

16. CENOZOIC OSTRACODA FROM DEEP SEA DRILLING PROJECT LEG 95 OFF NEW JERSEY (SITES 612 AND 613)¹

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ABSTRACT

Ninety-three samples from DSDP Leg 95, Sites 612 and 613, were examined for ostracodes to aid in the study of paleoceanography and paleodepth. In total, more than 25 genera were recovered. The most abundant and diverse ostracode assemblages were from the middle Eocene at both sites; lower and upper Eocene and Pliocene-Pleistocene assemblages were less abundant and were dominated by only three or four species.

The middle Eocene assemblages were the most diagnostic of paleoenvironment and suggest water depths of 1000 to 2000 m. These assemblages are similar to other middle Eocene assemblages known from the Caribbean and North Atlantic, and signify a relatively cosmopolitan fauna that inhabited moderately deep but relatively warm bottom waters.

INTRODUCTION

The principal scientific objectives of drilling at Sites 612 and 613 (DSDP Leg 95) were to determine Cenozoic depositional environments, to date biostratigraphic gaps, and to evaluate these data in the light of sea-level changes and paleoceanography for the middle continental slope and upper rise. Ostracodes from ninety-three 20-cm³ samples were studied to aid in achieving these objectives. In addition to yielding regional paleodepths, the Eocene faunas discovered at Sites 612 and 613 also fill a geographic gap in our data on Eocene bathyal faunas and thus contribute to our understanding of deep-water ostracode biogeography.

Cenozoic ostracodes from several DSDP sites in the North Atlantic have been studied previously. The following papers were used in determining paleoenvironments and in taxonomic identifications discussed later: Benson (1972a, 1972b, 1974, 1975, 1977), Benson and Sylvester-Bradley (1971), Bold (1969), Brady (1880), Ducasse and Peypouquet (1979), Guernet (1982), Le Roy and Levinson (1974), Peypouquet (1975), Puri and Hulings (1976), Steineck (1981), Steineck et al. (1984), and Tressler (1941). Our report must be considered preliminary until other deep-sea material can be compared directly with the material from Leg 95.

SUMMARY OF OSTRACODE FAUNAS

Site 612 (Table 1)

Ostracodes are relatively common in the middle and upper Eocene sediments at this site, but are rare in the lower Eocene and Pliocene-Pleistocene sediments. Juvenile specimens usually constitute more than fifty percent of each sample. A low-diversity assemblage, including *Krithe*, *Cytherella*, *Argilloecia*, and *Paranesidea*, characterizes the lower Eocene section at Site 612. There is a distinct faunal change near the lower Eocene-middle Eocene transition that corresponds approximately to the boundary between lithostratigraphic Units III and II. This change is characterized by an increase in diversity and the appearance of the following taxa: *Abyssocythere*, *Agrenocythere*, *Bythocypris*, *Cytheropteron*, *Eucythere*, *Henryhowella*, "*Loxoconcha*," *Macrocypris*, *Phacorhabdotus*, "*Hazelina*," *Trachyleberidea*, and *Xestoleberis*. These taxa, plus abundant *Krithe*, *Cytherella*, and *Paranesidea*, occur in most middle Eocene samples.

Another distinct faunal change occurs at the transition from middle Eocene to upper Eocene-Oligocene sediments (Cores 22 and 21), where *Argilloecia*, *Bairdopplata*, *Bythocypris*, *Cytheropteron*, *Eucythere*, "*Hazelina*," *Phacorhabdotus*, and "*Thalassocythere*" have their uppermost occurrences. The upper Eocene is characterized by the occurrence of the *Messinella*, a genus that is restricted to this age at this site, although it occurs in the middle Eocene of Site 613. *Henryhowella* constitutes a greater proportion of the upper Eocene assemblage than it does in older sediments.

Pliocene and Miocene sediments from Cores 8 to 13 were barren of ostracodes. A sparse assemblage that includes *Henryhowella*, *Krithe*, *Cytheropteron*, *Heterocyprideis*, *Finmarchinella*, and *Muellerina* occurs in Cores 1 to 7.

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Site 613 (Table 2)

Site 613 yielded ostracode assemblages similar to those at Site 612 in the abundance of *Krithe*, *Cytherella*, and *Paranesidea* in middle Eocene and the relative sparseness of the lower Eocene and Pliocene-Pleistocene assemblages. The following important differences should be noted, however, for the middle Eocene at the two sites:

	Site 612	Site 613
<i>Messinella</i>	Absent	Common
<i>Trachyleberidea</i>	Few	Abundant
" <i>Hazelina</i> "	Absent	Few
" <i>Loxoconcha</i> "	Common	Few
<i>Aratrocypis</i> sp.	Few	Absent
<i>Abyssocythere</i>	Common	Absent
" <i>Bairdia</i> " sp.	Few	Absent

¹ Poag, C. W., Watts, A. B., et al., *Init. Repts. DSDP, 95*: Washington (U.S. Govt. Printing Office).

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Table 1. Ostracoda from Hole 612 (water depth 1404 m).

Core-Section, interval (cm)	Series/ subseries	<i>Abyssocythere</i> spp.	<i>Agrenocythere gonoldi</i>	<i>Alaiacythere</i> sp.	<i>Argilloecia</i> spp.	<i>Aratocypris</i> sp.	<i>Bairdopillata</i> spp.	<i>Bythocypris</i> spp.	<i>Cytherella</i> sp. A	<i>Cytherella</i> sp. B	<i>Cytheropteron</i> spp.	<i>Eucythere</i> sp.	<i>Finnarchinella finnarchica</i>	"Hazelina" sp.	<i>Henryhowella</i> sp.	<i>Heterocyprideis sorbyana</i>	<i>Krithe</i> sp. A	<i>Krithe</i> sp. B	<i>Krithe</i> sp. C	" <i>Loxoconcha</i> " sp.	<i>Macrocypris</i> sp.	<i>Messinella guajayensis</i>	<i>Muellerina</i> sp.	<i>Paranesidea</i> cf. <i>cespedensis</i>	<i>Phacorbabdonus</i> aff. <i>sculptilis</i>	<i>Semicytherura</i> sp.	" <i>Thalassocythere</i> " spp.	<i>Trachyleberidea</i> cf. <i>cubensis</i>	<i>Xestoleberis</i> sp.	Other		
1H-3, 80-84	Pleistocene												1									1										
2H-3, 80-84													1			2						2										
3H-3, 80-84														1								3										
4H-3, 80-84														1																		
5H-3, 80-84																1																
7X-3, 80-84	Barren																															
7,CC																																
8X-3, 80-84																																
to																																
13X-3, 80-84																																
14X-3, 80-84	Pliocene																															
15X-3, 80-84																																
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19X-3, 80-84	upper Eocene																															
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49X-3, 80-84	lower Eocene																															
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55X-3, 80-84																																
56X-3, 80-84																																
52 samples																																

Note: 15X-3, 80-84 cm, 16X-3, 80-84 cm, 41X-3, 80-84 cm and 44X-3, 80-84 cm barren.

These differences probably signify differences in paleodepth and/or oceanographic conditions, which are discussed in the section following.

EOCENE ENVIRONMENTS

Several characteristics of deep-water ostracodes and their populations have been used to reconstruct paleoenvironments and to estimate paleodepth. The most commonly used of these characteristics are (1) environmental evidence (using modern distribution data on a genus or species to infer past conditions), (2) morphologic evidence (such as the presence or absence of eyes, carapace size and ornament, vestibule size), and (3) species diversity and abundance (Benson, 1984). Ostracodes have proved particularly useful in determining conditions during the Eocene-Oligocene, when major oceanographic changes occurred (Benson, 1975).

The location of Sites 612 and 613 on a continental margin offers an opportunity to compare local changes in ostracode assemblages with contemporaneous sequences from other DSDP cores and outcrop sections, and with global paleoceanographic events. Benson (1975) in-

ferred, from the changes in deep-sea ostracode faunas, a period of transition in the world ocean from a thermospheric state to a two-layer psychrospheric ocean about 40 m.y. ago. More recently, Benson et al. (1984), drawing on data from 1044 ostracode samples from 156 deep-sea sites, have characterized the change in ostracodes between 40 and 36 m.y. ago as a gradual turnover, characterized by an increase in origination of new taxa related to the origin of the psychrosphere.

Ducasse and Peypouquet (1979) described a sequence of ostracodes from the Rockall Banks area in which lower Eocene assemblages of *Cytherella* and *Krithe* were replaced in the middle and upper Eocene by more diverse assemblages including *Atlanticythere*, *Trachyleberidea*, *Bythocypris*, and *Bairdia*. At DSDP Site 401, lower to middle Eocene to Oligocene ostracode faunas were abundant and moderately diverse. The trend toward increasing diversity is also present at Sites 612 and 613, where the lower Eocene faunas are sparse and of low diversity (primarily krithids, *Cytherella*, and *Paranesidea*) compared with the middle Eocene faunas. Although this trend might be related to local events such as subsidence (Du-

the 2000 to 2500 m for the Oceanic Formation. Ducasse and Peypouquet (1979) suggest that this genus occurs below 1000 m. Cronin (1983) found it most common in the slope off the southeastern U.S. between 400 and 900 m, but this study did not examine samples deeper than 1100 m. Further, modern species of *Trachyleberidea* may have depth ranges quite different from their Tertiary congeners, and the significance of this genus with regard to paleodepth requires additional study. The significance of the abundant undescribed species of *Abyssocythere* is not understood, but its absence at Site 613 suggests that it preferred the shallower depths of Site 612 in this region during the middle Eocene.

Species diversity should be used as an indicator of paleodepth with the knowledge that there are conflicting opinions about diversity patterns in the deep sea (Benson, 1972a, 1984; Whatley, 1983). Data are especially sparse for the bathyal zone (Cronin, 1983), although Peypouquet (1980) indicates a moderate diversity in the epibathyal zone (400–1500 m) and Cronin (1983) found surprisingly high species diversity in epibathyal sediments of the Florida–Hatteras Slope and the Blake Plateau.

In summary, the Eocene ostracode faunas of Sites 612 and 613 fit into the general pattern of a cosmopolitan fauna inhabiting a circumglobal belt, although minor differences with respect to faunas from more equatorial regions may signify minor biogeographic differences at the margins of this ocean. Middle Eocene faunas probably represent paleodepths between 1000 and 2000 m. A significant change in ostracode faunas occurs at the Eocene–Oligocene transition, but the Oligocene faunas are not abundant enough for comparison with contemporaneous faunas elsewhere.

TAXONOMIC NOTES

The following comments discuss possible taxonomic affinities of Leg 95 species with those described or illustrated from other regions. Because bathyal and abyssal ostracodes have only recently attracted attention, there remains a high degree of uncertainty in species-level taxonomy. This problem is complicated by our poor understanding of bathyal and abyssal biogeography, intraspecific variability in carapace morphology, and the seemingly cosmopolitan distribution of some species. Nevertheless, the situation is improving; additional studies that include high-quality scanning electron photographs are appearing, and specialists are beginning to link ostracodes from exposed onshore sections with those in deep-sea drilling material (Steineck et al., 1984). Illustrated specimens are deposited in the U.S. Museum of Natural History (USNM numbers 401504–401553).

Abyssocythere spp. Three morphotypes are present. The type illustrated in Plate 3, Figure 5 has an ornament pattern slightly different from the type in Plate 3, Figures 2 and 4. No previous illustrations of these species are known to the authors.

Agrenocythere gosnoldi Benson, 1972 (Plate 4, Figs. 2, 4). Benson (1972b) described this species from outcrops of middle Eocene sediments in submarine canyons along the east coast of the United States.

Alatocythere sp. (Plate 1, Fig. 2). This species resembles *A. ivani* Howe, 1951, which occurs in the Tertiary of the Atlantic and Gulf Coastal Plains.

Aratocypris sp. (Plate 8, Fig. 4). Whatley et al. (1985) described this genus from Tertiary DSDP sites in the southwestern Pacific. Cronin (1983) also found a related species in modern sediments of the Blake Plateau off the Florida coast.

"*Bairdia*" sp. (Plate 8, Fig. 2). This species is referred to as Gen. 3 sp. by Guernet (1982), *Bairdia* sp. 6 by Ducasse and Peypouquet (1979), and "*Bairdia*" sp. 3 by Steineck et al. (1984).

Bairdoppilata spp. (Plate 8, Fig. 1). Most forms grouped in this category resemble the Eocene species *Bairdoppilata cassida* (van den Bold, 1946) illustrated by Steineck et al. (1984).

"*Costa*" aff. "*C. barri*" van den Bold, 1960. (Plate 4, Fig. 1). A few specimens of this species were found in Hole 613, Core 29 (listed in "other" category in Table 2). This species appears to be related to several other species frequently found in bathyal deposits in the Caribbean and Gulf of Mexico region. Guernet (1982) illustrated a similar form (Gen. 1 sp., pl. 5, figs. 2–5) from the middle Eocene of the Bahaman Basin. *Costa bellipulex* Le Roy 1974 may be related to this species. The resemblance of these forms to *Agrenocythere* should be noted, and until confirmed or denied by further study, the generic assignment remains uncertain.

"*Hazelina*" sp. (Plate 1, Fig. 4). In overall shape and the presence of three prominent longitudinal ridges, the species resembles *Hazelina* sp. 2 illustrated by Ducasse and Peypouquet (1979) from the Rockall Plateau (DSDP Leg 48)

Henryhowella sp. Two morphotypes were found at Sites 612 and 613. Plate 1, Figure 6 illustrates a reticulate form having subdued longitudinal ridges; Plate 1, Figure 5 and Plate 2, Figure 1 show a form lacking ridges but characterized by pustules and spines formed at the intersections of the reticulation.

Krithe spp. This genus is represented by several morphotypes, but it is not clear how many of these are distinct species and how many are ecophenotypic variants within single species. Dr. W. A. van den Bold (Louisiana State University) has kindly pointed out that the specimen illustrated in Plate 6, Figure 4 strongly resembles *K. crassicaudata* van den Bold, 1960.

"*Loxoconcha*" sp. (Plate 5, Fig. 3). This form is tentatively placed in the typically shallow-water genus *Loxoconcha*. Deeper-water species having a compressed periphery might belong in a separate genus.

Messinella guanajayensis (van den Bold, 1946) (Plate 7, Figs. 1, 2). This is probably the same species that Steineck et al. (1984) found in several locations in the Cenozoic of the Caribbean.

Paranesidea cf. *cespedecensis* (van den Bold, 1946) (Plate 8, Fig. 3). Some of these forms might belong to the morphologically similar species *Bairdia orion* van den Bold, 1972 (see Steineck, 1981).

Phacorhabdus aff. *P. sculptilis* (Alexander, 1934) (Plate 1, Fig. 3). *Phacorhabdus* is common in Upper Cretaceous and Cenozoic bathyal sediments in the Gulf of Mexico and western Atlantic Ocean, and has potential for biostratigraphic correlation. The species found in the middle Eocene at Sites 612 and 613 differs from *P. sculptilis* in having much shorter and thinner dorsal, medial, and ventral longitudinal ridges.

"*Thalassocythere*" spp. The lower Pliocene specimen illustrated in Plate 2, Figure 3 is probably "*T. acanthoderma*" (Brady, 1880); specimens from the Eocene represent a different species.

Trachyleberidea cf. *cubensis* (van den Bold, 1946) (Plate 4, Figs. 5, 6). This species assignment is tentative pending detailed study of this genus.

Xestoleberis sp. Some of the specimens from Sites 612 and 613 can be assigned to *X. chamela* van den Bold, 1960.

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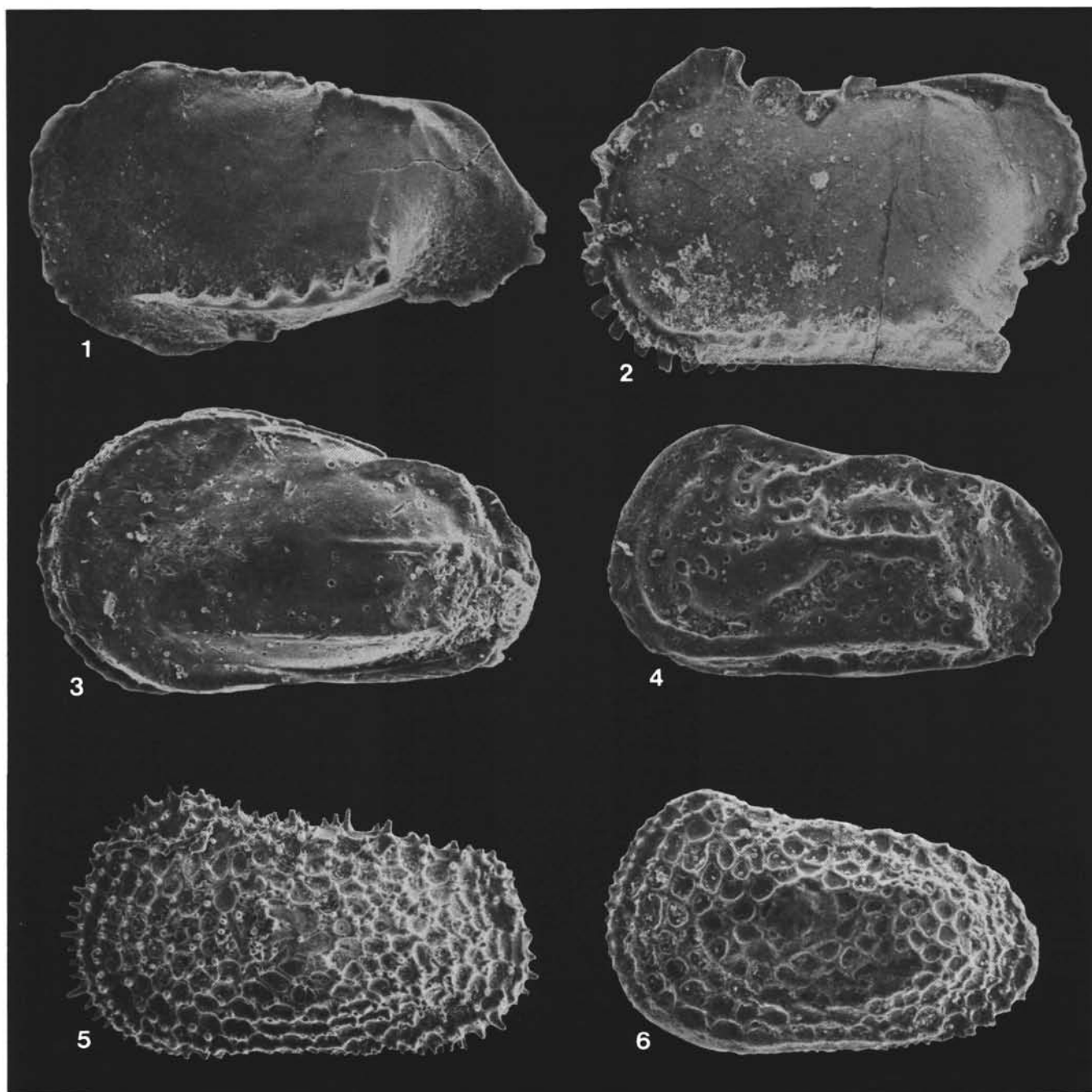


Plate 1. (Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1. *Pterygocythereis inexpectata* Blake, 1929, $\times 120$, exterior left valve, juvenile, Pleistocene, 613-6X-3, USNM 401504 (specimen broken after photography). 2. *Alatacythere* sp., $\times 72$, exterior left valve, adult female, middle Eocene, 612-24X-3, USNM 401505. 3. *Phacorhabdotus* aff. *P. sculptilis* (Alexander, 1934), $\times 110$, exterior left valve, adult female, middle Eocene, 612-25X-3, USNM 401506. 4. "*Hazelina*" sp., $\times 120$, exterior left valve, adult female, middle Eocene, 612-26X-3, USNM 401507. 5, 6. *Henryhowella* sp., exterior left valve, adult male, (5) $\times 100$, upper Eocene, 612-19X-3, USNM 401510, (6) $\times 120$, middle Eocene, 613-33X-3, USNM 401509.

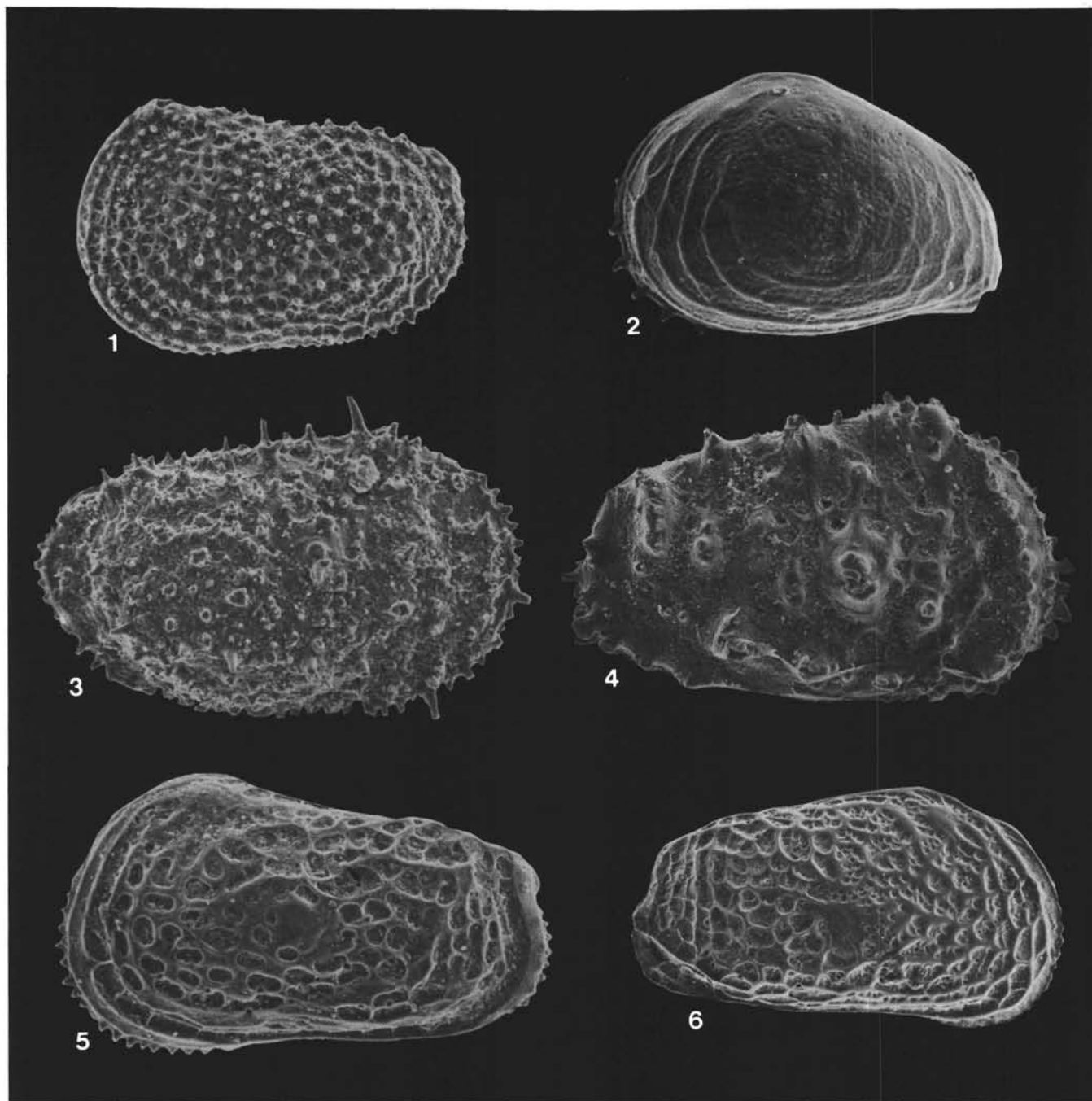


Plate 2. (Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1. *Henryhowella* sp., $\times 110$, exterior left valve, juvenile female, upper Pliocene, 613-14X-3, USNM 401508. 2. *Heterocyprideis sorbyana* (Jones, 1857), $\times 180$, exterior left valve, juvenile female, Pleistocene, 612-2H-3, USNM 401518 (specimen broken after photography). 3. *Thalassocythere* sp., $\times 94$, exterior right valve, juvenile female, lower Pliocene, 613-17X-3, USNM 401511. 4. *Acanthocythereis dunelmensis* (Norman, 1865), $\times 72$, exterior right valve, adult female, Pleistocene, 613-7X-3, USNM 401519. 5. *Muellerina* sp., $\times 150$, exterior left valve, juvenile female, Pleistocene, 613-6X-3, USNM 401526. 6. *Finmarchinella finmarchica* (Sars, 1865), $\times 130$, exterior right valve, juvenile female, Pleistocene, 612-1H-3, USNM 401527.

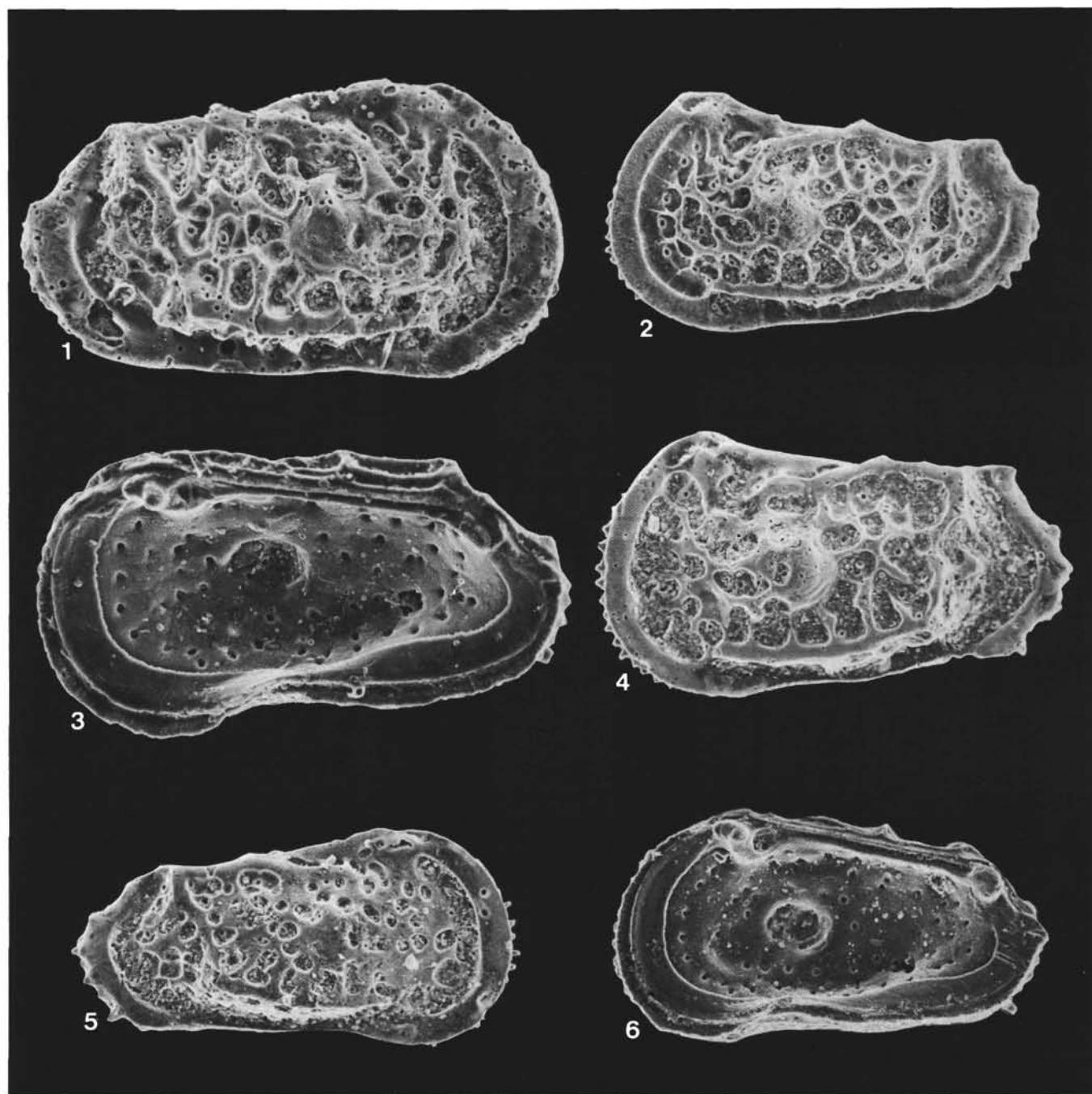


Plate 3. *Abyssocythere* spp. (All specimens magnified $\times 120$ unless otherwise indicated. Three-part designations beginning with 612 and 613 are DSDP section numbers.) 1, 3. $\times 150$, adult female, middle Eocene, 612-23X-3, (1) exterior right valve, USNM 401516, (3) interior right valve, USNM 401517. 2. exterior left valve, adult male, upper Eocene, 612-21X-3, USNM 401513. 4. exterior left valve, adult female, upper Eocene, 612-17X-3, USNM 401512. 5, 6. Middle Eocene, 612-27X-3, (5) exterior right valve, adult male, USNM 401514, (6) interior right valve, adult female, USNM 401515.

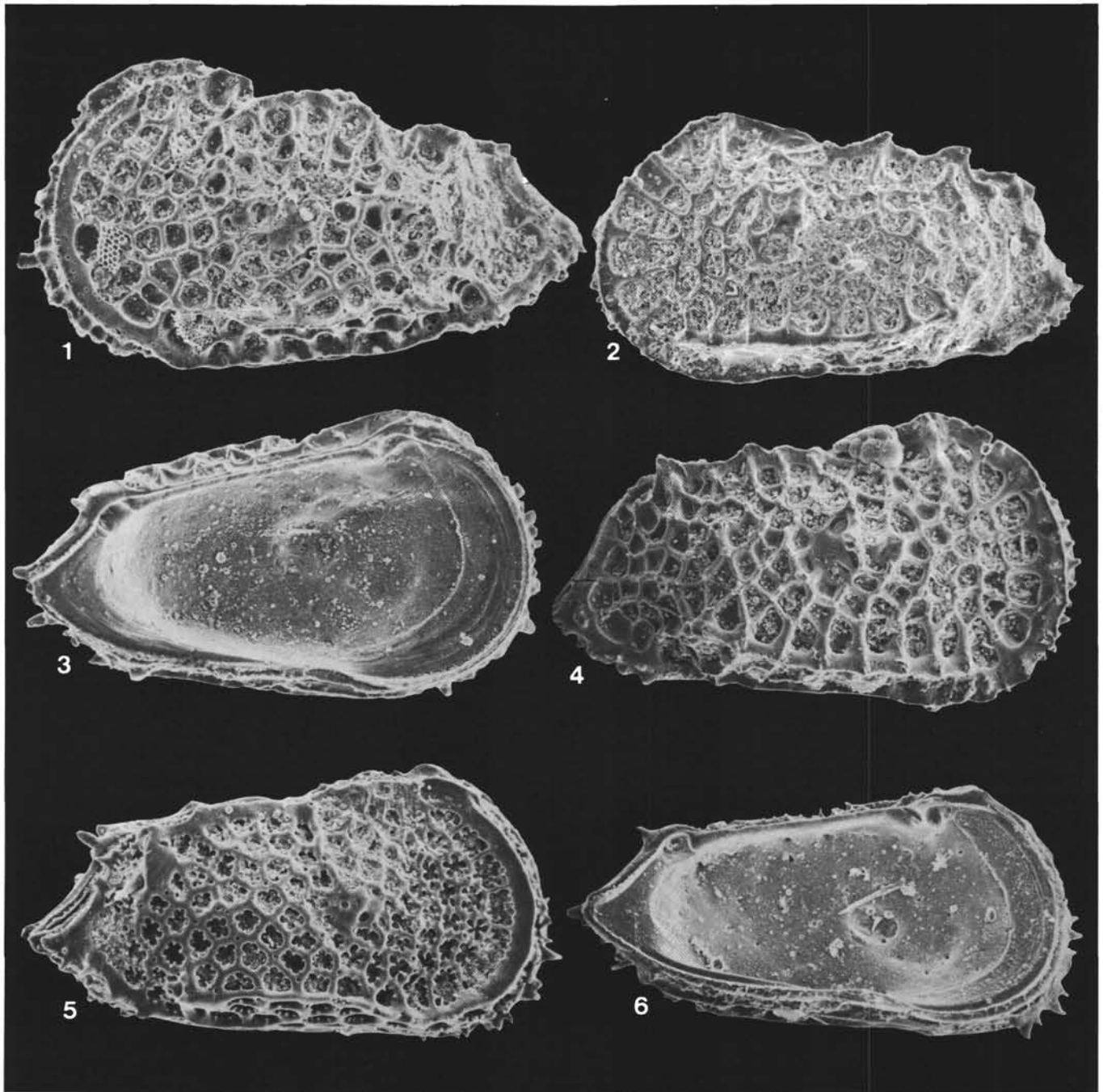


Plate 4. (All specimens magnified $\times 100$. Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1. "*Costa*" aff. "*C.*" *barri* van den Bold, 1960, exterior left valve, adult female, middle Eocene, 612-29X-3, USNM 401520. 2, 4. *Agrenocythere gosnoldi* Benson, 1972, juvenile female, middle Eocene, (2) exterior left valve, 613-35X-3, USNM 401521, (4) exterior right valve, 612-26X-3, USNM 401523. 3. "*Costa*" cf. "*C.*" *barri* van den Bold, 1960, interior left valve, adult female, middle Eocene, 612-26X-3, USNM 401522. 5, 6. *Trachyleberidea* cf. *T. cubensis* (van den Bold, 1946), (5) exterior right valve, adult female carapace, upper Eocene, 612-18X-3, USNM 401525, (6) interior left valve, adult female, middle Eocene, 612-23X-3, USNM 401524.

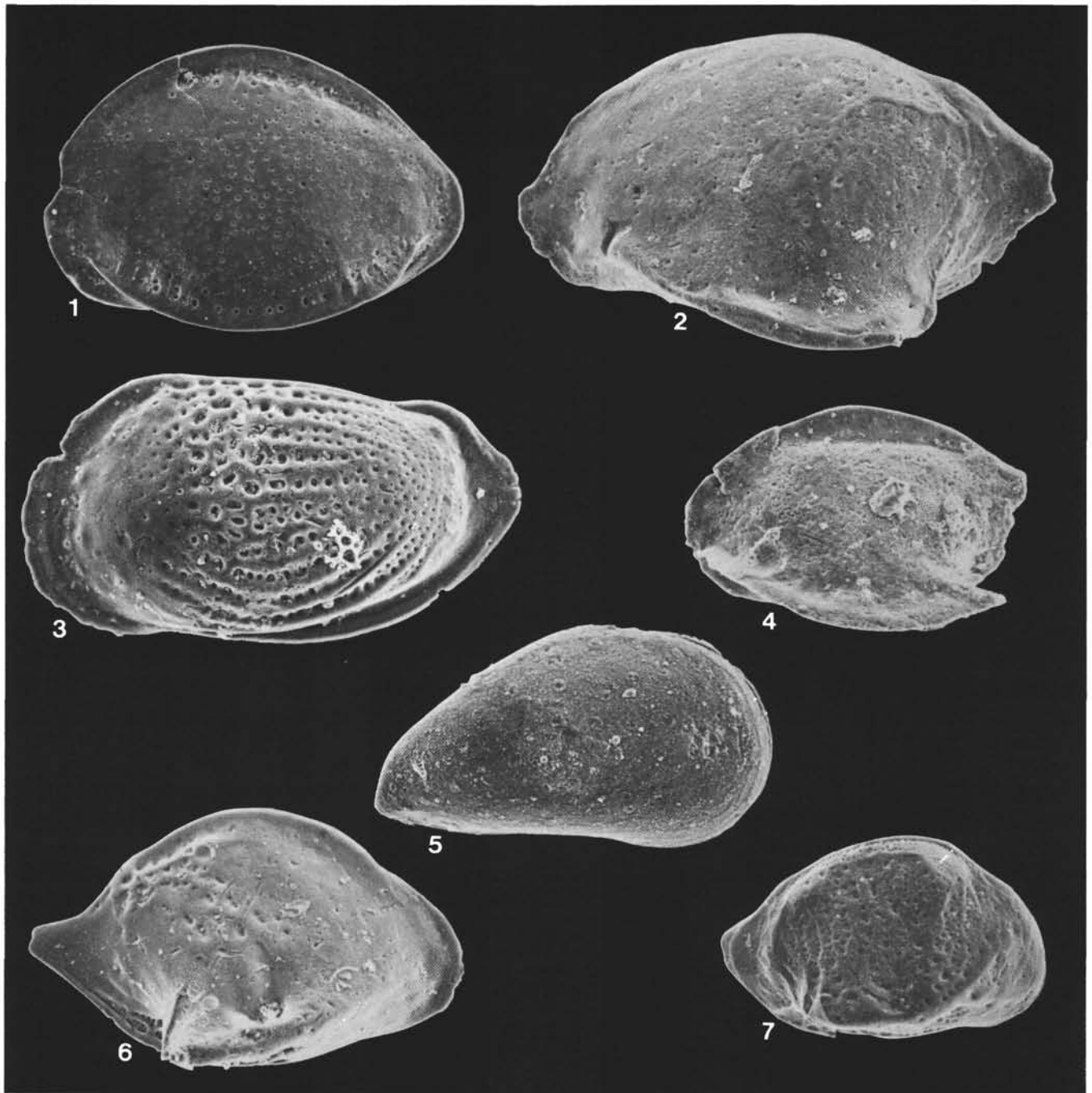


Plate 5. (Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1. "*Eocytheropteron*" *trinidadensis* (van den Bold, 1960), $\times 120$, exterior left valve, adult female, lower Pliocene, 613-17X-3, USNM 401528. 2, 4, 6. *Cytheropteron* spp., $\times 150$, adult female, middle Eocene, (2,4) exterior left valve (2, 612-22X-3, USNM 401529.; 4, 612-24X-3, USNM 401531), (6) exterior right valve, 612-23X-3, USNM 401532. 3. "*Loxoconcha*" sp., $\times 180$, exterior left valve, adult male, middle Eocene, 612-26X-3, USNM 401533. 5. *Eucythere* sp., $\times 150$, exterior right valve, adult female, middle Eocene, 612-22X-3, USNM 401535. 7. *Cytheropteron nodosum* Brady, 1868, $\times 120$, exterior right valve, adult female, Pleistocene, 613-10W-3, USNM 401530.

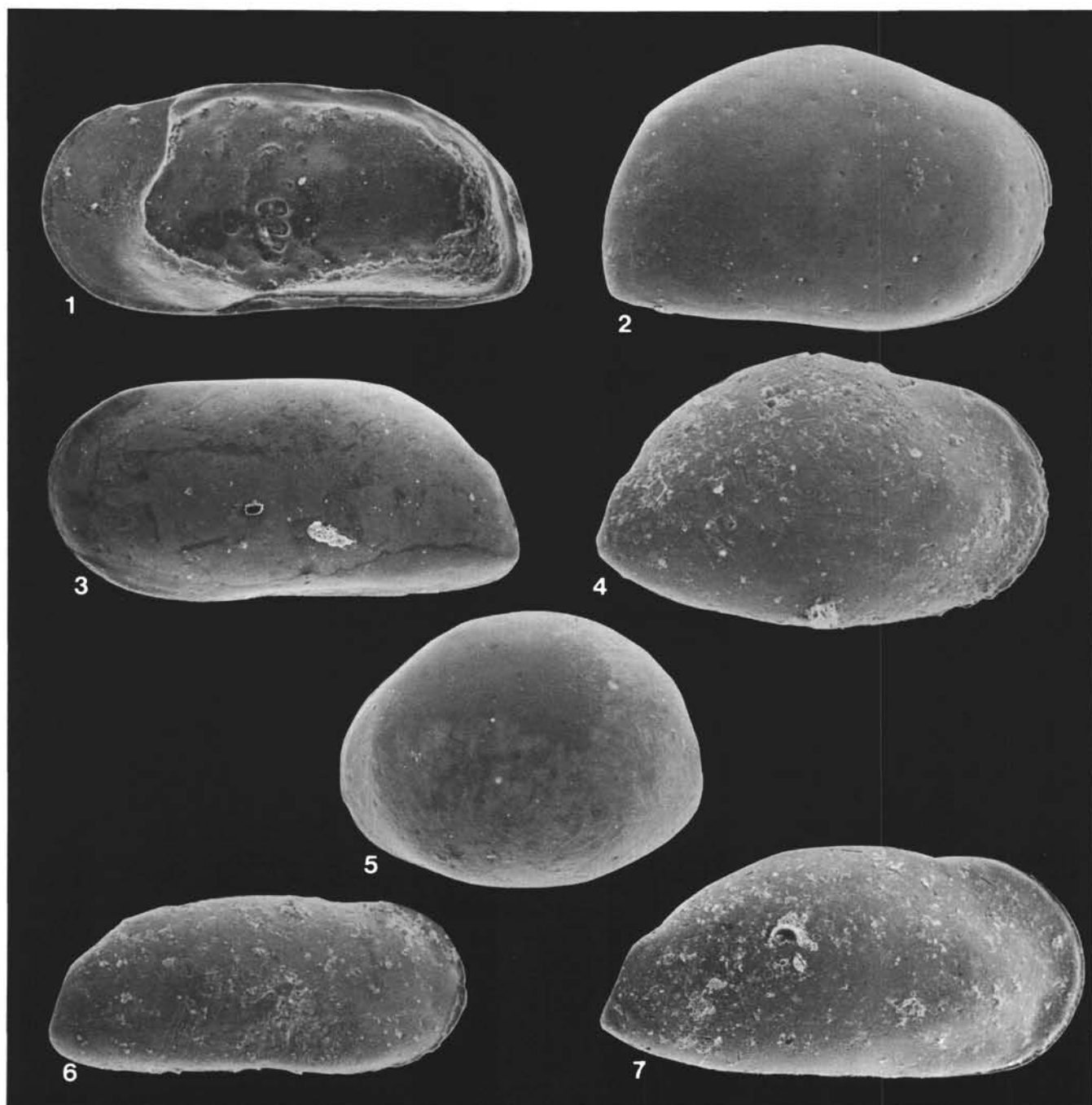


Plate 6. Krithids. (Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1, 2, 6. *Krithe* sp. B, (1) $\times 100$, interior right valve, adult male, Pleistocene, 613-8X-3, USNM 401538, (2) $\times 120$, exterior right valve, adult female, Pliocene 613-16X-3, USNM 401539, (6) $\times 110$, exterior right valve, adult male, middle Eocene, 613-23X-2, USNM 401542. 3. *Krithe* sp. A, $\times 94$, exterior left valve, adult male, Pleistocene, 612-3H-3, USNM 401540 (specimen broken after photography). 4, 7. *Krithe* sp. C, exterior right valve, middle Eocene, (4) $\times 110$, adult female, 613-21X-3, USNM 401541, (7) $\times 100$, adult male, 613-28X-3, USNM 401543. 5. *Krithe* cf. sp. B, $\times 120$, exterior left valve, adult female, Pliocene, 613-16X-3, USNM 401544.

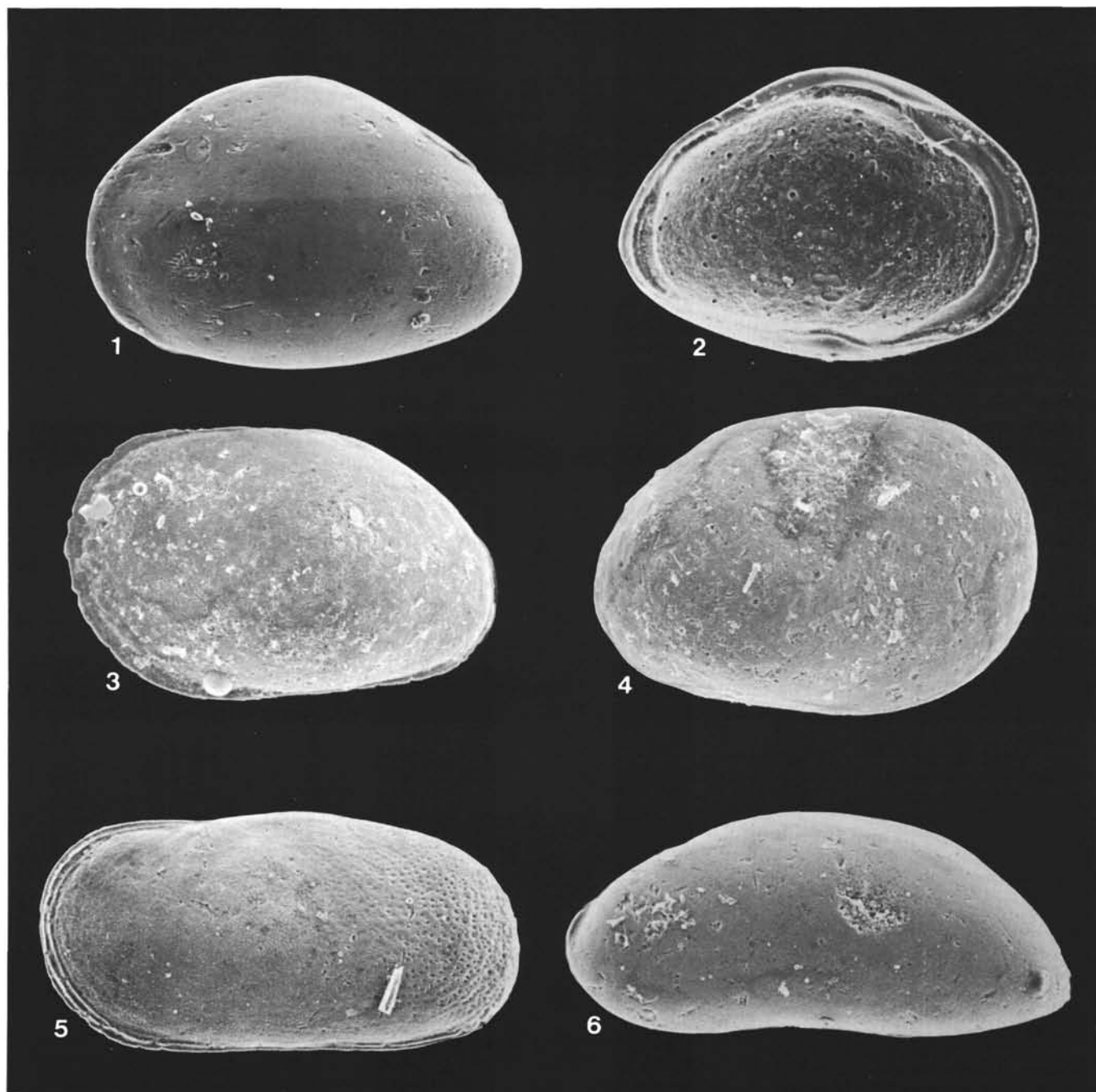


Plate 7. (Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1, 2. *Messinella guanajayensis* (van den Bold, 1946), $\times 120$, adult female, upper Eocene, 612-18X-3, (1) exterior left valve, USNM 401546. (2) interior left valve, USNM 401547. 3, 4. *Cytherella* sp. B, adult female, middle Eocene, 613-35X-3, (3) $\times 94$, exterior left valve, USNM 401536, (4) $\times 120$, exterior right valve, USNM 401537. 5. *Cytherella* sp. A, $\times 100$, exterior left valve, adult female, upper Eocene, 612-17X-3, USNM 401534. 6. *Argilloecia* sp., $\times 150$, exterior left valve, middle Eocene, 612-22X-3, USNM 401545.

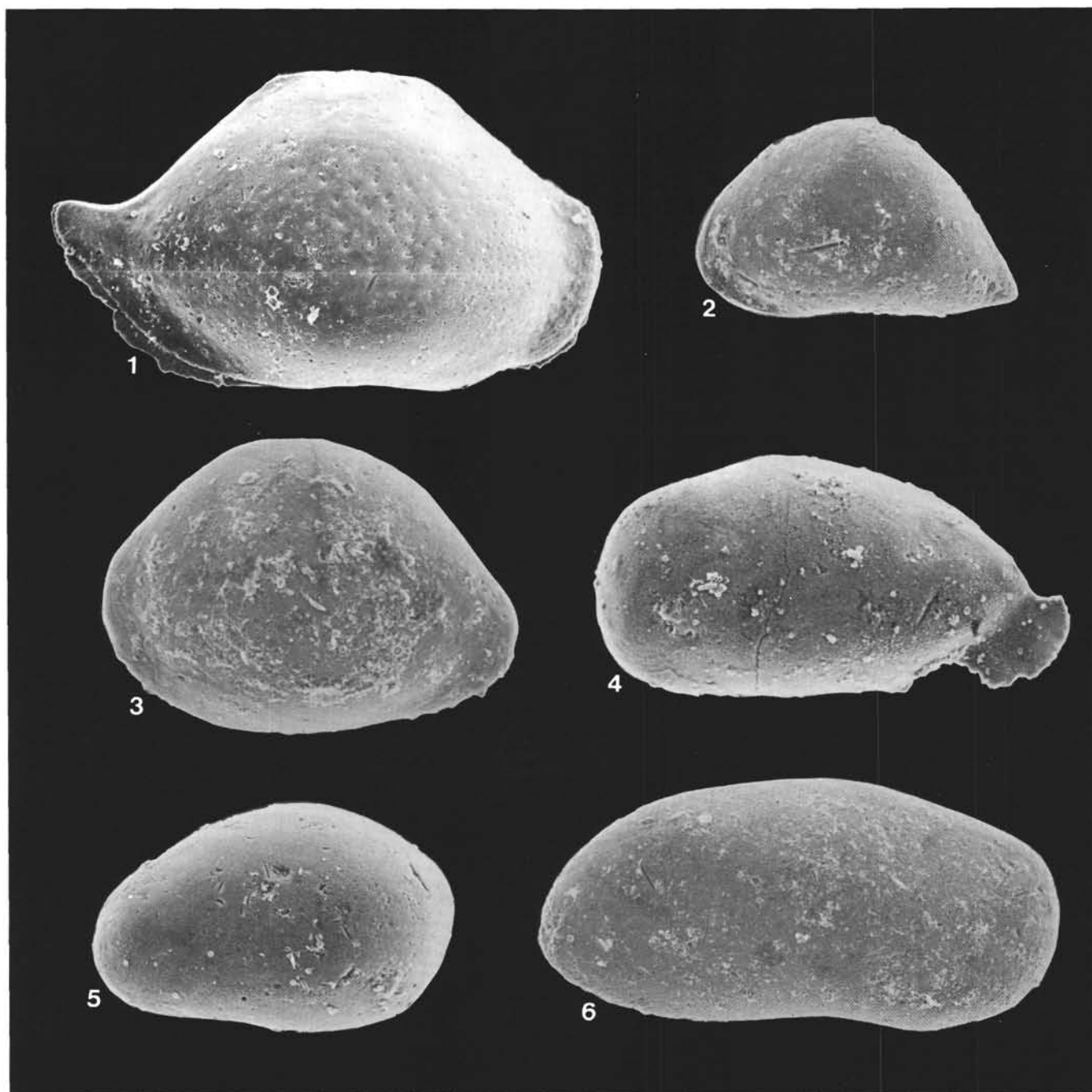


Plate 8. (All specimens are middle Eocene. Three-part designations beginning with 612 or 613 are DSDP section numbers.) 1. *Bairdoppilata* cf. *B. cassida* (van den Bold, 1946), $\times 78$, exterior right valve, adult female?, 612-25X-3, USNM 401548. 2. "*Bairdia*" sp., $\times 120$, exterior left valve, adult female, 613-23X-1, USNM 401551. 3. *Paranesidea* cf. *P. cespedesensis* (van den Bold, 1946), $\times 110$, exterior left valve, juvenile female, 613-25X-3, USNM 401549. 4. *Aratrocypris* sp., $\times 180$, exterior left valve, adult male, 612-24X-3, USNM 401553. 5. *Xestoleberis* sp., $\times 150$, exterior left valve, adult female, 612-22X-3, USNM 401552. 6. *Bythocypris* sp., $\times 86$, exterior right valve, adult male, 613-23X-1, USNM 401550.