearance of the fine secondary spirals. Your specimen numbered 17698 (the holotype) shows some relationship with *C. (A.) okadai* in its spirals. From the available data and from my experience, your species is new.

In my recently published monograph of the Japanese Turritellidae [1959], I have said that the Japanese Eocene forms with sharply keeled shells, named *Colpospira (Acutospira) okadai* (Nagao), etc., are immigrants and also descendants of what Beets described in 1950 from the Cretaceous and Eocene of

Celebes. These are thought to have migrated from Celebes via the Philippines and the Ryukyu Islands to Japan.

Strongly lirate *Turritella* were described from the Eocene of southwest Celebes by both Dollfus and Beets. One of these, *T. krooni* Dollfus (Beets, 1950, fig. 4), comes from the Maroro Formation, a formation whose upper part is assigned to the Tertiary *a* stage in the Van der Vlerk-Umbgrove Indonesian Tertiary time scale, and whose lower part is believed to be Cretaceous. It is difficult to see anything in the published figure except that it has a prominent peripheral keel.

Turritella krooni batakuensis Beets (1950, figs. 1–3), another Celebes form, resembles the present species superficially in that it has a strong central carina and on some specimens a weaker spiral below it. The general aspect of the shell is much like that of the specimen shown on plate 1, figure 18. If Beets is correct in his description of the growth line (which may be retouched on his fig. 2), however, the deep sinus falls below the prominent carina rather than above it as in the present species. This difference, if actual, would preclude any close relationship between Beets' subspecies and *T. kotakai*.

Type locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. 17698.

Other occurrences: Seacoast west of Ibaruma, USGS loc. D366(T); hillside localities northwest of Ibaruma, D360(T), D361(T), D363(T), D364(T), D365(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Family THIARIDAE

Genus MELANATRIA Bowdich 1822

Melanatria cf. *M. kahoensis* (Nagao)

Plate 1, figures 4, 9–11

Faunus (Melanatria) kahoensis Nagao, 1928, Tōhoku Imp. Univ. Sci. Repts., 2d ser. (Geology), v. 12, no. 1, p. 103, pl. 15, figs. 2, 2a, 2b.

Faunus (?) sp. indet. Nagao, 1928 Idem., p. 104, pl. 15, figs. 3, 3a.

Both Nagao's material and the specimens figured here are incomplete and poorly preserved. Neither the aperture nor the surface details of the species are known. It has one very distinguishing characteristic, however, there are three rows of blunt vertically elongate nodes, which on the last whorls may become higher and more pointed, and which are aligned in three vertical rows giving the shell a triangular cross section when viewed from the top (pl. 1, fig. 4). Some other large cerithids such as *Campanile* and *Vicarya* have many nodes and there is no vertical alinement of them. This feature alone is sufficient to make this stock unique among large high-spired gastropods and to indicate beyond question that the Ishigaki and Kyushu forms, if not identical, are very closely related species.

Nagao may have been unduly cautious in identifying one of his specimens as *Faunus* (?) sp. indet. It comes from the same locality and seems to have the same visible characteristics as his named species.

Melanatria kahoensis has axial ribs like those of *Pyrazisinus? haitensis* Dall (Guppy and Dall, 1898, pl. 29, fig. 8) but the latter has seven to eight per whorl rather than three. Nevertheless, I feel that these two species are related. *P.? haitensis* comes from supposed Oligocene beds exposed on an island in Lake Henriquillo, Haiti. *Texania texana* (Heilprin) (Palmer, 1937, p. 182, pl. 21, figs. 21-23) from the early middle Eocene of Alabama may also be related. *Texania* was renamed *Texmelanatria* Gardner 1945.

The largest figured specimen (USNM 638658) measures 135 mm in height and 55 mm in diameter. The smaller figured specimen is numbered 638659.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS locs. 17698, D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima; Eocene of Chikuzen province, Kyushu (Nagao gave the source bed as the Kamiyamada fossil bed but Hatai and Nisiyama (1952, p. 202) gave the horizon as the Takeya Formation, middle Eocene, a unit which in Nagao's correlation chart underlies his Kamiyamada fossil bed).

Family POTAMIDIDAE

Genus VICARYA d'Archiac and Haime 1854

Vicarya ibarumensis MacNeil, n. sp.

Plate 2, figures 2, 3

Shell small for the genus; medium inflated; spire outline very weakly convex; whorls nearly straight sided; sutures shallow but prominent; sculpture consisting of spiral lirae only and without prominent nodes; protoconch unknown; adult spire whorls bear five moderately coarse spiral threads of which the subsutural thread is coarsely beaded, the suprasutural thread less coarsely beaded, the middle thread indistinctly beaded, and the other two plain or weakly and irregularly beaded; basal angulation with two rather prominent smooth spiral ridges that are overlapped by the suture on the spire whorls; base smooth or with two faint spiral lines; complete aperture not seen but the inner lip is thickened and moderately raised.

The holotype (USNM 638660) measures 16.9 mm in height, and 5.1 mm in diameter. An unfigured specimen has a height of 21.7 mm. The paratype (USNM 638661), a mold and rubber cast, has a height of 11.0 mm.

This species is most closely related to *Vicarya eocenica* Cox (Cox, 1931, p. 44, pl. 1, figs. 7a, 7b, 8; and Yabe and Hatai, 1938, p. 150, pl. 21, figs. 1, 7, 8), a species described from the Ghazij Shales of the Laki Series

(early Eocene) of Baluchistan. Cox's species is the oldest known *Vicarya* and the present species is the only other Eocene species described. None are known from Oligocene rocks. The genus, which did not survive the late Miocene, is known from several Miocene species from India, Indonesia, the Philippines, and Japan.

Both *V. eocenica* and *V. ibarumensis* are without spines or nodes on the subsutural collar, a character that distinguishes them from most Miocene species. The subsutural spiral, however, is prominently beaded and compares in this respect with juvenile shells of the Miocene species.

Of the Miocene species of *Vicarya*, probably *V. notoensis* Masuda (1955, p. 161, pl. 26, figs. 2-4) from the Higashi-Innai Formation (early middle Miocene) of the Noto Peninsula, Japan, is closest to the species here described. The Miocene species seems to be more inflated with the sutures more tightly appressed, and the beaded subsutural collar is more prominent. There are no large nodes.

Vicarya ibarumensis differs from *V. eocenica* by being slightly more slender and without a tendency for the subsutural collar to be more expanded on the later whorls; the late whorls of *V. eocenica* are subtabulate whereas in *V. ibarumensis* they are not.

Type locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Other occurrences: D364(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Family NATICIDAE

Genus AMPULLINOPSIS Conrad 1865

A large naticid gastropod from the Miyara Formation is referred to the genus *Ampullinopsis*. It compares in all details, except for its larger size, with the type of *Ampullinopsis*, *Natica mississippiensis* Conrad, from the Mint Spring Marl Member (early middle Oligocene) of the Marianna Limestone in Mississippi. *Megatylotus* Fischer (type, *Natica crassatina* Lamarck Oligocene, Europe) is a synonym.

Yabe and Hatai (1939, p. 209) described a large gastropod from Eocene beds on the island of Haha-jima in the Bonin Islands as a new genus, *Hahazimania*. Their specimens were internal molds, and the hole representing the thick dissolved columella they took to be an umbilicus. They recognized and so stated that their shell resembled *Megatylotus crassatinus* in shape but that it could not be congeneric with *Megatylotus* because their shell was umbilicate. The species here figured from the Miyara Formation is believed to be *Hahazimania hahazimensis* Yabe and Hatai, but until something better than internal molds are found of the latter this is just a guess.

Ampullinopsis appears abruptly in the Oligocene of both Europe and America. I do not believe any Eocene form from either area is ancestral to it. It is likely that *Ampullinopsis* existed in the Far East during the Eocene.

Ampullinopsis cf. A. hahazimensis (Yabe and Hatai)

Plate 2, figures 1, 4, 5

Shell large and globose; spire low; suture moderately channeled; aperture subovate; parietal callus moderately thick and broad; protoconch unknown; sculpture consisting of crude lines of growth; whorls inflated and rounded except that the subsutural slope is weakly concave on some specimens; the suture is moderately broad and shallowly channeled and on mature individuals tends to descend at a greater angle than on the younger whorls; aperture subovate, narrower at the anal extremity, extended to form a moderate anal groove, anterior extremity broadly rounded, no siphonal groove; inner lip thickened and extended to form a moderately broad and moderately thick callus; no umbilicus; columellar shell thick as seen in cut section.

Largest figured specimen (USNM 638662) measures 99 mm in height and 90 mm in diameter. Smaller figured specimen (USNM 638663) measures 72 mm in height and 69 mm in diameter. Vertically sectioned figured specimen, 638664.

The smaller figured specimen is about the same size as the holotype of *A. hahazimensis* and a nonapertural view of this specimen corresponding to that in Yabe and Hatai's figure 4 has almost exactly the same shape.

As stated in the generic discussion, Yabe and Hatai believed their species to be strongly umbilicate, and they also stated that it has no callus. Their specimens, however, are clearly internal molds on which the callus could not be detected, and the large open umbilicus of their mold corresponds to the thick columellar or umbilical plug shown in the vertical section (fig. 5).

This is an exceptionally large *Ampullinopsis*, being over twice as large as any I have seen from Oligocene deposits of the United States.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima; *Camerina*-bearing tuff (Eocene) on Haha-jima, Bonin Islands. Otuka (1939, p. 483) lists limestone, calcareous tuff, and agglomerate in the Eocene of Haha-jima but (p. 508) gives only one formation name, the Hahazima Limestone.

Family NASSARIIDAE

Genus ANCILLOPSIS Conrad 1865

The type of *Ancillopsis* is *Ancilla altilis* Conrad from the Claiborne Group (middle Eocene) of Alabama. Palmer (1937, p. 287) concluded that *Ancillopsis* is a

synonym of *Bullia* Gray whose type is *Bullia semiplicata* Gray, a Recent species of unknown habitat. Granted that these forms may be related, the Eocene forms, which are larger, more globose, lower spired, and more heavily callused, are, in my opinion, distinct enough to be placed in a different genus.

The species treated here seems to belong to a group from the Japanese Eocene that Nagao (1924, p. 13) decided belonged to the genus *Orthaulax*, a genus that otherwise is restricted to the Oligocene and Miocene of the Gulf of Mexico region. Nagao concluded that *Orthaulax* probably originated in Japanese waters and that its asiatic occurrences are older than its American occurrences.

Woodring discussed the probable generic assignment of *Orthaulax japonicus* on two occasions. After examining two paratypes sent to him by Nagao he stated (1928, p. 91) that "this species represents some other genus, probably allied to *Pseudoliva*." Again in 1959 (p. 190) he said, "The Japanese fossil is not a strombid; it is evidently a buccinid." Although there is a resemblance to some species of *Pseudoliva*, particularly to a large specimens of *P. vetusta* (Conrad), I believe the strong right twist of the columella (pl. 2, fig. 17) makes it more likely that this shell is an *Ancillopsis*. The genus *Lisbonia* Palmer, which Wenz made a subgenus of *Bullia*, is also very closely related.

Nagao made some longitudinal sections of some specimens of his *O. japonicus* (1924, pl. 1, figs. 2, 2a, 4c) which in his opinion demonstrated his generic determination. In my opinion, his sections, as well as one prepared of the specimen here figured on plate 2, figure 17, do not resemble the longitudinal sections of *Orthaulax* published by Woodring (1923, pls. 1, 2). The Japanese species has ovate to kidney-shaped body chambers that are well separated by a thick columella. The bottom of the chambers is broadly rounded. Woodring's figures show the body chambers to be elongate with a narrow pointed bottom, and they are separated by a very thin columella. The successive layers of callus forming the dome extend in the Japanese species along and below the adjacent body chamber, whereas in *Orthaulax* they lie mainly above the adjacent body chamber. Although few gastropods have been studied in longitudinal section, it would certainly seem that the plan of these sections indicates shells of widely different construction, the only point of similarity being that both have heavy parietal calluses.

The Japanese species seems to compare in all respects with some of the *Ancillopsis* from Alabama, particularly with the more bulbously callused variant of *A. altilis subglobosa* occurring in the Hatchetigbee Formation (late early Eocene) (Palmer, 1937, pl. 40,

figs. 1, 2, 3, 5). Shells with similar inflation but with a less pronounced callus occur throughout the Claiborne Group (middle Eocene) (Palmer, 1937, pl. 39).

Possibly *Ancillopsis* occurs earlier in Japan than in America, and, if the present assignment is correct, an asiatic origin might be claimed for this genus rather than for *Orthaulax*.

A European Miocene species, *Ancilla (Baryspira) glandiformis* Lamarck (Mongin, 1958, p. 232, pl. 1, figs. 6a, b) has a remarkable similarity to those just discussed. In all probability the two forms are homeomorphic. The suggestion has never been made that they are related.

***Ancillopsis japonica* (Nagao)**

Plate 2, figures 6, 12, 17

Orthaulax japonicus Nagao, 1924, Japanese Jour. Geology and Geography, v. 3, no. 1, p. 15, pl. 1, figs. 1-4.

Tōhoku Imp. Univ. Sci. Repts., 1928, 2d ser. (Geology), v. 12, no. 1, p. 104, pl. 17, figs. 1-4.

Hatai and Nisiyama, 1952, Tōhoku Imp. Univ. Sci. Repts. 2d ser. (Geology), Spec. V. 3, p. 227-229. (See for extended bibliography.)

This species is reported throughout the Eocene in Japan. Presumably no differences have been detected on specimens from different levels that would indicate any change through time. This could be due to the fact that the material, for the most part, is very poorly preserved. There is no reason, however, for supposing the specimens figured here are closer to any particular specimens figured previously.

The present specimens seem to indicate that juveniles are less callused than adults and have a relatively higher spire. There is a moderately strong siphonal fasciole and a well-defined siphonal notch. The anal extremity is weakly notched, and the notch is subtended on the parietal wall by a weak prominence. The highest part of the callus lies above the suture, and unless the spire is eroded it marks the posteriormost part of the shell. There are no columellar folds.

A longitudinal cut was made of the specimen shown in figures 12 and 17, and its chambers and callus tracks are similar to those in Nagao's figure 4c (1924).

Larger figured specimen (USNM 638666) measures 64 mm in height and 49 mm in diameter. Smaller figured specimen, USNM 638665.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366 (T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima; lower, middle, and upper Eocene of Kyushu.

Family FASCIOLARIIDAE

Genus MAZZALINA Conrad 1860

?*Mazzalina* sp.

Plate 3, figure 1

A single, incomplete, and poorly preserved specimen is referred to this genus with reservations. It has a superficial resemblance to some forms figured by Palmer from Alabama (1937, pl. 47). Nagao (1928, v. 9, p. 126, pl. 19, figs. 3, 3a) described a much larger but similarly shaped shell from the Kachidachi Formation (upper Eocene) of Kyushu as *Sycum (Bulbifusus?) miikensis*. His specimen is an internal mold. *Bulbifusus* probably is a synonym of *Mazzalina* (Palmer, 1937, p. 349). Hatai and Nisiyama (1952, p. 252) reassigned this species to ?*Mazzalina*.

Figured specimen (USNM 638667) measures 28 mm in height and 23 mm in diameter.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366 (T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Family VOLUTIDAE

Genus CARICELLA Conrad 1835

The assignment of an Ishigaki species to this genus is done with some reservation. It may prove to be a new genus, but it is not being described on the basis of the material at hand. The strongly cone-shaped adults recall the earliest known American species, *C. podagrina* Dall, from the Tuscahoma Sand (lower Eocene) of Alabama. The American middle and upper Eocene species have higher spires and more subdued shoulders, and the Oligocene species are even higher. The Oligocene species, however, particularly *C. reticulata* Aldrich from the Red Bluff Clay of Mississippi, have a wide range in spire height. In some respects the Ishigaki species resembles some asiatic species of *Athleta (Volutospina)* as well as the Mexican Eocene genus *Volutocristata*, but there are no shoulder nodes or spines as in these genera.

I can find nothing like this described from the Eocene of Asia, and if its assignment to, or its relationship with, *Caricella* is correct it may prove to have had a common ancestor with the first American species. The appearance of *Caricella* in the American early Eocene is abrupt and it appears to have come from elsewhere.

Caricella fosteri MacNeil, n. sp.

Plate 2, figures 7-11, 13-16

Shell of medium size, subconical to conical; spire of medium height to low, pointed; columella has three

folds; aperture elongate and moderately narrow; protoconch unknown; surface not well preserved on any specimens, but there are patches showing narrow sharp-crested closely spaced axial riblets that extend to the suture; axials separated by round-bottomed interspaces, some of the axials have an undercut back slope; no spiral sculpture; spire ranging from moderately high and gently sloping with a rounded shoulder to low and steeply sloping with a moderately angulate shoulder. The more angulate specimens broader than the less angulate specimens; aperture elongate and moderately broad, rounded to moderately angulate at the position of the shoulder; produced anteriorly to form a well-defined siphonal canal; parietal wall moderately but narrowly callused and with a moderately strong bump well inside the aperture and about opposite the shoulder angulation; columella straight and moderately extended, bearing three moderately strong folds that are visible only well inside the aperture; shoulder smooth or irregular and without nodes but the axial riblets cross it without interruption.

The holotype (USNM 638668) measures 30.5 mm in height and 22.4 mm in diameter. Figured specimens, USNM 638669–638674.

The specimens which are thought to represent one species range from moderately high spired and with rounded shoulders to low spired and cone shaped. The younger specimens show a greater range in shape; the large specimens are all cone shaped. It is possible that two species are being dealt with here, but the similarity of the columellar folds on both types makes it unlikely.

The nearest apparent relative I can find of this species is *Caricella podagrina* Dall (Harris, 1899, p. 37, pl. 4, fig. 8) from the Bells Landing Marl Member of the Tuscahoma Sand (about middle early Eocene) of Alabama. *Caricella podagrina* is a much larger species, having a height of about 90 mm. Its three columellar folds are more inclined, but the shape of the shell is about intermediate between the less strongly shouldered and more strongly shouldered Ishigaki specimens. One of the Ishigaki specimens has a strong bump on the parietal wall about opposite the shoulder (pl. 2, fig. 11), but it is not apparent on other specimens.

I can find nothing like this described from Japan, India, or Indonesia.

Type locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Family TEREBRIDAE

Genus TEREBRA Bruguière 1789

Terebra miyarensis MacNeil, n. sp.

Plate 3, figures 2–4

Shell medium small for the genus; inflated; spire high; whorls broadly rounded and sutures subtabulate, making each successive whorl of noticeably greater diameter than the preceding whorl; siphonal fasciole sharp; parietal wall with a node subtending the anal notch; protoconch unknown; sculpture consisting of about seven to eight low flattened raised spiral threads, no axials; aperture incomplete but probably sub-rounded; siphonal canal not preserved but the siphonal fasciole is typical of *Terebra*.

The holotype (USNM 638675) measures 33.4 mm in height, and 15 mm in diameter. Figured specimen, USNM 638676.

The early whorls of this species appear to have a much stronger subsutural collar than the adult whorls. The parietal bump is unusual but not unknown in *Terebra*, although in this species it is exceptionally strong. Were it not for the well-preserved siphonal fasciole I would probably assign this shell to some other family.

This species may be related to one described from the Shiratake Formation (lower Eocene) of Kyushu by Nagao (1928, v. 9, p. 122, pl. 21, fig. 13) as *Melania miikensis*. The relationship, however, is assumed mainly from the size and shape of the whorls; the aperture on Nagao's specimen is incomplete.

Type locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. 17698.

Other occurrences: D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Doubtful occurrences: As *Melania miikensis* Nagao, Shiratake Formation (lower Eocene), Kyushu.

Family BULLIDAE

Genus BULLA Linné 1758

?*Bulla* sp.

Plate 3, figure 13

Two very poorly preserved specimens of what is probably a medium-sized *Bulla* were collected. If this assignment is correct it appears to belong to the group of *B. amygdala* Dillwyn (see Pilsbry, 1893, pl. 38, fig. 65), a Recent West Indian species. This group is characterized by a comparatively short anterior enlargement of the aperture and a moderately broad strongly

curved inner lip callus around the anterior part of the aperture. The callus has a sharp inclined edge. The posterior part of the aperture is moderately long and narrow, accounting for about two-thirds of the aperture. The spire is involute with the perforation moderately broad. No surface details are preserved.

The figured specimen (USNM 638677) measures 21 mm in height and about 12 mm in diameter (probably excessive due to crushing).

This species may also be related to *B. orientalis* Habe (1950, p. 21, pl. 3, fig. 10), a Recent species from the Ryukyu Islands and Formosa.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima Ryukyu Islands, USGS loc. D366(T).

Family SCAPHANDRIDAE
Genus SCAPHANDER Montfort 1810

?*Scaphander* sp.

Plate 3, figures 5, 6, 11, 12

It is not absolutely certain, the preservation being so poor, that this form is different from the preceding species. It is believed, however, that two genera of opisthobranchs are present. The anterior expansion of the aperture appears to be shallower on this form. The apical perforation is broader and funnel shaped, and the angular edge, unless this is a solution irregularity, is coarsely beaded.

If this is the same as the preceding species, both probably are *Bulla*.

The largest figured specimen (USNM 638680) measures 28.5 mm in height and 18 mm in diameter. Other figured specimens are numbered USNM 638678, 638679.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Class PELECYPODA
Family OSTREIDAE
Genus OSTREA Linné 1758

Ostrea sp.

Plate 3, figures 15, 16

Two valves of an oyster were obtained. It is of medium size, subtrigonal, moderately inflated, and has a thick shell. It appears to be crudely ribbed. No attempt is made to identify it. Its only significance is to indicate that the associated fauna lived in shallow water.

The figured specimen (USNM 638681) measures 76 mm in greatest diameter and has a height of 28 mm.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Family ANOMIIDAE
Genus ANOMIA Linné 1758

?*Anomia* sp.

Not figured

One very poorly preserved specimen was obtained. It resembles the *Anomia* sp. of Nagao (1928, v. 9, p. 106, pl. 21, figs. 10-12, 15, 15a) and is about the same size.

USNM 638682.

Locality: USGS loc. D360(T).

Family CARDITIDAE
Genus CARDITA Bruguière 1792

?*Cardita* sp.

Plate 3, figures 10, 14

An incomplete right valve and two incomplete left valves of what is thought to be the same species of carditid were obtained. Neither a hinge nor the complete shape of the valves is known, so that it is not certain whether it is a *Cardita* or a venericard. The left valve has narrower ribs with more or less V-shaped interspaces, and the right valve has narrow ribs on its posterior slope but broader rounded ribs on the central part of its disk, the interspaces being narrow and sharp. Nagao (1928, v. 9, 12) figured some venericards from Kyushu as *Venericardia nipponica* Yokoyama. According to Hatai and Nisiyama (1952, p. 150-151) all are from the upper Eocene except two which came from the middle Eocene. One of the middle Eocene specimens (Nagao, 1928, v. 12, pl. 13, fig. 11) bears some resemblance in ribbing to the right valve figured here.

Figured specimens are numbered USNM 638683 and 638684. Both are slightly under 25 mm in length (incomplete).

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Family LUCINIDAE
Genus MYRTEA Turton 1822

?*Myrtea* sp.

Plate 3, figure 7

Only a fragment of an external mold was found of this species. It has fine but well-defined concentric ribs between which are three or four very fine concentric threads.

The figured specimen (USNM 638685), a rubber cast, measures 4.5 mm in greatest diameter.

Locality: D364(T).

Family **CARDIIDAE**Genus **CARDIUM** Linne 1758**Cardium ishigakensis** MacNeil, n. sp.

Plate 3, figures 8, 9

Shell large, subcircular, and inflated; moderately thick; beaks prominent and recumbent, weakly orthograde; slightly more angulate anteriorly than posteriorly; right valve with a broad bifid cardinal tooth and a deep socket immediately above it, and a very strong deep anterior lateral socket and a weaker posterior lateral socket, the anterior socket closer to the beak than the posterior socket; ligamental nymph narrow and moderately long; external ribbing not well preserved on anterior and posterior extremities, but the ribs on the anterior dorsal slope are narrower than elsewhere, the ribs of the central disc are moderately broad, very low and smooth, with the interspaces being little more than incised lines. Left valve not known.

The holotype (USNM 638686) measures 85 mm in length, and 81 mm in height. Its convexity is 37 mm.

This species may be related to *Cardium* (*Cerastoderma* (?)) *kishimaense* Nagao (1928, v. 12, p. 63, pl. 10, figs. 23-25), which according to Hatai and Nisiyama (1952, p. 37) comes from the Kishima Formation of Oligocene Age of Kyushu. It is more than twice as large as any of the specimens measured by Nagao, but the sculpture appears to be of the same type. According to Nagao, his species is related to *Fulvia mutica* (Reeve), a Recent Japanese species. Although the ribs are similar, the anterior lateral socket of *F. mutica* is deeper and strongly inclined and extends inwards towards the umbonal cavity.

According to Dr. A. M. Keen, of Stanford University, the Ishigaki species is a *Plagiocardium* related to *P. pseudolima* (Lamarck), a Recent species from East Africa. *P. pseudolima* has coarser ribs, deeper interspaces, and the anterior lateral teeth and socket are much shorter.

Another *Plagiocardium*, *P. setosum* (Redfield) (= *latum* Born), Recent from the Philippines, has similar ribs and interspaces but the ribs have a central row of short spines. The spines break off, however, leaving a smooth surface like that of the Eocene species. The anterior ribs of *P. setosum* are narrower and sharper, and the posterior end of the shell is more elongate. Japanese malacologists have variously assigned *P. setosum* to *Maoricardium* Marwick and *Papyridea* Swainson.

Cardium ishigakensis has a shape similar to that of *C. hatchetigbeense* Aldrich from the lower Eocene of Alabama (see Harris, 1897, p. 59, pl. 12, figs. 2, 2a), but it is larger and the ribbing is different; in *C. hat-*

chetigbeense the ribs are narrower and higher and the interspaces are wider.

Although all of the details of this species are not preserved on the type, it is felt that enough are present to make it identifiable. Certainly the type of ribs is unique among known cardiids of this age.

Type locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

Family **CORBULIDAE**Genus **CARYOCORBULA** Gardner 1926**Caryocorbula** cf. *C. subtumida* (Nagao)

Plate 3, figure 17

?*Corbula* (*Corbula*) *subtumida* Nagao, 1928, Tōhoku Imp. Univ. Sci. Repts., 2d ser. (Geology), v. 12, no. 1, p. 87, pl. 9, figs. 14, 15.

A single moderately large corbulid is assigned tentatively to this species. According to Hatai and Nisiyama (1952, p. 49) this species ranges from the lower Eocene to the upper Eocene of Kyushu. The present species compares favorably with specimens figured by Nagao, but his are crushed. The size is comparable; he gives 18 mm as the length of his largest specimen, about the same as the one figured here. This species is closely related to the type of *Caryocorbula*, *C. alabamiensis* (Lea), from the Claiborne Group (middle Eocene) of Alabama (Vokes, 1945, pl. 1, fig. 17; and Stenzel and others, 1957, pl. 19, fig. 12).

The figured specimen (USNM 638687) measures 17.5 mm in length and 11.4 mm in height. Its convexity is about 5.0 mm.

Locality: Seacoast west of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D366(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima; lower to upper Eocene, Kyushu.

Class **ECHINOIDEA**Order **CLYPEASTEROIDA**Suborder **SCUTELLINA**Family new aff. **PROTOSCUTELLIDAE**

Genus and species new

Plate 3, figure 18

A single incomplete specimen of a clypeasteroid echinoid was collected which although not showing all of the details that might be hoped for, does retain enough to show that it is a member of an entirely new group. Dr. J. W. Durham of the University of California has examined this specimen and says that it represents a new family of the suborder Scutellina probably related to the family Protoscutellidae. This genus will be described with detailed illustrations at a later

date. In the meantime a few of its distinguishing characteristics are given herewith.

The ambulacral food grooves of the oral surface are simple and straight for the most part, although there is some indication that they may have branched distally. There are three discontinuous interambulacra visible on the oral surface. The interambulacra terminate adapically in two rows of plates, although all the plates within the petals are primaries. The last two characters indicate that this echinoid should be referred to the suborder Scutellina. The aboral surface has pores for secondary tube feet on both the ambulacral and interambulacral plates; those on the ambulacral plates are arranged in short double rows which slant adapically towards the midambulacral suture; those on the interambulacral plates are arranged in less regular double rows or small irregular elongate patches, all of them external to the ends of the petals proper. The anterior petal (the best preserved on the specimen) is open and slightly lyrate. The lateral petals are weakly constricted terminally but still open. The primary tube feet pores are nonconjugate; the inner row pores are round; the outer row pores are elongate, becoming more so towards the outer end. Three genital pores are visible; two other indistinct pits indicate there may be five. The periproct appears to be supramarginal; the surface of the test is gone in this region, but a matrix filled plug appears to be the opening.

The figured specimen (USNM 638688) measures 41 mm in greatest dimension.

Locality: Hillside northwest of the village of Ibaruma, Ishigaki-shima, Ryukyu Islands, USGS loc. D362(T).

Distribution: Miyara Formation (Eocene), Ishigaki-shima.

LOCALITIES

Tertiary locality (Washington catalog):
17698 (Is-DF-25-48).

Conglomerate bed in bedded volcanics just west of the town of Ibaruma, Ishigaki-shima. D. E. Flint, collector, 1948.

Tertiary localities (Denver catalog):
D366(T) (Is-F-27-55).

West coast of Ishigaki-shima on Funakuya-wan, two-fifths of a mile west of the northern part of the village of Ibaruma. H. L. Foster, collector, 1955. (Probably the same place as 17698.)

D360(T) to D365(T) inclusive.

From a conglomerate bed at the base of the Miyara Formation exposed on the north hillside of a small valley three-tenths of a mile northwest of the village of Ibaruma and about 900 feet inland from the coast, northern Ishigaki-shima. The conglomerate is estimated to be about 20 feet thick. H. L. Foster, collector, 1955.

D364(T) (Is-F-25-55).

D365(T) (Is-F-26-55).

Estimated to be 5-10 feet above the base of the conglomerate bed.

D363(T) (Is-F-24-55).

A few feet above D364(T) and D365(T).

D360(T) (Is-F-21-55).

D361(T) (Is-F-22-55).

Approximately in the middle of the estimated 20 feet of conglomerate.

D362(T) (Is-F-23-55).

About 8 feet above D360(T) and near the top of the conglomerate.

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PLATES 1-3

PLATE 1

FIGURES 1-3. *Lunella miyarensis* MacNeil, n. sp. (p. B2).

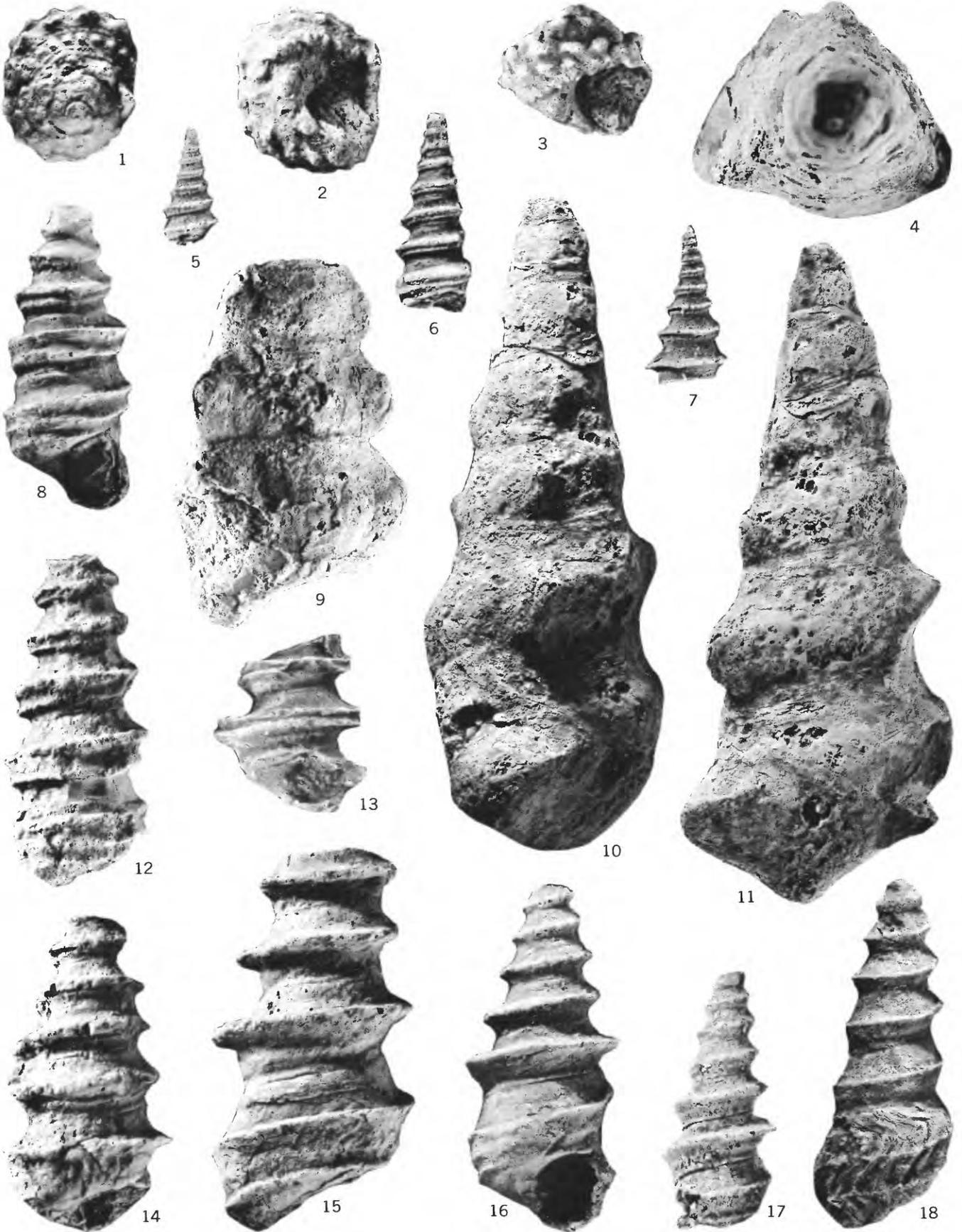
Holotype, USNM 638646. 1. Top view, greatest diameter 14.5 mm, height 11.9 mm. 2. Basal view. 3. Apertural view. USGS loc. D366(T). All views $\times 2$.

4, 9-11. *Melanatria* cf. *M. kahoensis* (Nagao) (p. B3).

Figured specimens: 4. USNM 638658, top view showing triangular outline. 9. USNM 638659, near apertural view of fragment, USGS loc. D366(T). 10. USNM 638658, side view. 11. USNM 638658, near apertural view, height 135 mm, diameter 55 mm; 4, 10, and 11 from USGS loc. 17698.

5-8, 12-18. *Turritella kotakai* MacNeil, n. sp. (p. B2).

Figured specimens: 5. USNM 638649, $\times 2\frac{1}{2}$, tip showing bicarinate early whorls with lower carina persisting. 6. USNM 638651, $\times 1\frac{1}{2}$, juvenile. 7. USNM 638650, $\times 2\frac{1}{2}$, tip showing bicarinate early whorls with lower carina becoming obsolete. 8. Holotype, USNM 638647. Apertural view, height 39 mm, diameter 17 mm, $\times 1\frac{1}{2}$. Paratype, USNM 638648. 12. USNM 638652, $\times 1\frac{1}{2}$, bicarinate adult with widely separated carinae. 13. USNM 638653, $\times 1\frac{1}{2}$, bicarinate adult with closely spaced carinae. 14. USNM 638654, $\times 1\frac{1}{2}$, bicarinate adult with weak lower carina. 15. USNM 638655, $\times 1\frac{1}{4}$, large monocarinate adult, height of fragment 48 mm, diameter 26.8 mm. 17. USNM 638656, $\times 1\frac{1}{2}$, young adult with weak lower spiral. 18. USNM 638657, $\times 1\frac{1}{2}$, adult with single weak carina and showing growth lines with deep anal sinus. Holotype and paratype from USGS loc. 17698. Two tips, figs. 5 and 7, are rubber casts from molds in rock, USGS loc. D364(T). All others from USGS loc. D366(T).



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PLATE 2

FIGURES 1, 4, 5. *Ampullinopsis* cf. *A. hahazimensis* (Yabe and Hatai) (p. B5).

Figured specimens: 1. USNM 638662, nonapertural view of largest specimen, height 99 mm, diameter 90 mm.

4. USNM 638663, apertural view of medium-sized specimen. 5. USNM 638664, vertical section showing shape of body chambers and thickness of columellar plug. USGS loc. D366(T). All figures natural size.

2, 3. *Vicarya ibarumensis* MacNeil, n. sp. (p. B4).

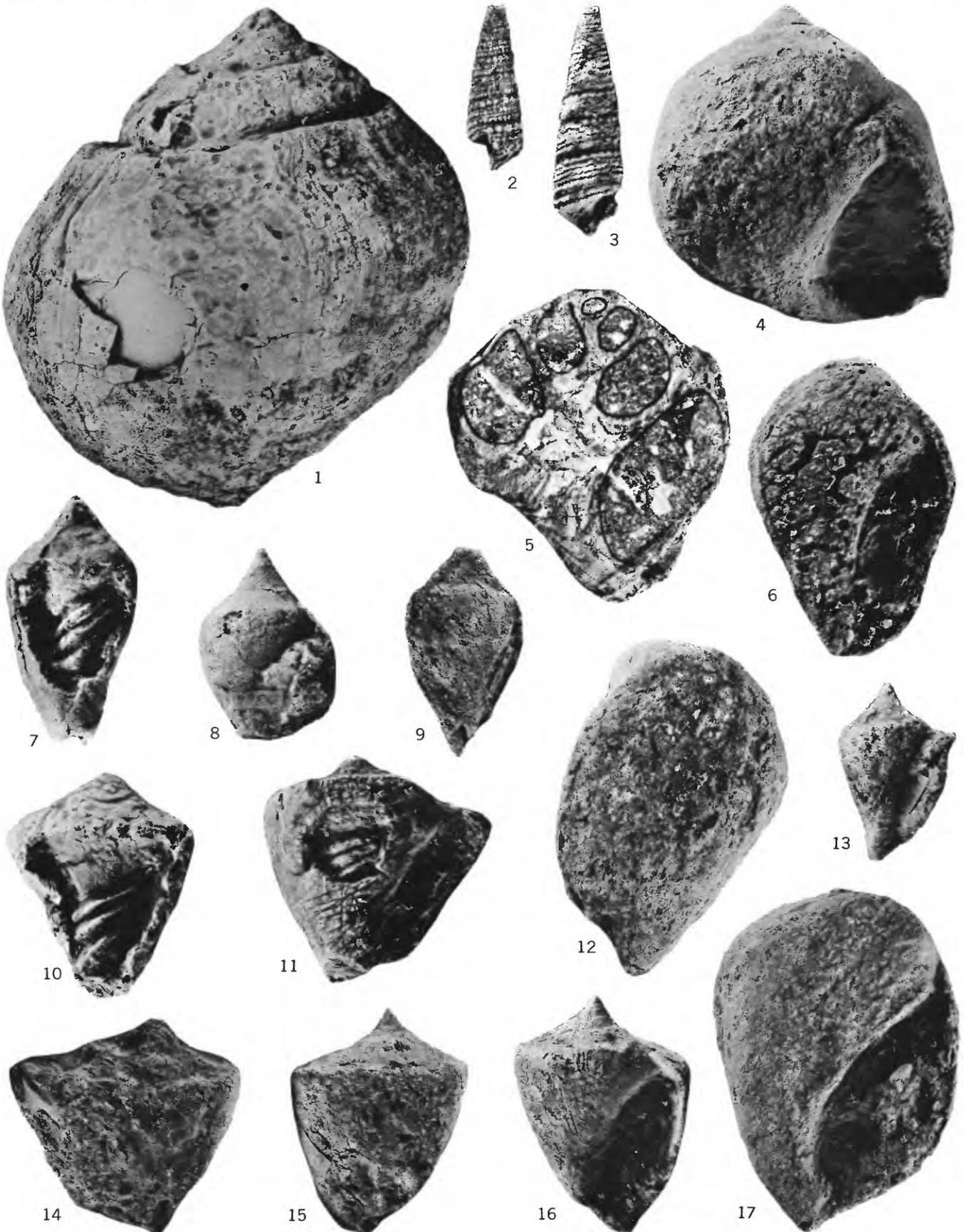
2. A rubber cast from a mold in rock. 3. Holotype, USNM 638660. Near apertural view, height 16.9 mm, diameter 5.1 mm. Paratype, USNM 638661. Holotype from USGS loc. D366(T). Paratype from USGS loc. D364(T). Views are $\times 2\frac{1}{2}$.

6, 12, 17. *Ancillopsis japonica* (Nagao) (p. B6).

Figured specimens: 6. USNM 638665, $\times 1\frac{1}{2}$, apertural view of a young specimen. 12. USNM 638666, $\times 1$, side of an adult showing projection of the callus. 17. USNM 638666, $\times 1$, apertural view, height 64 mm, diameter 49 mm. USGS loc. D366(T).

7-11, 13-16. *Caricella fosteri* MacNeil, n. sp. (p. B5).

Figured specimens: 7. USNM 638669, nonapertural view of young high spired specimen, broken to show columellar folds. 8. USNM 638670, apertural view of incomplete young high spired specimen. 9. USNM 638671, near apertural view of young specimen. 10. USNM 638672, nonapertural view of low spired specimen, broken to show columellar folds. 11. USNM 638673, apertural view of largest specimen showing a callus bump on the parietal wall and broken to show the higher position and lesser inclination of the columellar folds a full turn back from the aperture. 13. USNM 638674, apertural view of a young moderately angulate individual. USGS loc. D366(T). 14. Same. 15. Holotype, USNM 638668, nonapertural view. 16. Apertural view, height 30.5 mm, diameter 22.4 mm. All views $\times 1\frac{1}{2}$.



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PLATE 3

FIGURE 1. ?*Mazzalina* sp. (p. B6).

Figured specimen USNM 638667, apertural view, $\times 1\frac{1}{2}$. USGS loc. D366(T).

2-4. *Terebra miyarensis* MacNeil, n. sp. (p. B7).

2. Near apertural view showing spiral sculpture, $\times 2$. Holotype, USNM 638675. 3. Apertural view, $\times 1\frac{1}{2}$. 4. (Same) Side view showing sharp siphonal fasciole. Holotype from USGS loc. 17698. Figured specimen USNM 638676 from USGS loc. D366(T).

5, 6, 11, 12. ?*Scaphander* sp. (p. B8).

Figured specimens: 5. USNM 638678, $\times 2$, apical view. 6. (Same.) Nonapertural view. 11. USNM 638679, $\times 2$, nonapertural view of small specimen. 12. USNM 638680, $\times 1\frac{1}{2}$, apertural view of largest specimen, height 28.5 mm, diameter 18 mm. USGS loc. D366(T).

7. ?*Myrtea* sp. (p. B8).

Figured specimen USNM 638685. Rubber cast from a fragmental mold in rock. USGS loc. D364(T).

8, 9. *Cardium ishigakensis* MacNeil, n. sp. (p. B9).

Holotype, USNM 638686, a right valve. 8. View showing hinge. 9. Exterior of same. USGS loc. D366(T). Figures natural size.

10, 14. ?*Cardita* sp. (p. B8).

Figured specimens: 10. USNM 638683, fragment of a left valve. 14. USNM 638684, fragment of a right valve. USGS loc. D366(T). Views $\times 1\frac{1}{2}$.

13. ?*Bulla* sp. (p. B7).

Figured specimen USNM 638677, apertural view, $\times 1\frac{1}{2}$. USGS loc. D366(T).

15, 16. *Ostrea* sp. (p. B8).

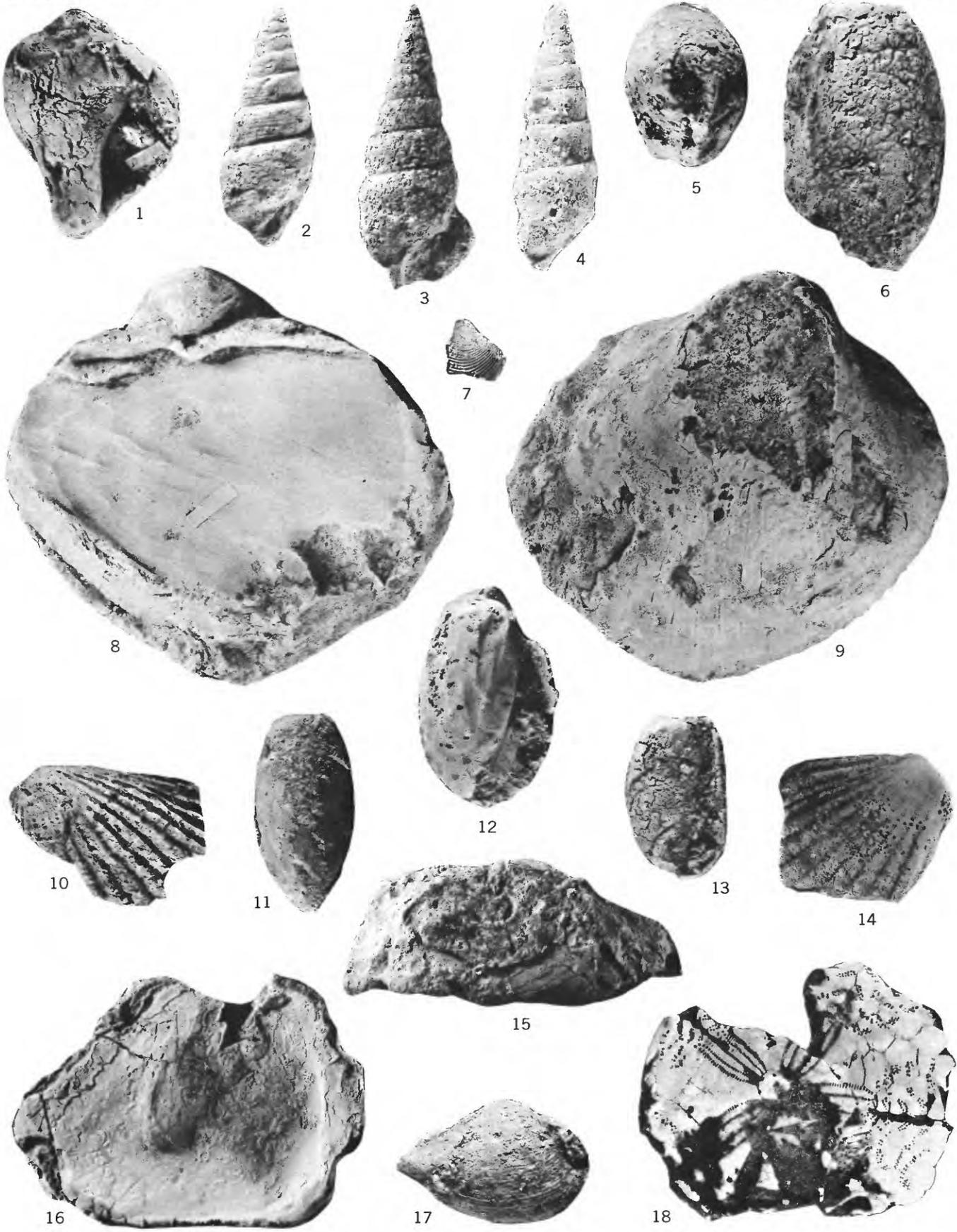
Figured specimen USNM 638681. 15. Ventral marginal view showing inflation. 16. Interior showing muscle scar. USGS loc. D366(T). Figures natural size.

17. *Caryocorbula* cf. *C. subtumida* (Nagao) (p. B9).

Figured specimen USNM 638687, length 17.5 mm, height 11.4 mm, convexity about 5 mm. USGS loc. D366(T). Figures $\times 2$.

18. Scutellinid echinoid, n. fam. n. gen. n. sp. (p. B9).

Figured specimen USNM 638688, greatest dimension 41 mm, aboral surface showing open petals. USGS loc. D362(T). Figures $\times 1\frac{1}{2}$.



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