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EOCENE STELLEROIDS (ECHINODERMATA) AT SEYMOUR ISLAND, ANTARCTIC PENINSULA

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ABSTRACT—The new asteroid species *Sclerasterias zinsmeisteri* (Asteriidae), *Paragonaster clarkae, Tesselaster clarki* (both Goniasteridae), and the new ophiuroid species *Ophiura hendleri* (Ophiuridae) are described from the late Eocene La Meseta Formation at Seymour Island, Antarctic Peninsula. The arm tip of an apparently new genus of the Oreasteridae is too incomplete to assign at the generic level. Other La Meseta asteroid species have been described elsewhere. Six of seven recognized stelleroid genera and all represented families survive, and differences between new species and existing congeneric species are subtle. Thus, the La Meseta fauna was similar to living faunas in basic composition.

Among La Meseta asteroids, *Zoroaster* aff. *Z. fulgens* and *Ctenophoraster downeyae* are known from numerous specimens; fossils of the other species are comparatively uncommon and given the uncertainties of sampling, further taxa might await discovery at Seymour Island. Although the Paxillosida is known from Jurassic rocks, fasciole-bearing, semi-infaunal genera are first known from Cretaceous deposits, and *Astropecten* and *Astropecten*-like *Ctenophoraster* are first recorded from Cenozoic rocks. *Zoroaster* and *Tesselaster* are only known from deep water settings today, although they are found in the La Meseta. *Ophiura hendleri,* the only ophiuroid recognized to date from the La Meseta, occurs singly, in small groups, and in Paleozoic-type ophiuroid-rich beds.

INTRODUCTION

THE LATE EOCENE La Meseta Formation at Seymour Island, Antarctic Peninsula, contains diverse echinoderms, including echinoids (McKinney et al., 1988; Radwanska, 1996), crinoids (Meyer and Oji, 1993; Baumiller and Gazdzicki, 1996), and stelleroids (Blake and Zinsmeister, 1979, 1988; Aronson et al., 1997). Holothuroids are as yet unrecognized. The late Eocene of the Southern Ocean area is interpreted as a temperate setting (Case, 1992; Stilwell and Zinsmeister, 1992), and many distinctive asteroid taxa found in the region today (A. M. Clark, 1962) are absent from the La Meseta Formation.

Many aspects of the geology and paleontology of Seymour Island have been treated in Feldmann and Woodburn (1988), and Vizcaino et al. (1997). The La Meseta Formation is a clastic deposit on Seymour Island, off the Antarctic Peninsula (Figure 1). Locally, it contains remarkably abundant and taxonomically diverse marine invertebrates, and it has become a setting of keen paleontologic interest (e.g., Feldmann and Woodburne, 1988; Stilwell and Zinsmeister, 1992). The La Meseta Formation has a lenticular form suggested to represent a trough or channel (Sadler, 1988). Basal unconformities crop out at the northwest extremity of the island and at the south side of Cross Valley, which marks the waist of the island. The axis of the trough is approximately central in the outcrop belt, at the plateau, and it appears to have extended in an approximately east-west direction. Within the La Meseta, facies are complex. Seven stratigraphic units have been recognized, all showing small-scale lenticularity; correlation is difficult within the regional depositional framework.

Stelleroids are widely distributed in the La Meseta, although most were collected from the middle part of the outcrop belt toward the axis of the inferred channelway. Asteroids decline in abundance near the top of the Formation, but dense ophiuroid assemblages are present in higher intervals. Many sediments closer to the northern and southern erosional bases generally contain fewer fossils but some stelleroids are present. Sediments in these areas are thinly bedded and not significantly disrupted by burrowing or storm beds.

Interpretations of the age of the La Meseta range from not older than late early Eocene in the lower portions to as late as early Oligocene in the uppermost portion. Stilwell and Zinsmeister (1992) interpreted the molluscan fauna of the upper La Meseta as late Eocene. Keller et al. (1992) related the turnover of planktonic foraminifera between the middle Eocene and the early Oligocene to onset of glaciation.

THE EOCENE STELLEROID FAUNA AT SEYMOUR ISLAND

Taphonomy.—The fossil record of stelleroids is generally poor and therefore the La Meseta occurrence is remarkable because of its comparative diversity. Fossil asteroids assignable to extant families, however, have been reported from Mesozoic rocks. Essentially complete specimens representing existing stelleroid families are known from the Hettangian, at the beginning of the Jurassic (Blake, 1984, 1990). A probable Bajocian (Middle Jurassic) occurrence from Switzerland (Hess, 1972) includes six surviving families representing four orders; all represented genera are extinct, however. Thus, diversification of living asteroid families and orders was taking place during the Jurassic; however, few Jurassic species and genera appear closely related living equivalents.

The Eocene La Meseta fauna (Figures 2–6), in contrast, has an appearance familiar to the student of living asteroids. It includes three genera of the Goniasteridae (*Paragonaster clarkae,* Figure 2.3–2.12; *Tesselaster clarki,* Figure 4.1–4.6; *Buterminaster elegans*) and one each of the Zoroasteridae (*Zoroaster* aff. *Z. fulgens,* Figure 7.5), Asteriidae (*Sclerasterias zinsmeisteri,* Figure 4.6–4.13), Oreasteridae (genus and species unknown, Figures 2.1, 2.2; 3), and Astropectinidae (*Ctenophoraster downeyae,* Figure 7.6). A single modern-appearing ophiuroid, *Ophiura hendleri* (Ophiuridae, Figures 5–7) is known as well. Familial affinities of a number of poorly preserved specimens are uncertain but they do not appear to represent undescribed taxa.

Given known asteroid diversity through time, the poor fossil record of stelleroids appears to be a taphonomic artifact. Asteroids tend to have a large coelom enclosed by small, unfused ossicles; most asteroids are epifaunal, and many are found in shallow, turbulent environments where they are readily dissasociated and ossicles rapidly dispersed after death. Many ophiuroids perhaps are sturdier but they, too, appear readily subject to destruction after death.

Only a single species of each La Meseta genus has been recognized, whereas multiple species of individual genera occur in many contemporary settings (e.g., Fisher, 1911; 1928; Walen-

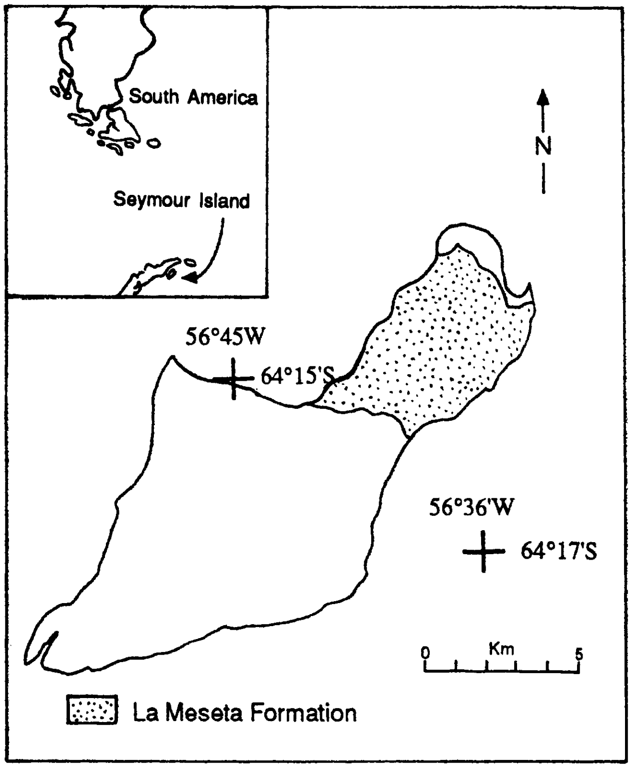

FIGURE *1*—Seymour Island, Antarctic Peninsula. The outcrop pattern of the La Meseta Formation, source of all fossils discussed here, is stippled.

kamp, 1976, 1979). In modern settings, individuals of many species are rare and congeneric species commonly do not occur together; presence of a single species of each genus in the La Meseta does not appear significant.

Feeding habits and occurrences.—Many asteroids are feeding generalists and therefore feeding habits of the La Meseta representatives are difficult to determine with confidence, although a few hints are available. Specimens of both *Ctenophoraster* and *Zoroaster* have been discovered with gastropods within the disk; *Struthiolarella variablis* (Struthiolarellidae) was found in *Ctenophoraster* and an unidentified but similar gastropod in *Zoroaster.* Gastropods parasitic in asteroids are known today, but most belong to the family Eulimidae (Jangoux, 1987), which is typified by slender, smooth shells very different from those of *Struthiolarella.* Further, living zoroasterids and especially astropectinids are well-known predators of invertebrates (Jangoux, 1982). One La Meseta *Ctenophoraster* specimen was discovered in an ophiuroid assemblage (Figure 7.6), although there is no suggestion of ophiuroid material in the gut position of this poorly preserved individual.

Another suggestion of predation is the occurrence of impressions of the ventral surface of asteroids with a dense population of a very small, undescribed (W. J. Zinsmeister, personal commun., 1994) bivalve (Figure 7.5). Among La Meseta asteroids, arm shape and disk form of the trace fossils are closest to those of *Zoroaster,* although *Sclerasterias zinsmeisteri* (Figure 4.6–4.13) also has long arms and a small disk, and the diet of the Asteriidae includes diverse invertebrates (Jangoux, 1982). Blake and Zinsmeister (1988) interpreted small individuals of fossil *Zoroaster* in a budlike posture as suspension feeders, although such behavior has not been reported in living *Zoroaster.*

Although data are limited, many living goniasterid species are omnivorous (Jangoux, 1982). *Tessellaster* has been observed with coral in the stomach, whereas recorded gut contents of living *Paragonaster* is varied, but includes sediment and bivalves. A third La Meseta goniasterid, *Buterminaster elegans* (Blake and Zinsmeister, 1988), is similar in form to *Pentagonaster* and *Tosia*; all three are stoutly constructed, and individuals generally are small. *Tosia* and *Pentagonaster* feed on sponges, bryozoans, ascidians, and detritus (Jangoux, 1982), and a similar diet would appear appropriate for *Buterminaster.*

The living asteroids *Astropecten* and *Luidia* are common on unconsolidated substrates in shelf settings. The two are unusual among asteroids in that they are capable of self-burial, pushing sediment laterally from beneath their bodies and gradually sinking beneath the surface as they do so (Heddle, 1967). True burrowing, involving lateral movement into and through the substate, is unknown among asteroids. In both of these genera, the presence of deep intermarginal channels (so-called "fascioles") seems important in that it allows unobstructed water flow over the animal body surface, aiding self-burial. *Ctenophoraster,* as a fossil genus known only from Seymour Island, is very similar to *Astropecten* and it, too, probably is and was capable of self-burial.

Although the Astropectinidae is known from rocks of Jurassic age (e.g., Hess, 1972), the oldest clearly identified fasciole-bearing taxon is from the Early Cretaceous (Hauterivian and Barremian, Hess and Blake, 1995); somewhat younger Cretaceous occurrences of fasciolar paxillosidans are known from the Cenomanian (Breton, 1995), Campanian (Blake, 1988; Blake and Sprinkle, 1996) and Maastrichtian (Blake and Sturgeon, 1995). *Astropecten* and *Ctenophoraster,* however, are first known from Cenozoic rocks, and the 102 recognized living species of *Astropecten* (A. M. Clark, 1989) suggest speciation is active, perhaps indicating the value of a semi-infaunal habit. Although the fossil record of asteroids is poor, the habit of self-burial enhances opportunity for preservation, suggesting that the known stratigraphic ranges might be approximately correct and that asteroid self-burial evolved in the Cretaceous and *Astropecten*-like taxa in the Cenozoic.

The Zoroasteridae today is known only from water depths beyond 220 m in the Atlantic (A. M. Clark and Downey, 1992), yet *Zoroaster* is abundant in the shallow-water La Meseta Formation. Jablonski and Bottjer (1990) included *Zoroaster* among

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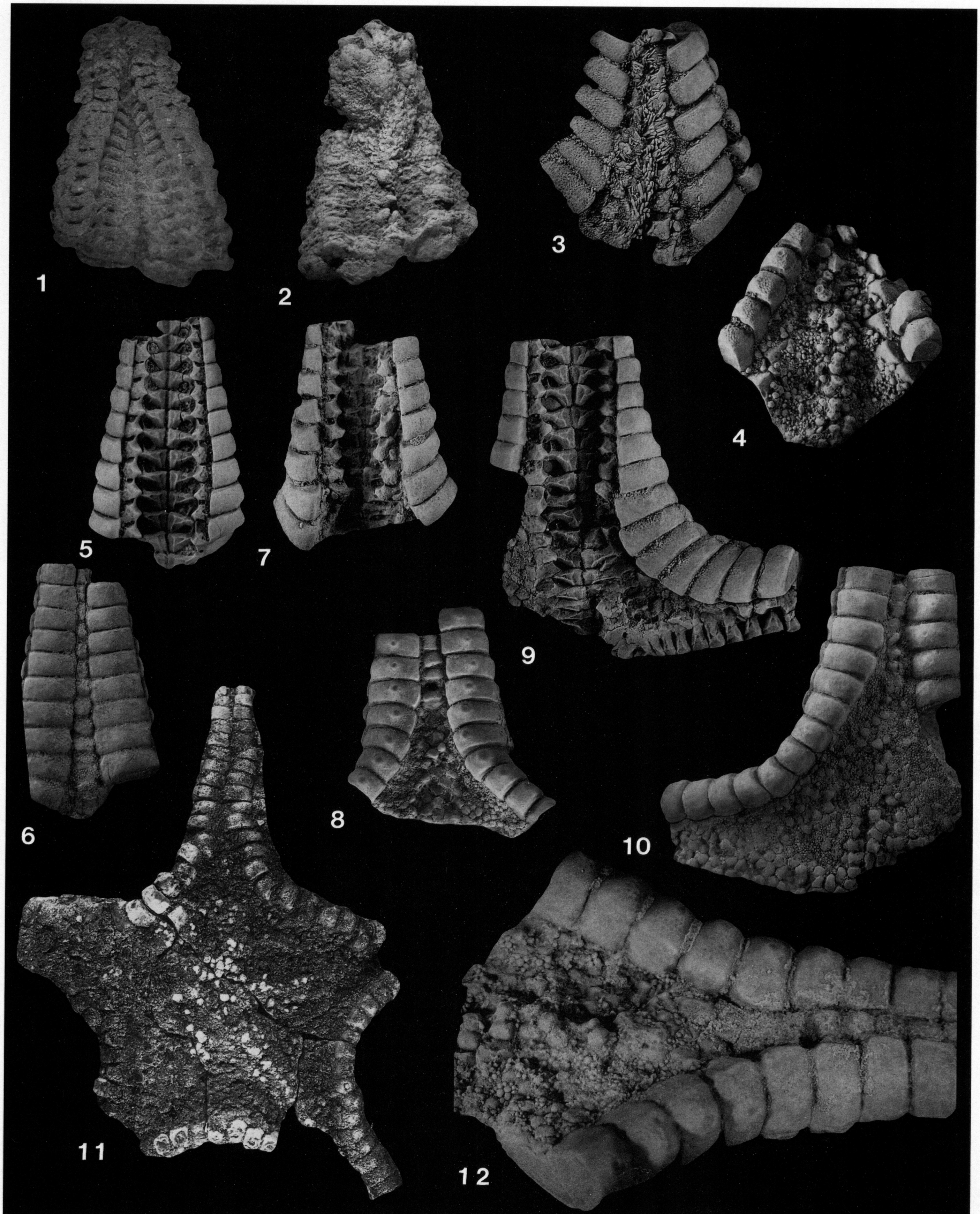
FIGURE 2—*1, 2,* Oreasterid sp., ×3, loc. 86-04, hypotype, USNM 490418; *1,* ventral view, ambulacrals and adambulacrals dominate the view, with the edges of the marginals exposed; *2,* dorsal view, marginals are to the sides and radials forming an irregular midline; an enlarged distal radial is present near the arm tip, compare with Figure *3. 3–12, Paragonaster clarkae,* new species, all loc. 94-03; *3–10,* alternate ventral and dorsal views of four fragments showing ossicular form and arrangement, ×1.5; *3,* inferomarginals separated by adambulacral columns with some spines remaining, *4,* paxillae are displaced but granules remain, paratype, USNM 490415; *5,* form of ambulacrals and adambulacrals, *6,* single series of angular radials, paratype, USNM 490421; *7, 8,* fragment from just distal to the juncture of an arm with the disk, spine bases on the superomarginals, and a single series of radials, paratype, USNM 490422; *9,* marginals, paxillae, ambulacrals; *10,* radials enlarged compared to adjacent paxillae, paratype, USNM 490422; *11,* dorsal view showing general shape, ×3, holotype, USNM 490423; *12,* dorsal view, superomarginals with spine bases, paxillae, radials, granules, ×3, paratype, USNM 490424.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