

*Richard H. Benson*

A New  
Cenozoic  
Deep-Sea Genus,  
*Abyssocythere*  
(Crustacea:  
Ostracoda:  
Trachyleberididae),  
with Descriptions  
of Five New  
Species

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## ERRATUM

The lower two photographs of the two stereopairs of Figure 8 are reversed and give a negative image instead of a positive image as was intended. This error was caught too late in the process of publication to be corrected.



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## ABSTRACT

Benson, Richard H. A New Cenozoic Deep-Sea Genus, *Abyssocythere* (Crustacea: Ostracoda: Trachyleberididae), with Descriptions of Five New Species. *Smithsonian Contributions to Paleobiology*, number 7, 25 pages, 1971.—The new genus *Abyssocythere* Benson has been erected to receive five new species and one described species of psychrospheric ostracode ranging in age from the Paleocene to the Recent. These species include *Abyssocythere casca* Benson, new species (Indian Ocean), herein designated the type species, *A. pannucea* Benson, new species (eastern Pacific), *A. japonica* Benson, new species (western Pacific), *A. atlantica* Benson, new species (Atlantic), *A. australis* (Southern Ocean), and *A. trinidadensis* (van den Bold) from the Caribbean region. Modern species are typical of the deep-sea floor and are common to depths below 2,000 meters. Fossils have been found in deep-water Paleocene and Miocene strata in Trinidad and in deep-sea cores in Pleistocene sediments. These species are thought to have descended from a yet unknown form of the complex of species assigned to the Cretaceous genus *Cythereis* (sensu lato). There seems to be an evolution of finer surface features of the carapace and an increase in size throughout the Cenozoic.

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*Richard H. Benson*

# A New Cenozoic Deep-Sea Genus *Abyssocythere* (Crustacea: Ostracoda: Trachyleberididae), with Descriptions of Five New Species

## Introduction

Over a five-year period I have obtained several hundred dredge and core samples containing ostracodes from the deeper parts of the world ocean. I have discussed the nature of the fauna found in these samples in several preliminary reports (Benson, 1969, 1970), but a formal presentation of taxa is needed to make these forms useful and their names available. The purpose of this report is to record and describe five new species of a new deep-sea psychrospheric genus of ostracode and to assign to it one previously described fossil species. This is the first in a series of taxonomic reports of new ornate ostracodes typical of deep-sea sediments.

## Methods

Because deep-sea ostracodes are difficult to obtain, there have been few efforts to describe them. The *Challenger* Report by Brady (1880) is still the most important descriptive work available. An indication of the morphologic complexity of deep-sea ostracode carapaces can be clearly seen in Brady's plates. A species level comparison of such forms, however, is very

difficult without the use of the Scanning Electron Microscope. One can compare the conventional optical photographic results of the present report with those of the Scanning Electron Microscope to see the importance of this latter instrument. Many new features can be seen in minute detail. For their description I have used much of the terminology of Sylvester-Bradley and Benson (1971), as well as suggesting some new terms particularly applicable to this new genus.

The collections of the specimens on which the present descriptions are based were obtained from piston cores trawl, grab and dredge, and outcrop samples (Table I). The small number of specimens obtained in these samples precluded estimation of variation or relative abundance within the respective species populations. In most instances only one or two specimens were found in a single sample. Relative to many other animal taxa described from the deep-sea floor, this is not an unusually small sample for taxonomic description. The validity of these rare species as separate taxa is based primarily on morphologic distinctiveness.

The ages of the Pleistocene and older specimens given in this report were supplied by David B. Erickson and W. A. van den Bold from foraminiferal zonation.

For the illustrations by conventional light photography (Plate 1) silver nitrate stain was used

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*Richard H. Benson, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.*

TABLE I.—Station and locality area

Map Designation (See Fig. )	Station Number*	Location Latitude	Longitude	Depth (in meters)	Temp. (°C)	Core Level (in cm.)	<u>Abyssocythere</u> Species	Specimens	Age
1	CAP 38 BP	14°16'S	119°11'W	3400	--	68-70	japonica	1	Late Quaternary
2	ALB 4693	26°30'S	105°45'W	2089	--	Dredge	pannucea	4	Recent
3	ALB 4611	10°32'N	88°25'W	3292	1.9	"	"	2	Recent
4	A 156-1	28°35.5'N	77°10'W	1005	--	370	aff. trinidadensis	1	
5	Renz 75	Trinidad		outcrop	--	Navet Fm.	trinidadensis	1	U. Eocene
	Ky 7	"	"	"	--	--	"	1	U. Eocene
	RHC 1047	"	"	"	--	Navet Fm.	"	1	L.-M. Miocene
	RHC 1051	"	"	"	--	--	"	1	L.-M. Miocene
	RHC 1052	"	"	"	--	--	"	1	L.-M. Miocene
	RHC 1055	"	"	"	--	--	"	1	L.-M. Miocene
	B 6972	"	"	"	--	Lizard Springs Fm.	"	1	Oligocene
	FM 995	"	"	"	--	Cipero Fm.	"	1	Oligo-Miocene
	GF 56a	"	"	"	--	"	"	1	Oligo-Miocene
	Wz 213	"	"	"	--	Leugua Fm.	"	1	U. Miocene
6	V16-200	1°58'N	37°04'W	4095	--	710	atlantica	1	Sangamon Interglacial
	V16-200	1°58'N	37°04'W	4095	--	1080	atlantica	1	Illinoisan Glacial
7	V16-203	9°21'N	39°52'W	4149	--	800	"	1	Sangamon Interglacial
8	RO8-91	33°25'S	41°54'W	2723	--	90	"	1	Pleistocene
9	AII-155	0°3'S	27°48'W	3730-3783	--	Dredge	"	1	Recent
10	V9-19	11°23'S	14°15'W	3730	--	160-170-180	"	1-1-1	Sangamon Interglacial
	V9-19	11°23'S	14°15'W	3730	--	260	"	1	Sangamon Interglacial
	V9-19	11°23'S	14°15'W	3730	--	440-460	"	1-1	Illinoisan Glacial
	V9-19	11°23'S	14°15'W	3730	--	600-720	"	1-1	Yarmouth Interglacial
11	V19-297	2°37'N	12°00'W	4120	--	140	"	1	Yarmouth Interglacial
12	IIOE 361G	25°51'S	37°21'E	2750	2.5	Trawl	casca	1	Recent
13	IIOE 363B	23°45'S	43°10'E	2980	2.0	Grab	"	2	Recent
	IIOE 363D	23°45'S	43°11'E	1605	3.6	Trawl	"	1	Recent
	IIOE 366C	23°09'S	43°07'E	2710	2.3	Trawl	"	1	Recent
14	IIOE 367C	22°37'S	41°22'E	3250	1.9	Trawl	"	2	Recent
	IIOE 367G	22°42'S	39°19'E	3140	1.9	Grab	"	2	Recent
15	IIOE 410A	15°07'S	44°21'E	3100	2.2	Trawl	"	4	Recent
16	IIOE 416A	8°45'S	43°39'E	3850	1.4	Trawl	"	1	Recent
17	RC10-161	35°05'N	158°00'E	3587	--	80	japonica	1	Pleistocene
	RC10-161	35°05'N	158°00'E	3587	--	300	"	1	700,000 BP (340 cm)
	RC10-163	32°43'N	157°30'E	3550	--	430-520	"	1-1	Pliocene
	RC10-164	31°43'N	157°38'E	3766	--	250-260	"	1-1	Pleistocene
	RC10-164	31°43'N	157°38'E	3766	--	290	"	1	Pleistocene
	RC10-164	31°43'N	157°38'E	3766	--	420	"	1	Pleistocene
18	ELT 39-10	48°03.1'S	126°17'E	3390	--	Grab	australis	20	Recent

\*See under Acknowledgments for sample source.



(Benson 1965) and reduced by the heat of a very hot Bausch and Lomb microscope lamp, especially assembled for this purpose. The Leitz Panphot system with Ultrapack lenses was used with substage as well as incident lighting. The Kent-Cambridge "Stereo-scan" was used for the SEM photographs (all photographs exclusive of Plate 1). Some specimens were coated with aluminum, others with gold. No discernible differences in the final product due to use of these different metals has been noted.

In the section on "Systematics" the cataloged "paratypes" refer only to figured paratypes. Other specimens belonging to the new species were indicated but not cataloged. The non types loaned by Dr. van den Bold reside in his collections, one holotype and paratype set (*Abyssocythere australis*) is the property of the University of Kansas.

### Acknowledgments

The author is indebted to W. A. van den Bold of Louisiana State University, Francis Parker of Scripps Institution of Oceanography (Capricorn sample, CAP 38BP), David B. Erickson and Goesta Wollin of Lamont-Doherty Oceanographic Laboratory (*Vema* and *Chain* core samples), Howard Sanders of Wood's Hole Oceanographic Institution (*Atlantic II* sample), and Meade Cadot of the University of Kansas (*Eltanin* sample) for sample material and specimens. The samples of the International Indian Ocean Expedition were collected by me in 1964; the *Albatross* samples are property of the National Museum of Natural History. Thanks are expressed to Joseph E. Hazel and Louis S. Kornicker for their critical reviews of this manuscript and to Laurie Jennings and L. B. Isham who helped me prepare and illustrate the specimens. Work on this project and collections were funded through Smithsonian Research Foundation Grant SRF-436020 and National Science Foundation Grants GA-17325 and GA-12472.

### Biogeography

Fossil specimens have been recovered in core and trawl or grab samples from twenty-five ocean floor localities in eighteen areas from throughout the world ocean, and from ten surface outcrops of "deep-water" strata in Trinidad (Figure 1, Table I). Sampling has been unevenly distributed, but thus far *Abyssocythere* seems

to be: (1) cosmopolitan but restricted to sediments found in "deep" marine environments (depths usually greater than 2,000 meters and often greater than 3,000 meters; Figure 2); (2) absent (in about 50 samples) in the North Atlantic (except near the Blake Plateau in the North American Basin and physiographically restricted deep basinal regions over 5,000 meters; and (3) divisible into distinct species, consistent morphologically and generally widely separated geographically (one in each ocean region; Figure 3).

Although *Abyssocythere* is represented by fossils in at least eight localities in the deep sea of the equatorial and western Atlantic, ranging in age from Paleocene through late Pleistocene, only two Recent specimens have been found (one by Brady 1880, *Challenger* Station 323 off Uruguay, see discussion next section; another by me from near St. Paul's Rocks, Station 9 of this report). Almost sixty Recent samples from the deeper parts of this region were examined in which this genus did not occur. Specimens appear concentrated near the Yarmouth to Sangamon interglacial (including the Illinoian glacial) time intervals (Table I).

*Abyssocythere* was found at eight dredge stations in the western Indian Ocean (Mozambique Channel). No cores were examined from this area. All of the specimens are presumed to be Recent in age. The lack of samples in the eastern Indian Ocean precludes an estimate of its importance there. But finding *A. australis* in abundance south of Australia suggests that in the future it may be found to be common in the Southern Ocean. There are obvious morphological similarities between the species of these two areas.

Specimens from Pliocene and Pleistocene sediments in the Pacific are quite distinctive and morphologically distant from those found elsewhere. Two species were described from the eight Pacific stations in three regions. Solution of calcium carbonate in the great depths common to the North Pacific and lack of samples from the South Pacific make the distribution of these species difficult to estimate. However, *Abyssocythere japonica* was found in cores (localities 1, 3, and 17, Table I) on both sides of the Pacific.

Specimens of *Abyssocythere trinidadensis* supplied to me by W. A. van den Bold came from ten outcrop samples ranging in age from Eocene to Miocene from Trinidad. This species was found with "*Bradleya*" *hazela*, *Krithe*, and other forms characteristic of a deep marine environment and has been reported from

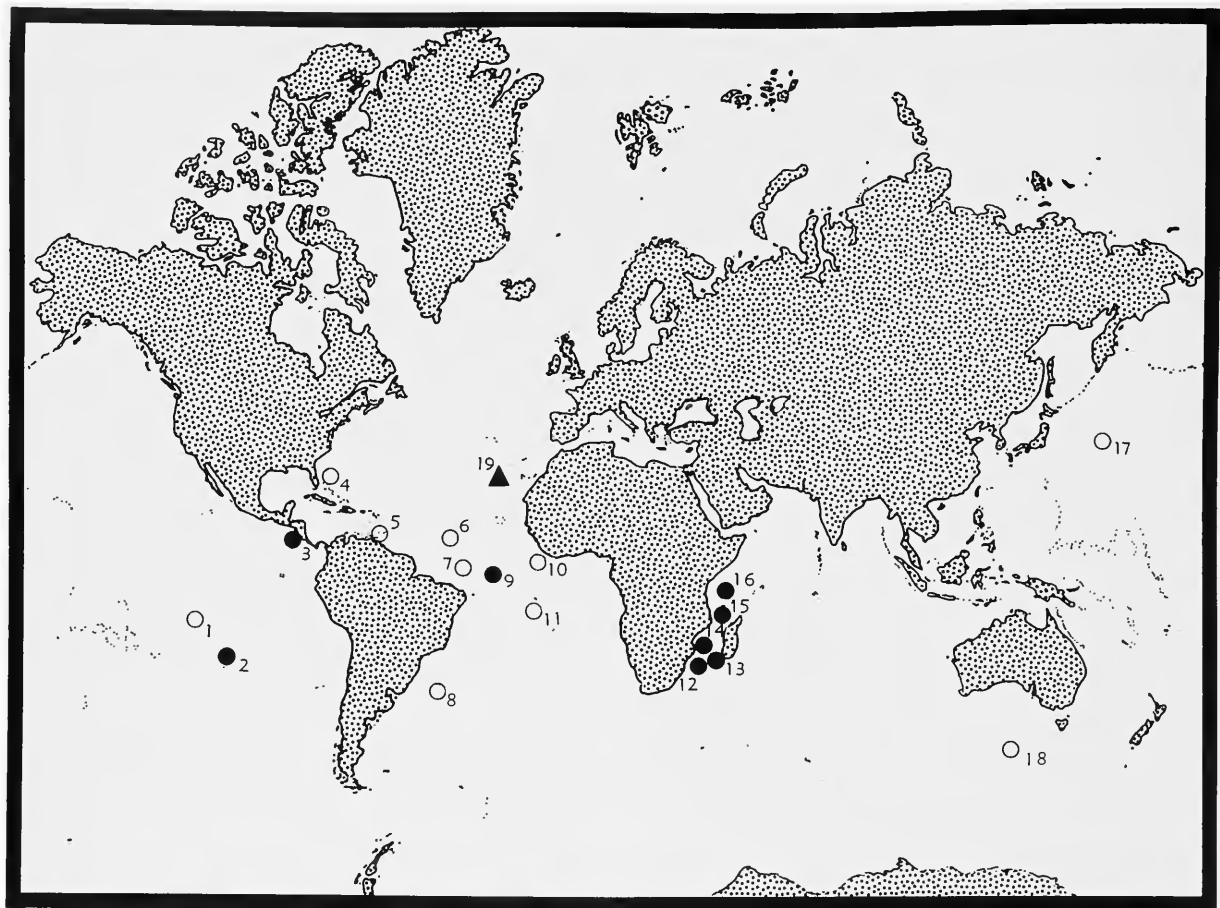


FIGURE 1.—Localities of samples from which specimens of *AbyssocytHERE* were obtained (also see Table I): ○=core or outcrop (locality 5) localities; ●=dredge or trawl sample localities; ▲=site of the JOIDES core (hole 12c, leg 2) given in Table I (Station 19) and discussed in the Addendum.

strata as old as Late Cretaceous. The absence of shallow benthic Foraminifera in these strata supports the hypothesis that *A. trinidadensis* has been a “deep-water” inhabitant since the Mesozoic. More data are required to determine the extent that this species and *A. atlantica*, which probably is a descendant, both lived in an abyssal depth.

It is early yet to say, but from judgments of morphologic similarity, fossil and present distribution, some phyletic relationships among the species described here might be inferred. From the evidence at hand *AbyssocytHERE* seems to have lived on the deep-sea floor at the end or soon after the end of the Mesozoic (if the conjecture about the habitat of the Trinidad species is correct), and apparently it spread throughout

the world ocean during the early and middle Cenozoic. During the Pleistocene it seemingly became rare and restricted in its distribution. Its present restriction to cold waters ( $4^{\circ}\text{C}$  or less) is correlated with an increase in size (from about 0.9 mm to 1.1 mm) and the emphasis of greater morphologic detail, including secondary reticulation. Earlier in somewhat warmer oceans (assuming cooling of abyssal waters is a product of late Cenozoic history), its range was probably controlled more by substrate type and competition and less by psychrospheric conditions.

*AbyssocytHERE* species are rare but widespread in deep-ocean samples. It is curious that such a morphologically complex form can be maintained through long periods of time over such great distances. There are



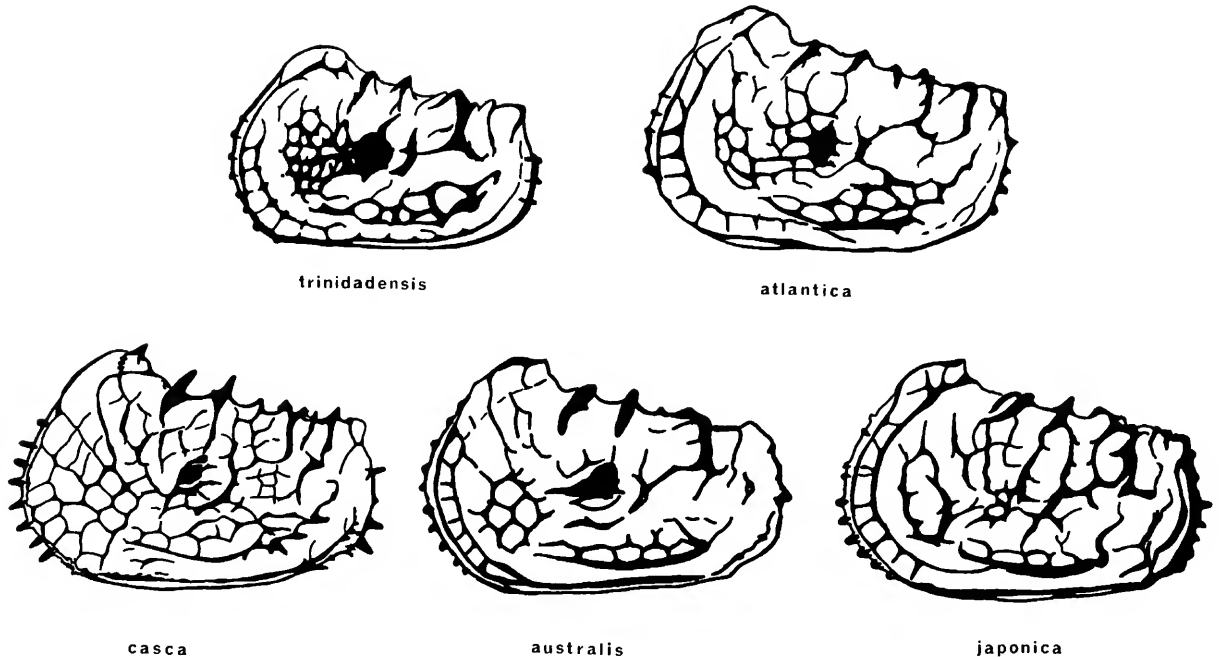


FIGURE 3.—Five of the six species of *Abyssocythere* described herein as seen through variation in the patterns of the reticulum.

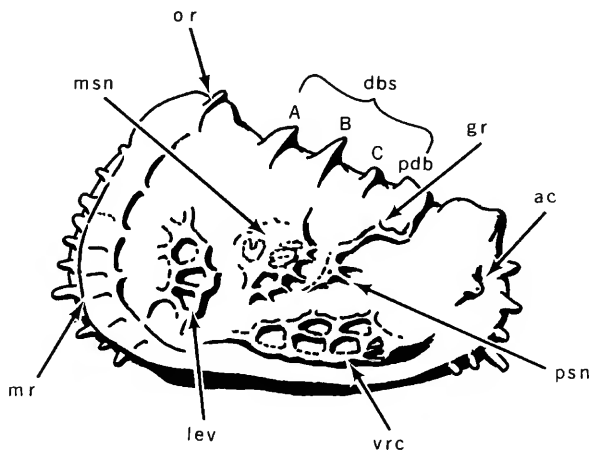


FIGURE 4.—General morphology of the carapace exterior of *Abyssocythere*: or=ocular ridge; dbs=dorsal bullar series; pdb=posterodorsal bulla; gr=gamos ridge; ac=anal conulus; psn=postsulcular node; vrc=ventrolateral reticulate complex; lev=levatum; mr=marginal rim; msn=muscle-scar node.

reticulate complex or **levatum** (lev; raised), the ventrolateral reticulate complex (vrc), the muscle-scar node (msn), the **postsulcular node** (psn), and the **dorsal bullar series** (dbs) of which the aftermost, the posterodorsal bulla (pdb) is the most prominent. As stated above, the intensity of the expression of the reticulum varies within these six regions, making it possible to distinguish among species.

The levatum (anterior reticulate complex) may be evenly reticulate joining the rest of the reticulum without a noticeable change in relief (as in *Abyssocythere casca* or *A. australis*) or may be raised and quadrafoil (*A. atlantica*) or raised, seriform, and open (*A. japonica*). The tendency to form a discrete elevated reticulate complex, set apart from the rest of the reticulum, is distinctive of *Abyssocythere*.

The ventrolateral ridge is comprised of a box-work structure (the ventrolateral reticulate complex, vrc) within which the reticulum forms the region of greatest carapace width. It usually has five rectangular fossae

joined ventrally by a strong ventrolateral carina. This structure is especially well developed in *casca* (Plate 1: figure 4), and becomes narrowest in *japonica*.

The muscle-scar node varies from a smooth bulbous prominence in *A. trinidadensis* to produced and laterally elongate in *australis* to subdued, but murose, in *casca* and *pannucea*. The muscle-scar node is very poorly developed in *japonica*. The prisms of muscle scars generally interfere with both the primary and the secondary reticulation of this structure.

Just posterior of the muscle-scar node and across the vertical row of fossae and laddered muri is a conspicuous intramural pore on, what is called here, the postsulcular node. There are other intramural pore nodes, but this is one of the most conspicuous. From it (especially conspicuous in *australis* and *trinidadensis*) runs a ridge to the posterodorsal bulla. This "psn-pdb" ridge is called the gamos (union) ridge as it joins these other prominent features. In *japonica* it joins two other prominent vertical posterodorsal ridges. In *australis* and *trinidadensis* the gamos ridge is straight, whereas in the other four species it bends sharply at least once throughout its extent. In *casca* this bend comes at the point where a second pore (the "psn" pore being the first) interferes with continuity of the ridge.

The dorsum is punctuated by the presence of the anterodorsal "ear" (prominent on the left valve only), the four mural processes of the dorsal bullae series (A, B, C, and the pdb), and the somewhat sharp posterior cardinal angle. The first (most anterior) two dorsal bullae (A, B) are usually the highest dorsally (especially in *casca*), the third (C) is often diminished (as in *australis*, *pannucea*, and *trinidadensis*), and the fourth or posterodorsal bulla (pdb) is the most prominent and massive (most in *australis*, least in *atlantica*). The anterodorsal bullae (A, B) are often bladelike (*australis* and *japonica*). They can be blunt or diminished (*trinidadensis*), attenuated and spinose (*casca*), or "cocked" (*pannucea*).

The marginal rim is usually confined (in the left valve) to the anterior and venter (*atlantica*, *australis*, *trinidadensis*); however, *japonica* has both an anterior and posterior rim, whereas *casca* has only a trace of a rim on the anterior. The rim is crossed by muri from the reticulum. On its distal or outward margin it may have very irregular secondary reticulation. It grades anterodorsally into a flange or "ear" that is produced distally, but its relief and reticulate pattern is continuous with the main part of the carapace surface. This

"ear" has a blunt spine in *casca*, *pannucea*, *australis*, and *japonica* (Indo-Pacific species) but is unadorned in the other known species (Atlantic species). In the area of the eye tubercle there is a bifurcated (ocular) ridge and the uppermost branch may be absent (*pannucea*), interrupted as a series of small spines (*casca*, and less so in *japonica*), or simple (*atlantica*, *trinidadensis*, and *australis*).

Several pores (mostly intramural celate pores) are present in all species of *Abyssocythere* and are considered homologous within the genus. One is found associated with the postsulcular node, usually at its ventral end. This could be homologous with the pore-conulus of *Cythereis*. A second prominent pore node is present in the posterior (Plate 2: figure 6) portion of the valve near the median line and is herein called the anal conulus as it occurs in the region of the anus, although its actual functional association with this organ is doubtful. Its prominence and consistency among species of *Abyssocythere* give reason to call attention to it as a special feature. Other pores are also present, but their homology is not yet traceable throughout all of the species with the material at hand.

For further morphologic description see that discussion under the type species (*A. casca*).

COMPARISONS.—Species of *Abyssocythere* are not demonstrably closely related to any genus known to the author. However, *Abyssocythere* is similar in many respects to *Cythereis* (sensu van Morkhoven 1963). Its hinge has crenulate anterior terminal elements (Figure 5). The median element is smooth and quite typical of

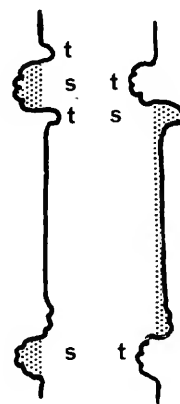


FIGURE 5.—A diagram of the hinge of *Abyssocythere* showing the tooth (t) and socket (s) arrangement.

a holamphidont hinge. The hinge is similar to that illustrated for "*Cythereis*" by Sylvester-Bradley in 1948 except that the posterior element is less boldly crenulate. The anterior end is "eared" at the anterodorsal cardinal angle as is *Cythereis*, but its posterior is blunt rather than acuminate. The surface ornament of *Abyssocythere*, as described above, is unusual and diagnostic. The median ridge of *Cythereis* or other comparable genera is absent, but the muscle-scar node is in evidence. The V-shaped frontal scar and the four complete adductors with the lower two set somewhat oblique to the others suggest a primitive trachyleberine affinity (Figure 6). The significance of the offset of the lower

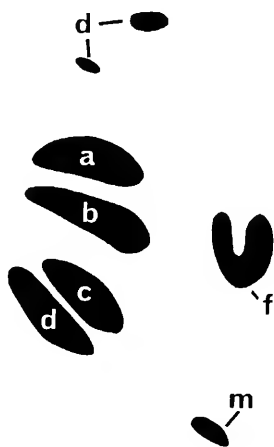


FIGURE 6.—Muscle-scar pattern of the type species of *Abyssocythere casca* with the adductor scars (a-d), dorsal scars (d), frontal scar (f), and mandibular scar (m).

two adductors is not yet understood. The surface sculpture of *Abyssocythere* differs from "*Cythereis*" (sensu Triebel 1940) in that the median ridge (mittelrippe) is poorly developed or absent (not homologous with the gamos ridge), the dorsal marginal ridge is replaced by several prominent tubercles or spines (dorsal bullar series), and the posterior marginal rim is subdued and rounded. The interior morphology of the two forms (as shown in comparison of Plate 1: figure 6 with Figure 2 of Triebel 1940) is quite similar, with the exception of the snubbed posterior margin and less crenulate posterior tooth of *Abyssocythere*, as now conceived.

In 1957, when van den Bold described *Cythereis? trinidadensis*, he made note of the distinctiveness of

this form and then suggested that it may belong to a new genus. Because he had only the one species he deferred making a new taxon for which six species are now available:

*Abyssocythere casca* Benson, new species; Madagascar Basin, Recent; herein designated the type species.

*A. pannucea* Benson, new species; Eastern Pacific, Recent.

*A. atlantica* Benson, new species; South Atlantic, Pleistocene.

*A. japonica* Benson, new species; Northwest Pacific, Pleistocene.

*A. australis* Benson, new species; South of Australia, Recent.

*A. trinidadensis* (van den Bold), 1957, Trinidad, Paleocene to Lower Miocene.

?*A. squalidentata* (Brady), 1880, nomen dubium, Recent of the South Atlantic (35°S–50°W, *Challenger* Station 323, 1,900 fms.); lectotype British Museum 81.5.29 (Plate 1: figure 9). A whole specimen of an early instar with characteristics of *Abyssocythere*. With the immature and poorly preserved specimen at hand, it would be impractical to perpetuate this name to represent a valid species. I suggest that the name *squalidentata* should be suppressed. If mature specimens with soft-parts of species living in the South Atlantic are found, they should not be assigned to *A. squalidentata*. A new species should be described because association with the specimen in the *Challenger* collections would be difficult if not impossible to prove. The early instars do not possess the identifying characteristics of the different species, although they do have those of *Abyssocythere*.

### 1. *Abyssocythere casca*, new species

FIGURE 7; Plate 1: FIGURES 1–8; Plate 2: FIGURES 1–9

ETYMOLOGY.—Latin *casca*, old.

HOLOTYPE.—Left valve adult male; Plate 1: figures 1, 3, and 8; USNM 170276 (stained).

PARATYPES.—Left and right valves, adult female and male; Plate 1: figures 4–6; USNM 170277 (stained).

TYPE LOCALITY.—Indian Ocean, Madagascar Basin off Tulear, Madagascar, in the vicinity of IIOE sample 363B; latitude 23°45'S, longitude 43°11'E. 2,980 meters depth; temperature approximately 2°C.

AGE.—Recent; no living specimens were found.

DIAGNOSIS.—Distinguished from other species of *Abyssocythere* by its prominent and spinose dorsal bullar series, subdued or absent marginal rim, and high

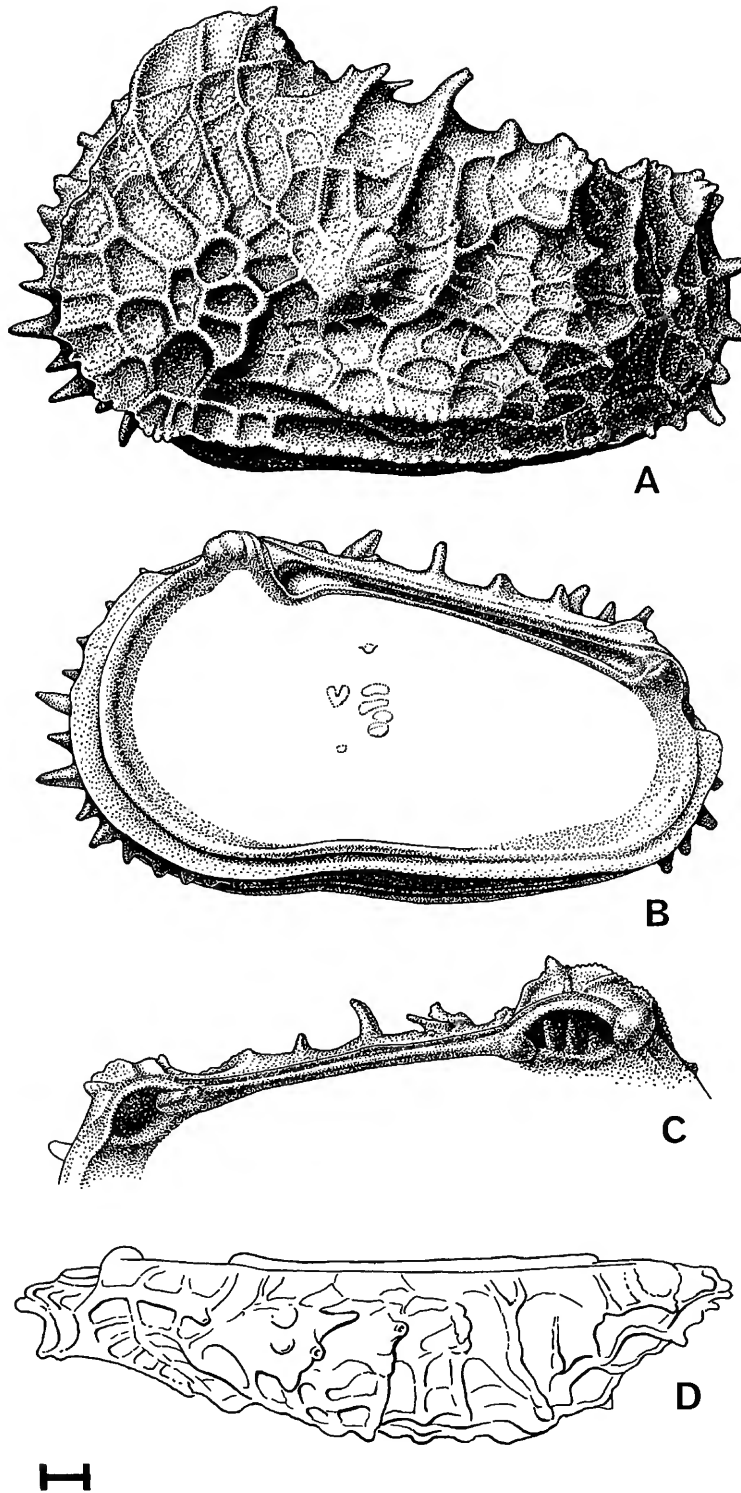


FIGURE 7.—*AbyssocytHERE casca* showing A, the exterior lateral view of the left valve; B, interior of right valve; C, the hinge of the left valve; and D, the dorsal view of the left valve (magnification scale =  $100\mu$ ).

anterior. The anterodorsum of the left valve is "eared." The anterior margin has no distinct rim and the reticulate pattern of this region focuses on the muscle-scar node, with the intermediate mural design of the anterior reticulate complex (levatum) suppressed in relief, but its member elements are well developed.

**DESCRIPTION.**—General shape subquadrangular to subrectangular and moderately inflated as shown in Figure 7 and Plates 1 and 2. The left valve is strongly "eared" in the region of the anterior hinge element, which is crossed by a denticulate ridge. This feature is absent in the right valve. The posterior of the left valve appears blunted and is subround in lateral view because of a marginal protuberance that is missing in the right valve. The dorsal margin is marked in both valves by prominent dorsal bullae. The anterior and extreme posterior margins are denticulate. The spines of the latter regions are related to the commissure, whereas those of the dorsum emerge from the murae of the reticulum. The venter is marked by a series of subparallel ridges with the distal and strongest forming the ventrolateral ridge, the widest part of the carapace.

**ORNAMENTATION.**—The reticulum of the carapace (of which many aspects are discussed under the genus) consists of primary and secondary reticulation (one of the most conspicuous aspects of sculpture) with intramural pores and emergent processes forming spines, bullae, and bosses toward the dorsum and ventrolateral ridge areas. The reticulum is interrupted in the area of the muscle-scar node by the adductor and frontal muscle scars. Anterior to the muscle-scar node the reticulum is elevated to form an open to quadrafoil and multifoil pattern of muri. An intramural pore is present posteroventrally to the muscle-scar node (in the region of the postsulcular node) and may be homologous with the pore conulus of *Cythereis*. No other general homology of sculptural detail is suggested. Two (celate sieve) pores (Plate 2: figures 7, 8) occur along the median line of the posterior region (Plate 2: figures 1, 6) and the one is found near the lower end of the vertical ridge of the posterodorsal bulla (Plate 2: figure 6). These latter pores are seen in *A. pan-nucea* from the eastern Pacific, and *A. australis* from the Southern Ocean. Positions of pores in the anterior regions may be conservative among other species of *Abyssocythere* but are not associated with prominent processes as in *A. casca*. The anal conulus pore is present as with all species of *Abyssocythere*.

An eye tubercle is missing, and the animal is presumed to be blind. The region of the eye tubercle is marked by an ocular ridge formed by a series of small spines (Plate 2: figure 5). This ridge is smooth, simple, or missing in other species.

The ventrolateral ridge consists of an emphasized segment of the reticulum, of which the muri form a box-work structure (Plate 2: figure 4) with conjunctive intramural pores and disjunctive ventral spines. No pores seem to be associated with the spines. A larger posterior terminal spine is present.

**HINGE.**—The hinge is mixed between holamphidont and lobodont (Figures 7B and c, Plate 1: figures 6 and 7) with the further addition of a tooth anterior to the front socket in the left valve. The anterior boss-like tooth of the right valve is frontally highest, lobate to crenulate with at least four well-defined subdivisions. The corresponding socket of the left valve is equally well formed with subdivisions to receive the crenulate tooth. The posterior tooth is smaller and crenulate with the subdivisions ill-defined and missing in the corresponding socket.

The median hinge element is typically holamphidont with a small, smooth anterior tooth in the left valve and with a crenulate posterior terminus. A small tooth is formed by the selvage just anterior to the socket in the left valve (first observed by van den Bold 1957 in *A. trinidadensis*). Its corresponding socket is obscure in the right valve.

**INNER MARGIN AND DUPLICATURE.**—The duplicature is typically trachyleberid with straight, moderately spaced radial pore canals. A vestibule is absent. The selvage is a simple continuation of the hinge.

**MUSCLE-SCAR PATTERN.**—The frontal muscle scar is "V"-shaped; the adductors are undivided with the upper two oriented horizontally and the lower two somewhat oblique (Figure 6). Two other scars were noted above the adductors as was the presence of a small mandibular scar.

**DIMENSIONS.**—Adults are typically from 1.0 mm to 1.1 mm in length; 0.7 mm to 0.8 mm in height. The slightly more elongate forms are considered as males.

**SOFT-PART ANATOMY.**—No living specimens with "soft-parts" were found.

**MATERIAL.**—Fourteen recent specimens of this species were considered for this study, all obtained from dredges, trawls, and grabs from the depths of Mozambique Channel, in Madagascar Basin and North Madagascar Basin. Their localities are listed in Table I.



**ECOLOGY.**—With one exception (IIOE 363D, depth 1,605 meters) all specimens were found in depths greater than 2,700 meters with the deepest find at 3,850 meters. The sediment type was pelagic globigerinid ooze. The temperature range was less than 2.0°C about a mean of about 2.0°C. This species is psychrospheric and abyssal.

**REMARKS.**—*Abyssocythere casca*, the type species of the genus and the best known of those described here, appears to be morphologically conservative over its range. The processes and reticulate pattern that distinguish it from other species seem to be most like *A. australis*, which is closest in age and geography. This and other relationships are given above under consideration of variation within the genus.

Van Morkhoven (1963) remarked that the crenulate anterior hinge of *Cythereis* is always higher proximally than it is distally. The significance of this observation with regard to this hinge element in other genera is unclear. It may be noted, however, that in *Abyssocythere casca* the converse is true, with the anterior tooth higher distally.

## 2. *Abyssocythere trinidadensis* (van den Bold) 1957

FIGURES 8, 9; PLATE 3: FIGURES 4, 5, 6.

*Cythereis? trinidadensis* van den Bold, 1957:8, pl. 3: figs. 1a-d; 1960:165.

**HOLOTYPE.**—Whole specimen, originally designated by van den Bold 1957, is figured for the first time herein, Figure 8; Plate 3: figure 6; USNM 562037. The specimen figured by van den Bold (1957, pl. 3: fig. 1) was much younger (Oligo-Miocene; Cipero Fm.) than the holotype.

**HYPOTYPES.**—Figured (Plate 3: figure 5) left valve; USNM 170278; right valve USNM 170279 (Figure 9; Plate 3: figure 4).

**TYPE LOCALITY.**—The Navet Formation, lower and middle Eocene of southwestern Trinidad (San Fernando Bypass, RHC Sample 1047).

**AGE.**—According to van den Bold (1957) this species is found in strata ranging in age from Late Cretaceous to Late Miocene. A form transitional between *A. trinidadensis* and *A. atlantica* was found (but later lost during examination) in the Pleistocene of the western portion of the North American Basin.

**DIAGNOSIS.**—Distinguished from other species of *Abyssocythere* by exterior features of the carapace such

as its bulbous muscle-scar node, a massive anterior reticulate field (without a distinct levatum) between the muscle-scar node and the anterior marginal rim. It is usually somewhat smaller (length 0.8–0.9 mm) and more massive than the other species (average 1.1 mm in length). The straight gamose ridge and posterior marginal rim are pronounced in some older (Eocene) specimens, but less so to negligible in younger (Miocene) forms. The internal features of the carapace are similar to the type species and typical of the genus.

**REMARKS.**—In his original description van den Bold (1957) noted that *Cythereis? trinidadensis* had “slightly grooved terminal teeth . . . a crenulate anterior tooth . . . and a peculiar tooth in front of the anterior socket of the left valve,” which separated this form from *Cythereis*. He also called attention to the posterior rim, the ridge connecting the muscle-scar node to the anteriormost member of the dorsal bullar series, and the reticulate ventrolateral ridge.

Professor van den Bold kindly sent fourteen additional specimens (belonging to him) of *Abyssocythere trinidadensis*, besides the type, to me for the writing of this report. These included specimens (see Table I) from the upper Eocene (samples Renz 75; see Plate 3: figure 5; Ky 7; see Figure 9 and Plate 3: figure 4, RHC 1051, 1052, and 1055); Lizard Springs, Oligocene (B6972); Cipero Formation, Oligo-Miocene, *Globorotalia fohsi lobata* Zone (PM 995 and GF 56a, Figure 3); and the Lengua Formation, upper Miocene, “*Globorotalia menardii*” Zone (Wz 213).

Evolutionary change in the morphology of this species throughout the Cenozoic seems to be slight. The older Eocene specimens are generally ten percent shorter than Miocene forms and twenty percent shorter than known Pleistocene and Recent species. Features such as the gamose ridge, ventrolateral ridge, dorsal bullar series, and marginal rims are more discrete and pronounced on a generally more massive carapace (Figures 8 and 9). The larger younger forms assume a more delicate aspect but are still more massive and smaller than modern abyssal species.

*Abyssocythere trinidadensis* seems to be ancestral to *A. atlantica*. *A. atlantica* originated from *A. trinidadensis* and became larger with a better developed secondary reticulation and a generally finer, more delicate reticulum. The muscle-scar node of *A. atlantica* is attenuated compared with the bulbous node of *trinidadensis*. A specimen (now lost) of an intermediate form

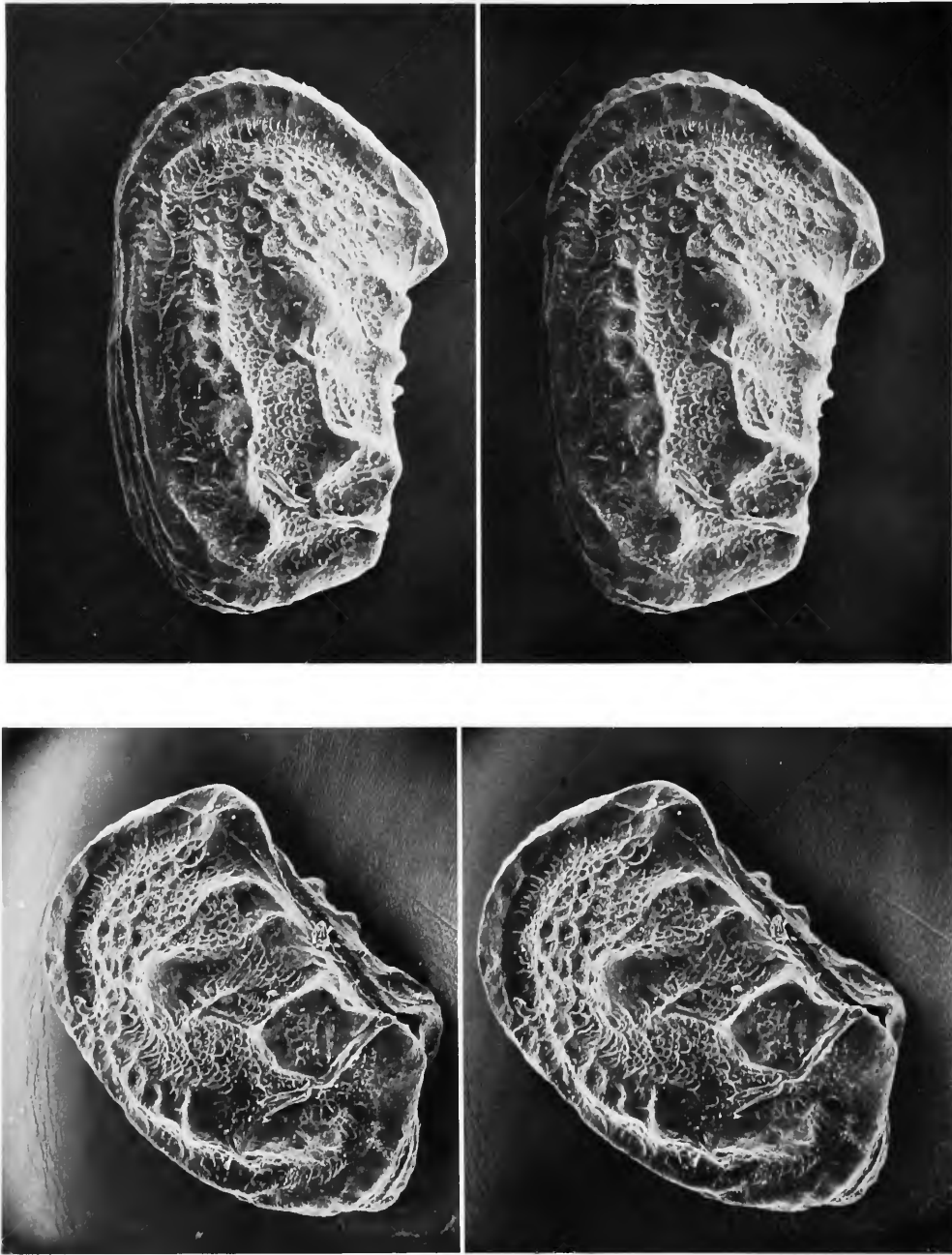


FIGURE 8.—Stereophotographic pairs of the holotype (USNM 562037) of *Abyssocythere trinidadensis* van den Bold as seen from the lateral, posterodorsal oblique, and ventrolateral oblique views (magnification  $\times 80$ ).

of Pleistocene age was found in a core (Lamont A 156-1, 370 cm) in 1,005 meters depth from the North American Basin off Florida (Locality 4). This specimen was about 1.0 mm in length. It had the massive aspect of

the younger (Miocene) *trinidadensis*, especially in the region anterior reticulate complex or field (compared to the emerging levatum of *A. atlantica*); its gamos ridge was diminished like *atlantica*; and there was a

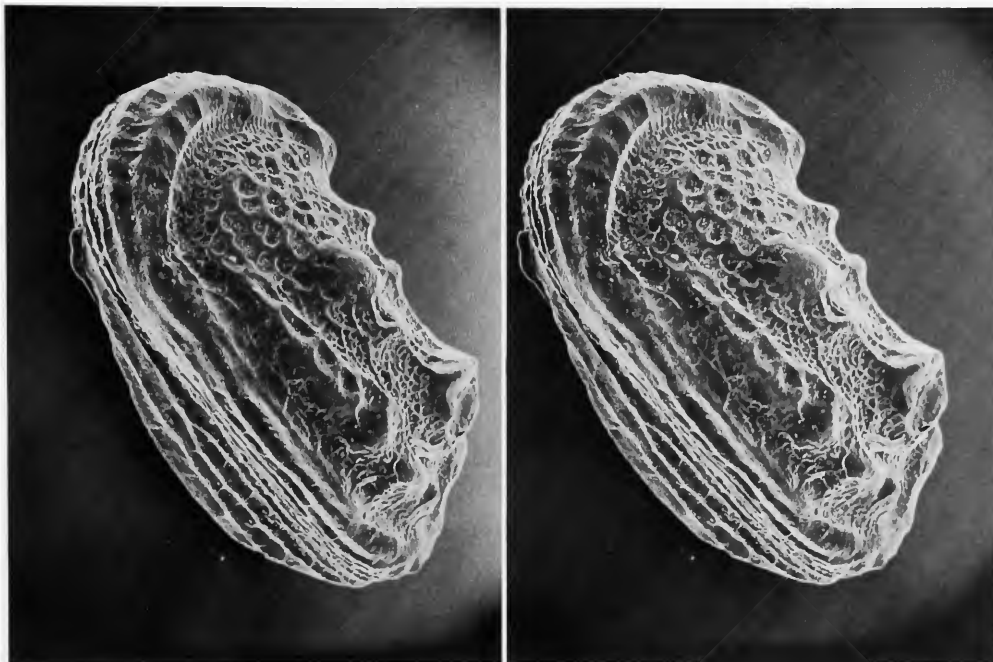


FIGURE 8.—Continued

trace of the posterior rim remaining. The shallower depth (1,005 meters) may have influenced the size and massive aspect of the carapace of all of these older forms, but its development from a small and massive aspect, with prominent but fewer muri, to a larger form, with produced but more delicate prominences and secondary reticulation, is indicated by the specimens at hand.

Morphological comparisons of this species with the others described herein are given under the discussion of the genus.

**DIMENSIONS.**—Length of holotype, 0.90 mm; height 0.58 mm. Length of hypotype figured herein 0.90 mm; height 0.60 mm.

**MATERIAL.**—Only fossil specimens are known. Fourteen specimens from Trinidad ranging in age from Eocene to Miocene were considered (see Table I).

**PALEOECOLOGY.**—Considering the size, architecture, and faunal association of the older specimens (Eocene) in comparison with the morphology and distribution of the youngest related (*A. atlantica*) species, one would estimate that *A. trinidadensis* was upper bathyal

(500 to 1,000 meters) rather than abyssal. If, however, the waters were warmer during the Early Cenozoic, the animals could possibly have lived at greater depths. The present psychrospheric species are larger and more delicate, yet their general faunal association is similar. *A. trinidadensis* has no eye tubercle and is presumed blind, suggesting again a habitat at considerable depth.

### 3. *Abyssocythere atlantica*, new species

FIGURE 10; PLATE 3: FIGURE 1

**HOLOTYPE.**—Left valve adult, sex unknown. Plate 3: figure 1; USNM 170280.

**PARATYPES.**—USNM 170281.

**TYPE LOCALITY.**—Equatorial and southern Atlantic in the region of Lamont core V9-19, latitude 11°23'S, longitude 14°15'W, depth 3,730 meters, horizon approximately 460 cm down in core.

**AGE.**—Pliocene to Recent; found in JOIDES core in Cape Verde Basin (Hole 12c Core 4, 100-106 cm level, see Addendum; in Middle to Upper Pliocene strata; found in seven cores in strata dated as Pleistocene (Yarmouth, Illinoian, Sangamon) by plank-

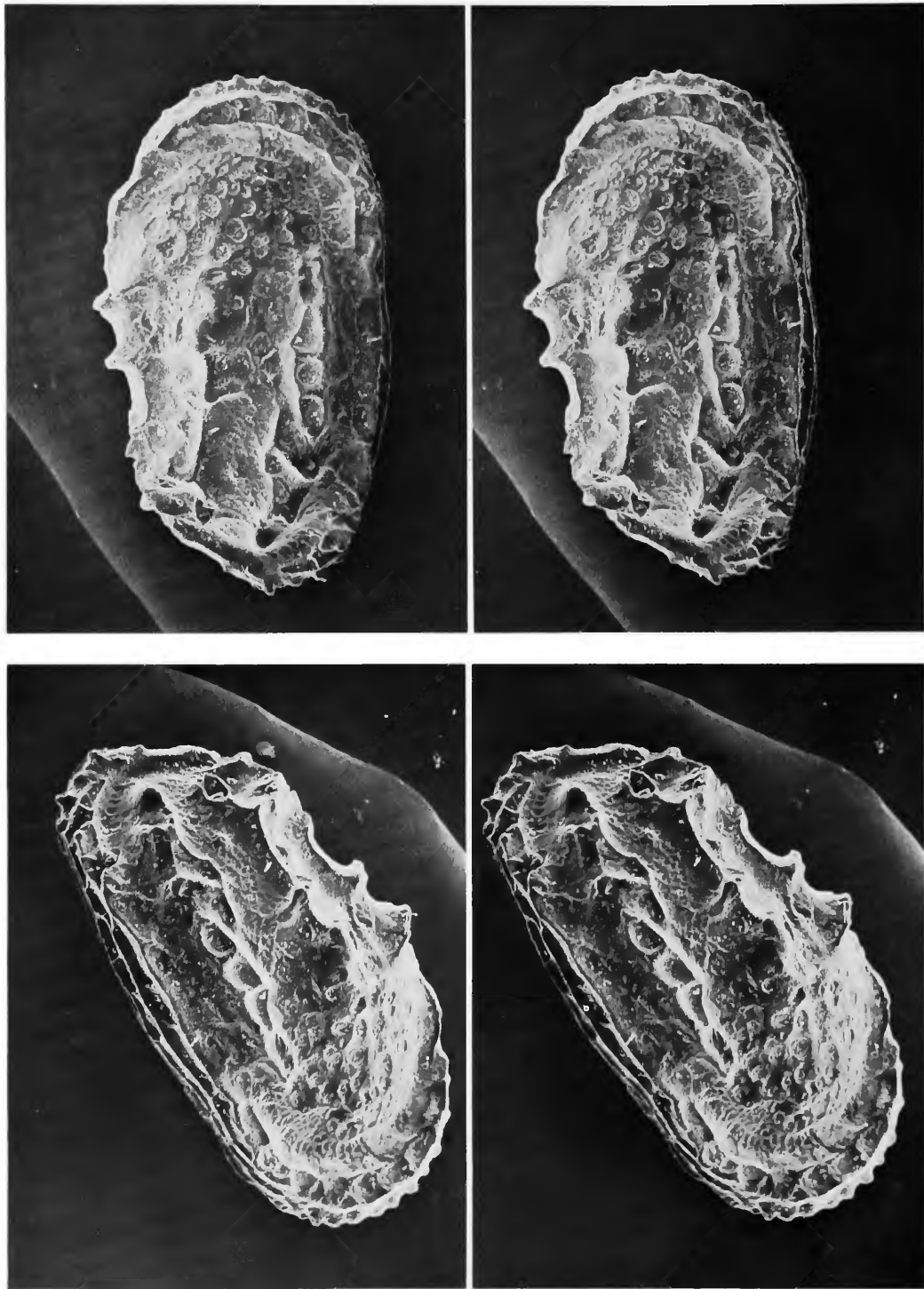


FIGURE 9.—Stereophotographic pairs of a hypotype (USNM 170279), right valve of *Abyssocythere trinidadensis* from the upper Eocene of Trinidad (van den Bold locality Ky 7; magnification  $\times 80$ ).

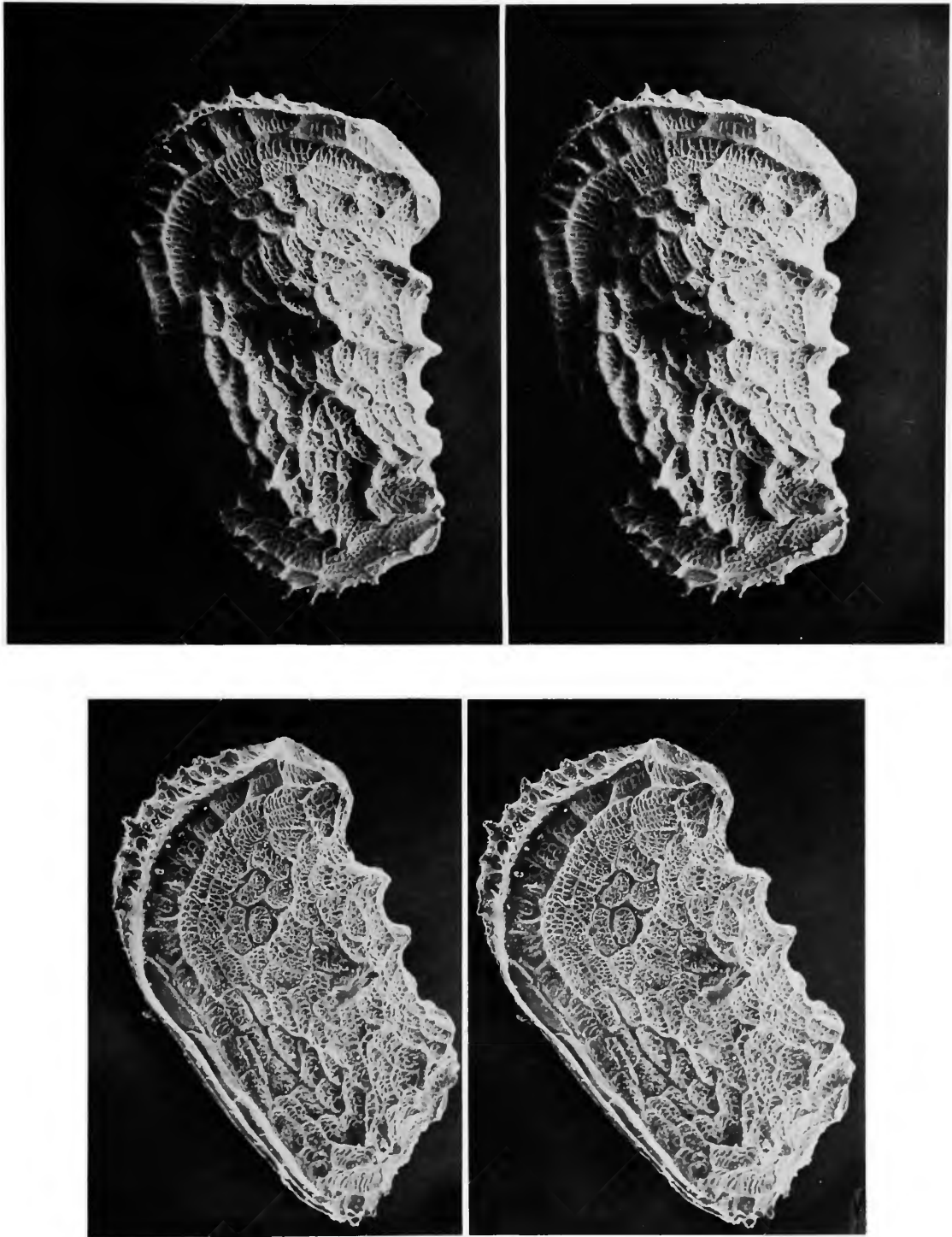


FIGURE 10.—Stereophotographic pairs of the holotype (USNM 170281) of *Abyssocythere atlantica*, new species, a left valve from the Pleistocene of the equatorial Atlantic (see text) from lateral view and anteroventral oblique view (magnification  $\times 80$ ).

tonic Foraminifera (Erickson and Wollin 1964) and one Recent dredge sample. None have been found living at the time of this report. The range, in shallow core penetration (Pleistocene record) below sediment-water interface, is from 160 to 800 cm. Occurrence in deep penetration JOIDES core approximately 3,360 cm below sediment-water interface.

**DIAGNOSIS.**—This species of the genus *Abyssocythere* can be distinguished by external carapace features such as its attenuated muscle-scar node (often spinose), a raised anterior reticulate complex (levatum), the presence of a murose anterior marginal rim but no posterior marginal rim (on the left valve), a suppressed gamos ridge, secondary reticulation, and prominent, yet spineless, anterodorsal "ear." The internal features are like that of the type species and typical of the genus.

**REMARKS.**—This species, which is thought to be a descendant of *A. trinidadensis* (see Remarks under that species), is large and delicately ornate. Its levatum is similar to that of *A. japonica*, except that it has inner muri, making it multifoil rather than seriform and open. Its ventrolateral reticulate complex is also well developed like *A. casca*, whose dorsal bullar series is more produced, and has no discrete anterior marginal rim. Its posterodorsal bulla is angular but less produced than *A. australis* and is not as complex as *A. japonica*.

**DIMENSIONS.**—Holotype, length 1.15 mm; height 0.73 mm.

**MATERIAL.**—Only fossil forms have been found, all from the equatorial and southern Atlantic. One Recent specimen (a right valve) was found, also from the equatorial Atlantic (locality 9, Figure 1). In all fifteen specimens were found. Their localities and horizons are listed in Table I (see Addendum for data on JOIDES core specimen from Cape Verde Basin).

**ECOLOGY.**—Although no living specimens and only one Recent specimen were found, it seems unlikely that the older fossil specimens have ever been in an environment different than the one now extant in the area where they were found. With the exception of the transitional form discussed in the preceding section (Remarks; under *Abyssocythere trinidadensis*, which see), all occurred in depths greater than 2,700 meters and most samples (six of seven) were collected in depths greater than 3,700 meters. Three of the deepest records of *Abyssocythere* were with this species, all over 400 meters (4,095, 4,120, 4,149, and 4,542

meters). The structure of the eye tubercle indicates the species was (is?) blind. *A. atlantica* is presently considered a true psychrospheric, abyssal species.

#### 4. *Abyssocythere japonica*, new species

FIGURE 11; PLATE 3: FIGURE 3

**HOLOTYPE.**—Left valve adult, female(?); Plate 3: figure 3; USNM 170282.

**PARATYPE.**—Right valve adult, male(?); USNM 170283.

**TYPE LOCALITY.**—Northwestern Pacific, east of Japan, vicinity of Lamont core RC10-163; latitude 32° 43'N, longitude 157° 30'E; 3,550 meters depth.

**AGE.**—Pleistocene-Pliocene; holotype found at 430 cm below sediment-water surface in core (RC10-163), other specimens found in core samples ranging in sediment penetration from 80 to 420 cm (see below under Material).

**DIAGNOSIS.**—Distinguished from other species of *Abyssocythere* by external features of the carapace, such as the well-developed muri of the reticulum that form vertical ridges in the middorsal and posterodorsal region of the carapace running obliquely from the muscle-scar node and the postsulcular node to the posterior three members (B, C, and pdb) of the dorsal bullar series; by the open, seriform muri of the levatum; and especially by the presence of a posterior marginal rim (best developed in the right valve, present in both). The muscle-scar node is not well developed, the ventrolateral reticular complex is abbreviated. Internal features of the carapace are similar to the type species and typical of the genus.

**REMARKS.**—The presence of strong seriform mural ridges and marginal rims separates this species from others with sufficient morphologic difference to be recognized as a separate taxon, however, its geographic remoteness is enough reason to suggest its status as a separate species. As with the other *Abyssocythere* species found in the deep sea, it has secondary reticulation. The anterior and posterior teeth are both crenulate but narrow. This species is an end member of a morphologic series. For more comparisons see discussion of morphologic features under the genus.

**DIMENSIONS.**—Holotype, 1.1 mm long, 0.6 mm high. Paratype, 1.2 mm long, 0.7 mm high.

**MATERIAL.**—Only fossil specimens were found. Six specimens were found in three cores (RC 10-161,

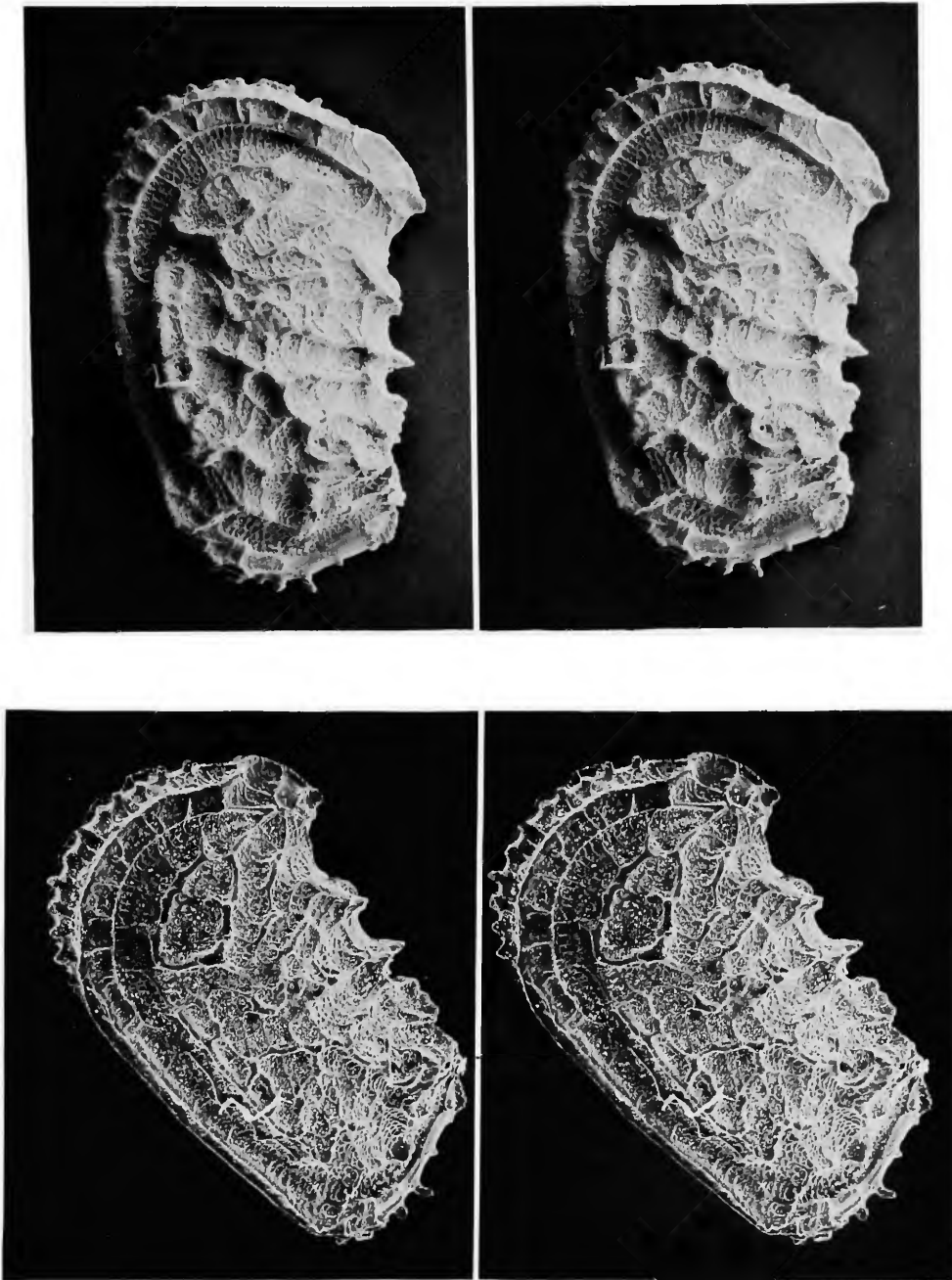


FIGURE 11.—Stereophotographic pairs of the holotype (USNM 170282) of *Abyssocythere japonica*, new species, a left valve from the northwestern Pacific (see text) from lateral view and anteroventral oblique view (magnification  $\times 80$ ).

163, and 164) from the northwestern Pacific (locality 17, Figure 1); one specimen was found from a core (CAP 38P) from the east central Pacific (locality 1, Figure 1).

ECOLOGY.—Specimens from all four cores were obtained from depths exceeding 3,400 meters, in “globigerinid” ooze. The average temperature is estimated at near 2°C. The great disparity in distance between the main group of samples and the one isolated sample is probably due to the lack of available samples and the scarcity of calcareous sediments from the central and northern Pacific. *Abyssocythere japonica* is probably widespread in the Pacific. It is blind, abyssal, and psychrospheric.

### 5. *Abyssocythere australis*, new species

FIGURE 12; PLATE 3: FIGURE 7

HOLOTYPE.—Left valve, adult, sex unknown, Figure 12, Plate 3: figure 7, University of Kansas, Museum of Paleontology No. 1007897.

PARATYPE.—Right valve, adult, sex unknown, KU 1007898.

TYPE LOCALITY.—The Southern Ocean about halfway between Australia and Antarctica on the Indian-Antarctic Rise in the vicinity of *Eltanin* Station 39-10 (longitude 126°16.6'E, latitude 48°03.1'S) at a depth of 3,390 meters.

AGE.—Recent; no living specimens were found.

DIAGNOSIS.—Distinguished from other species of the genus *Abyssocythere* by its relatively bold general surface carapace features. The produced muscle-scar node slopes toward the anterior as a broad ridge supporting the reticulum until it diminishes beneath the anterior reticulate complex, which is without special relief. The dorsal bullar series is pronounced with a very pronounced posterodorsal bulla. The ventrolateral reticulate ridge also stands high in relief relative to the rest of the carapace. The anterior marginal rim is well developed but not pronounced; the posterior marginal rim is absent. Secondary reticulation is present and more massive than in other species. The internal features are similar to those of the type species and typical of the genus.

REMARKS.—*Abyssocythere australis* has a boldness in the relief of the character complexes, characteristic of this genus, except for the anterior reticulate complex in which a levatum is absent. Whereas *A. japonica* has an emphasis in the development of muri, especially in

the dorsomedian and posterodorsal areas, the relief boldness of *A. australis* underlies the muri from an enlargement deeper within the carapace wall structure. This aspect is also noted in *A. atlantica*, but only in the region of the ventrolateral reticulate complex. Other comparisons are given in the discussion of general carapace morphology of the genus.

DIMENSIONS.—Holotype, length 1.1 mm, height 0.72 mm. Paratype, length 1.1 mm, height 0.6 mm.

MATERIAL.—The one Recent sample (*Eltanin* 39-10) had 20 specimens, all fossil (see Table I).

ECOLOGY.—Blind, psychrospheric, abyssal. The single sample containing specimens came from 3,390 meters depth. No further environmental data is presently known.

### 6. *Abyssocythere pannucea*, new species

PLATE 2: FIGURES 9-11; PLATE 3: FIGURE 2

ETYMOLOGY.—Latin *pannuceus*, wrinkled.

HOLOTYPE.—Left valve adult(?), presumed male; Plate 2: figures 9-11, USNM 170286.

PARATYPE.—Right valve, adult, USNM 170287.

TYPE LOCALITY.—Vicinity of U.S. Fisheries ship *Albatross* Station 4693 near Easter Island in the southeastern Pacific (latitude 26°30'S, longitude 105°45'W, 2,089 meters depth, temperature approximately 2°C).

AGE.—Recent; no living specimens were found.

DIAGNOSIS.—The most elongate of all of the species of *Abyssocythere*; also distinguished by its broad anterior rim with irregular secondary reticulation, poorly defined anterior and posteroventral reticulate complexes, low dorsal profile, the absence of an ocular ridge, a second (B) “cocked” dorsal bulla, and even, uniform development of primary reticulation.

REMARKS.—Although only two specimens (two penultimate or possible adult instars), a left (holotype) and a right (paratype) valve, were available for study, their outer surface was examined in considerable detail. This is the least secure species of the group described here. It has been given a name with the hope that what appear to be diagnosable differences in morphology will be confirmed by specimens yet to be found. The primary muri of the broad marginal rim are suppressed, and the secondary reticulation is very irregular. Most of the rest of the secondary reticulation is open and quite regular. The muscle-scar node is not prominent. An oblique ridge running between the adductor and frontal muscle-scar is conspicuous



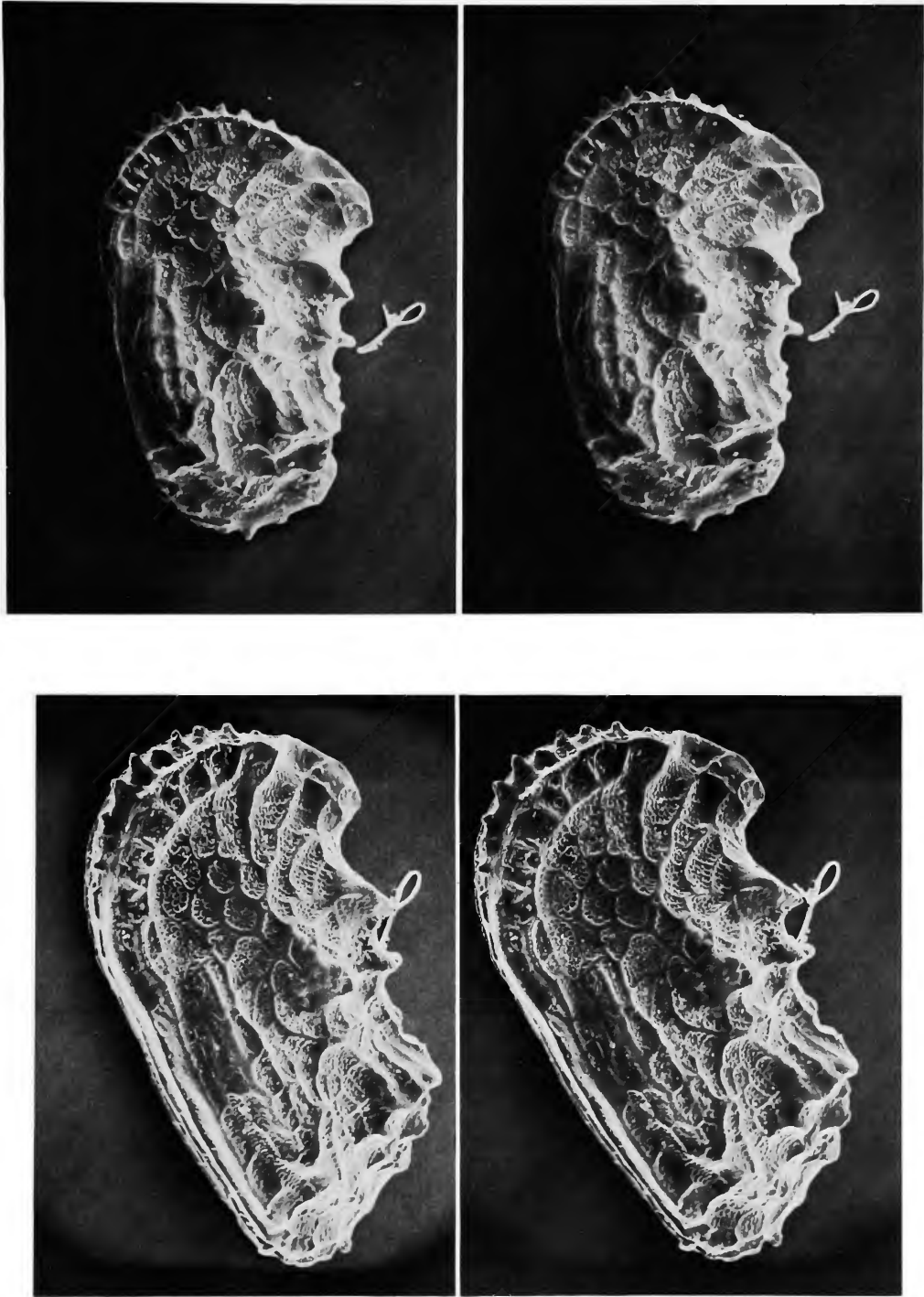


FIGURE 12.—Stereophotographic pairs of the holotype (USNM 170284) of *Abyssocythere australis*, new species, a left valve from the Southern Ocean south of Australia (see text) from lateral view and anteroventral oblique view (magnification  $\times 80$ ).

as it is also in *A. japonica* and *A. atlantica*. The gamos ridge is straight, joining a moderate posterodorsal bulla. The second bulla of the dorsal series (B) is "cocked" posteriorly. This is especially pronounced in the right valve. In the rest of the species of *Abyssocythere* this particular bulla stands erect as a spine (*A. casca*) or simply as a ridge (*A. trinidadensis* and *A. atlantica*).

**DIMENSIONS.**—Holotype, length 0.93 mm; height 0.60 mm. Paratype, length 0.85 mm; height 0.55 mm.

**MATERIAL.**—Five fossil specimens were obtained from the eastern Pacific in the vicinity of Easter Island and just west of Costa Rica (see Table I). Of these, only two, those illustrated (Plate 2: figures 9–11 and Plate 3: figure 2), were mature or near mature.

**ECOLOGY.**—Found in waters over 2,000 meters deep, one sample in almost 3,300 meters. Blind, psychrospheric, abyssal. The ambient bottom temperature at one station (Table I) was 1.9°C.

### Addendum

After the final typescript had been prepared, a single specimen of *Abyssocythere atlantica* was found in a JOIDES core (*Glomar Challenger* Hole 12c of leg 2) in Cape Verde Basin (latitude 19°40'N, longitude 26°01'W) at approximately 3,360 cm below the sediment-water interface (level 100–106 in Core 4). This horizon was identified as middle(?) Pliocene, probably Zone N. 20 or the upper part of Zone N. 19 on the basis of the Foraminifera present. The ocean floor in which the hole was drilled was 4,542 meters below the surface.

This record of *Abyssocythere atlantica* represents its most northeastward, its deepest, and its oldest known occurrence. The specimen (USNM 170294), which was somewhat obscured by chalk or marl, nevertheless, was clearly identifiable as *A. atlantica* without noticeable difference from specimens found in Pleistocene sediments to the south and west.

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PLATES 1-3

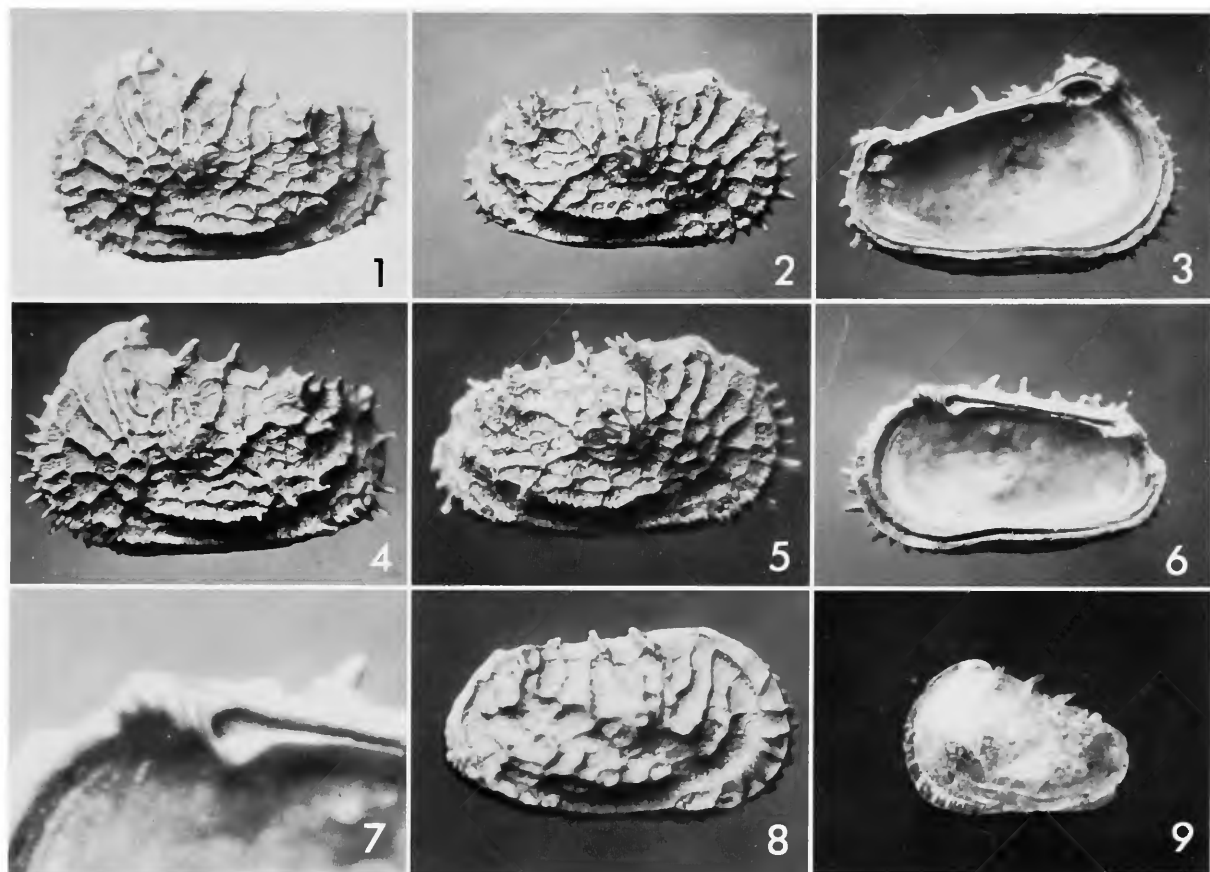


PLATE 1.—*Abyssocythere casca*, new species: exterior views of left (1) and right (2, 5) valves of paratypes (USNM 170277a); interior views of left (3) and right (6) valves with enlargement of the anterior hinge tooth and postjacent socket (7) showing crenulation; exterior view (4) of holotype (USNM 170276). 8, Right valve of late instar *Abyssocythere* aff. *A. japonica*, new species, from the eastern Pacific (locality 3, see Table I). 9, Left valve of the lectotype (BM 81.5.29) of *Abyssocythere squalidentata* (Brady) 1880, designated nomen dubium herein, an early instar from *Challenger* Station 323 in the South Atlantic. All magnifications  $\times 50$  except Figure 7 which is  $\times 160$ .

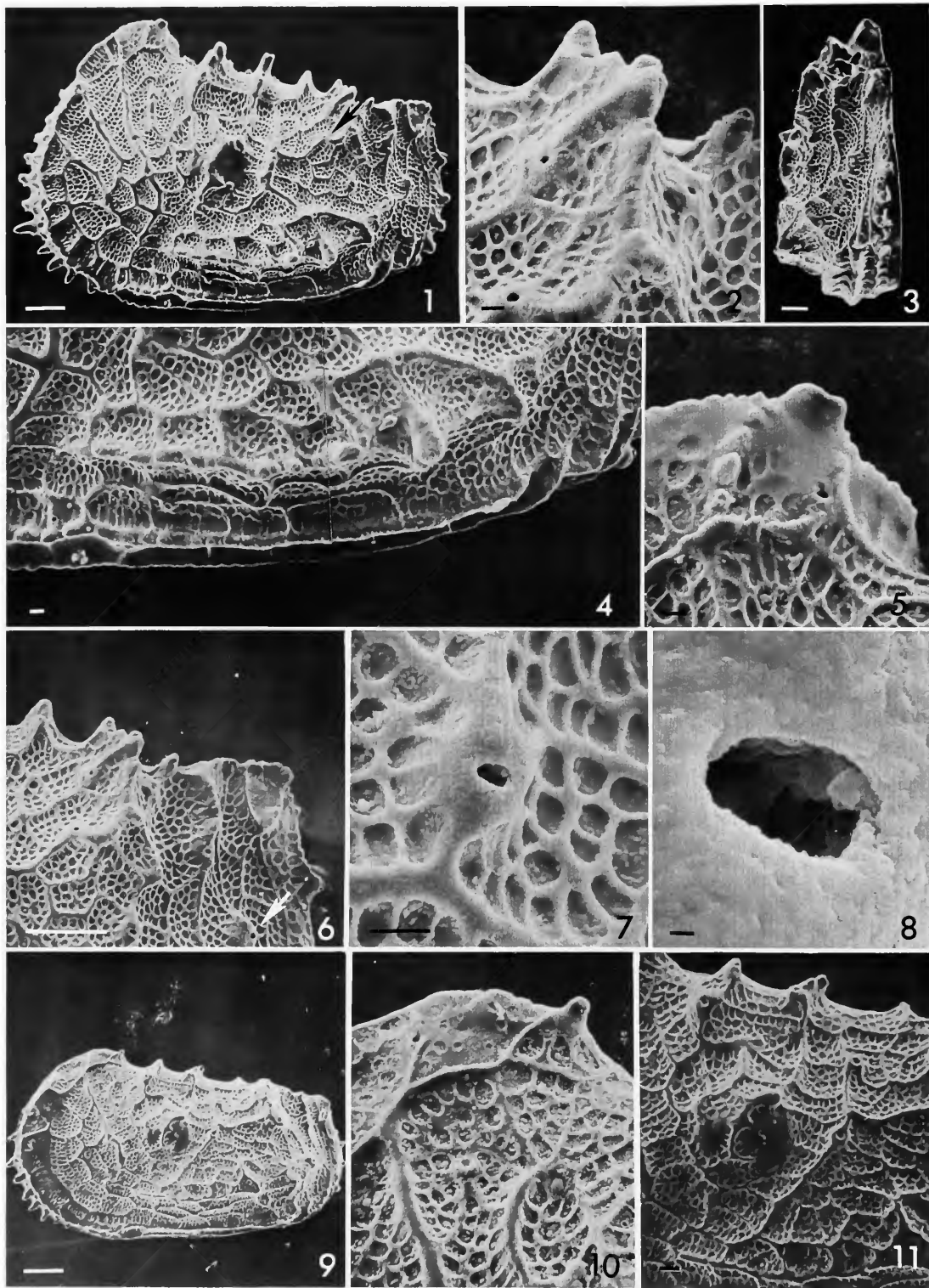
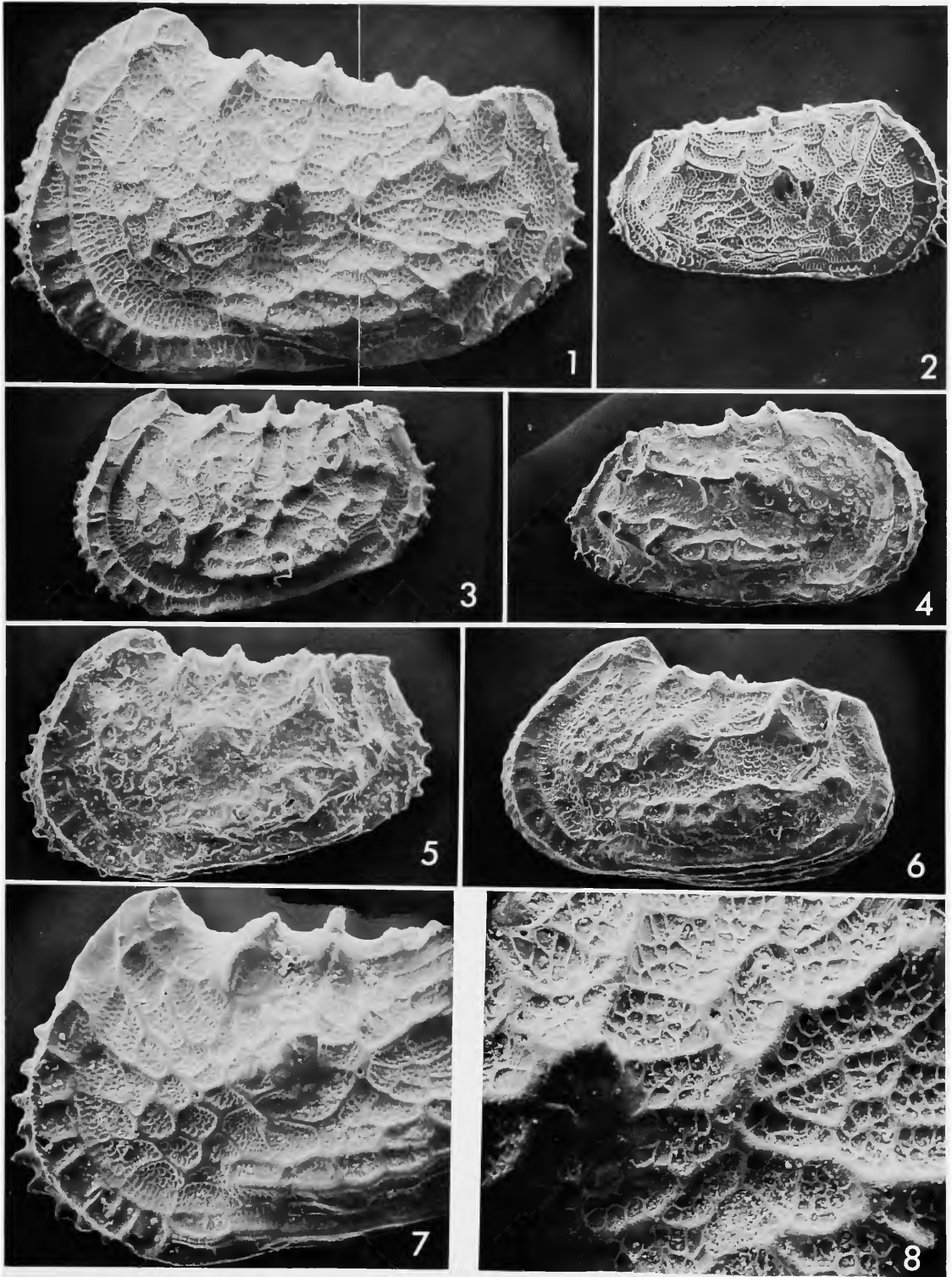


PLATE 2.—*Abyssocythere casca*, new species: (1) left valve of paratype (USNM 170277b) with views of the posterodorsal bulla (2), the posterior (3), the ventrolateral reticulate complex (4), the ocular ridge (5), the posterodorsum with anal conulus arrowed (6), an intramural pore and detailed view of secondary reticulation (7), a celate pore with sieve plate (8, enlargement of Figure 7). *Abyssocythere pannucea*, new species: left valve (9) of holotype (USNM 170286), the anterodorsum (10) showing a suppressed ocular ridge, the dorsocentral region of the same left valve (11) showing the fine structure of the reticulum on the muscle-scar node, the postsulcular node, three elements of the dorsal bullar series, and parts of the gamos ridge and ventrolateral reticulate ridge. The scales indicate 100 $\mu$ , 10 $\mu$ , and 1 $\mu$ .

PLATE 3.—*Abyssocythere atlantica*, new species: 1, left valve, holotype (USNM 170280;  $\times 80$ ); 8, muscle-scar node and postsulcular node ( $\times 180$ ). *Abyssocythere pannucea*, new species: 2, right valve, paratype (USNM 170287;  $\times 55$ ). *Abyssocythere japonica*, new species: 3, left valve, upper Eocene (Ky 7) hypotype (USNM 170279;  $\times 65$ ); 5, left valve, Oligo-Miocene valve, holotype (USNM 170282;  $\times 55$ ). *Abyssocythere trinidadensis* van den Bold: 4, right (GF 56a; Cipero Fm) hypotype (USNM 170278;  $\times 65$ ); 6, left valve, holotype (USNM 562037;  $\times 65$ ). *Abyssocythere australis*, new species: 7, anterior portion of the holotype (USNM 170284) showing details of the reticulum ( $\times 80$ ).







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