15 Middle Devonian Arkona Shale of Ontario, Canada, and Silica Shale of Ohio, USA

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The two related fossil assemblages discussed in this chapter occur in possibly age-equivalent Middle Devonian mudstones in southern Ontario and Ohio (Fig. 137). The Arkona Shale is exposed along the banks of the Ausable River and in its tributary streams in the vicinity of Arkona, Lambton County, Ontario, Canada. The Silica Shale is exposed in the quarries of the Medusa Cement Company and the New Genstar Cement Company, both north and south of Centennial Road in the town of Silica, Lucas County, Ohio. These mudstones are considered to be in the lower part of the Hamilton or Traverse Group and are of Early Givetian age, approximately 385 million years before present.

LIMESTONE LENSES WITH BRYOZOANS, BRACHIOPODS, TRILOBITES AND COMPLETE CRINOIDS

The thin skeletal limestone lenses within the Arkona and Silica Shales carry a moderately diverse fauna of bryozoans, brachiopods, gastropods, bivalves and trilobites, as well as crinoids and blastoids. Approximately 40–50 species can be found with considerable effort. The Silica fossils are described in a richly illustrated volume compiled by Kesling and Chilman (1975). Among the most common fossils are the stick-like bryozoans, *Sulcoretepora*, as well as *Fenestella*. Brachiopods include abundant, small, concavo-convex chonetids and *Mucrospirifer*. The trilobite *Phacops* is also commonly associated and has been found in clumps of articulated individuals in the Silica Shale of Ohio; it has become the landmark of these strata and is a highly valued collector's item. The surrounding mudstones are quite sparsely fossiliferous, but do occasionally contain isolated specimens of chonetids, *Mucrospirifer* and other brachiopods. Scattered, pyritized specimens of small bivalves (nuculids), goniatites and bactritids also occur.

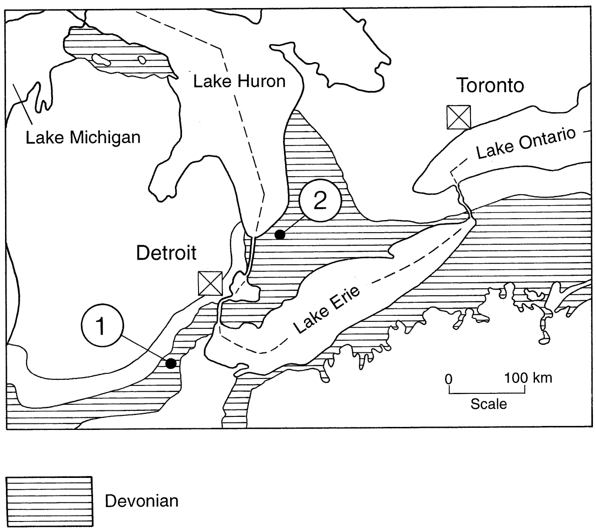

Fig. 137. Location map for Devonian Arkona and Silica Shales in southern Ontario and Ohio. (1) Silica; (2) Arkona.

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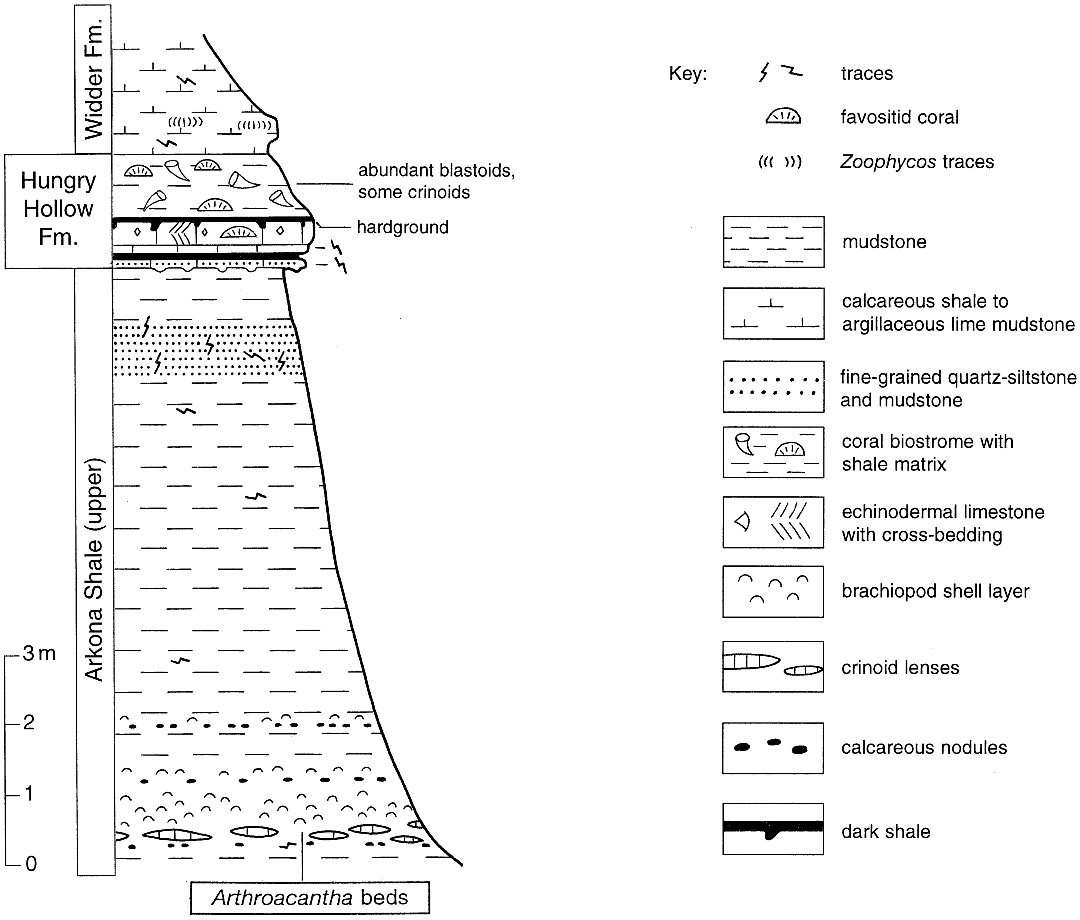

Fig. 138. Stratigraphic section of Middle Devonian Arkona Shale, exposed in a brick pit on the north side of the Ausable River near Arkona, Ontario. (Modified from Landing & Brett 1987.)

Ostracodes are common on some parting planes in the mudstone.

Complete crinoids in both areas appear on the top of thin lenses of skeletal debris of crinoids, bryozoans and occasional brachiopods. These lenses are included in soft, slightly petroliferous, bluish-grey mudstone (often termed shale, although it lacks fissility). Surrounding mudstones are nearly barren of fossils. However, crinoids and other fossils occur in great densities at the interface between some lenticular pods of skeletal debris and the overlying sparsely fossiliferous mudstone (Figs. 138, 139). In some cases, completely articulated crinoids are also found at the margins of lenses on bedding planes that are otherwise obscure. That is, they occur at the boundary between one mudstone and another, with only a very thin scattering of skeletal debris and/or complete crinoids marking this interface. In at least one horizon within the Arkona Shale, crinoids are also associated with the top of a thin, somewhat concretionary siltstone layer within the mudstone.

The lenses of skeletal debris form an apparent substrate beneath the crinoid colonies. In both cases, debris consists of broken crinoid stems (individual columnals and very short sections), plates of the crown and even partly articulated cups. Brachiopod shells are usually whole valves, although many are disarticulated. Bryozoans, which are predominantly of the narrow blade-like cryptostome *Sulcoretepora*, tend to be fragmented into short segments no more than 1 cm in length. In contrast, crinoids, blastoids and other delicate fossils found at the interface between the skeletal lenses and the overlying mudstone may be perfectly preserved with a considerable length of stem and radicular cirri, carrying complete crowns with delicately pinnulate arms and, in many cases, attached platyceratid gastropods. The pinnulate arms on the camerate crinoids are usually stretched out or splayed, although in some cases the arms appear to have been drawn together. The perfect preservation of these crinoids suggests a complete lack of transport and nearly immediate burial by the clay-rich sediment.

SPINY CRINOIDS AND PLATYCERATID SNAILS

The crinoid assemblages are of relatively low diversity and are dominated by one or two species of camerates. In both the Silica and the Arkona Shales, the most common crinoid is the simple, monocyclic camerate *Arthroacantha*. This crinoid had a stem approximately 20–30 cm long, with whorls of radicular cirri towards the distal end, and a relatively large crown with pinnulate arms (Fig. 140). Its most unique feature is the presence of small articulated, movable spines on the cup plates and of larger spines on the axillaries (hence the name 'spiny joints'). A majority of these crinoids have platyceratid gastropods, such as the spiny *Platyceras dumosum*, attached to the tegmen. Another, relatively common crinoid in the Silica Shale is the spiny camerate *Gilbertsocrinus*. This crinoid is unique in having peculiar, snake-like tegminal appendages that were originally mistaken for arms; in the famous Mississippian species *Gilbertsocrinus tuberosus* (see Chapter 18) the appendages are pendent and dominate the crown, with the delicate, pinnulate, biserial arms being inserted between them. *Gilbertsocrinus ohioensis*, the more common species in the Silica Formation, has much stronger arms and only weak, string-like appendages. The function of the appendages, which are hollow, remains something of an enigma. The box-like cup carries on its base long spines that are directed downward. The large, flat tegmen of these camerates also commonly supported com-

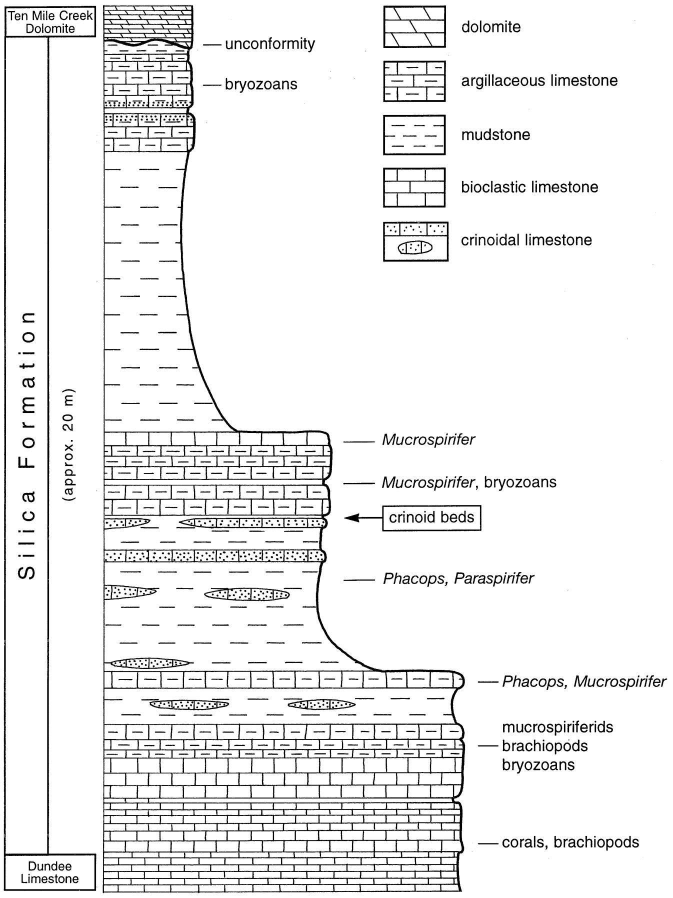

Fig. 139. Section of the Middle Devonian Silica Formation exposed in quarries near Silica, Ohio. The thickness of the Silica Formation is approximately 20 m. (Modified from Kesling & Chilman 1975.)

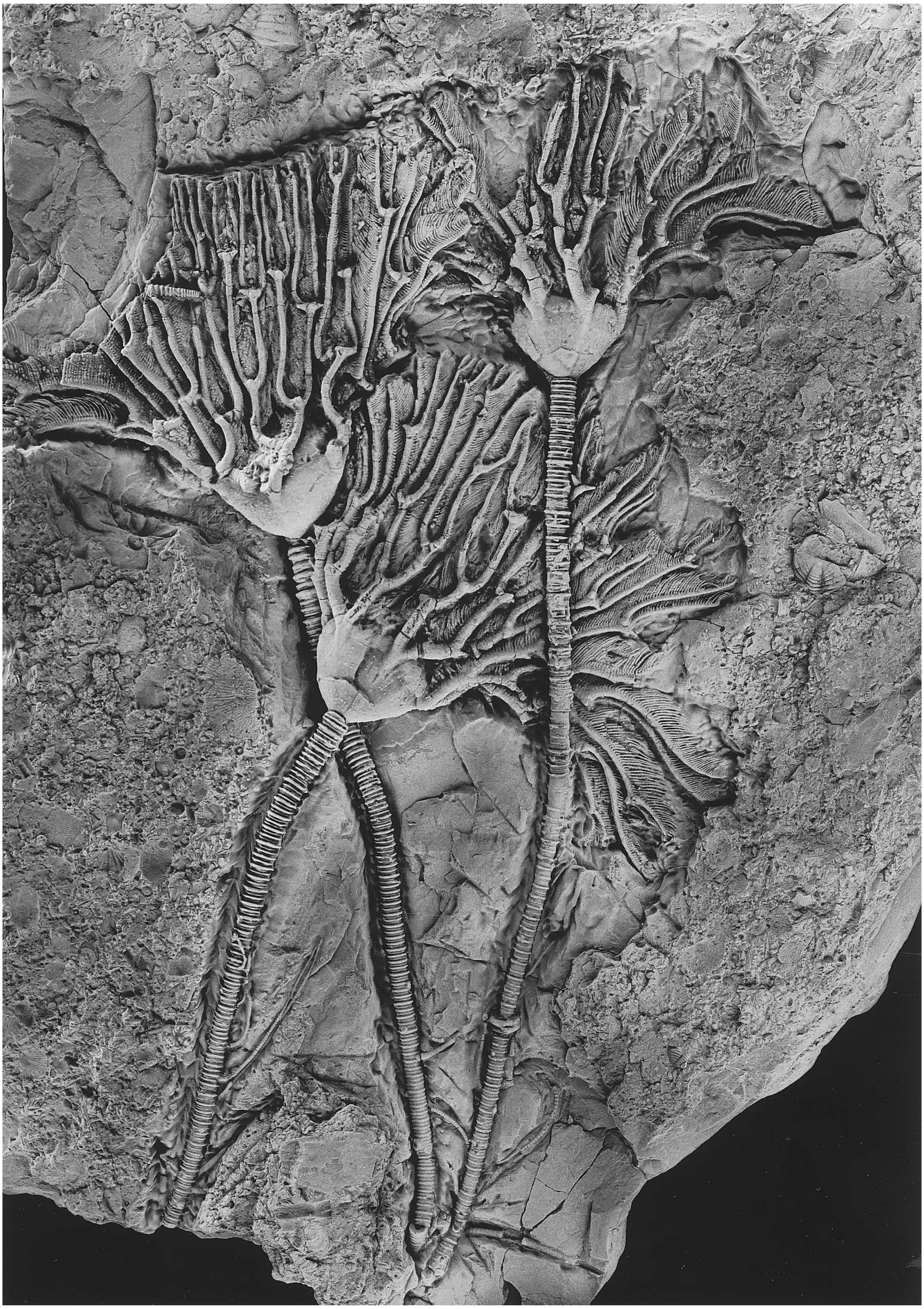

Fig. 140. *Arthroacantha carpenteri*. Silica Formation, Medusa Cement Quarry, Sylvania, Ohio. (Hess Collection; photograph S. Dahint.) ×1.

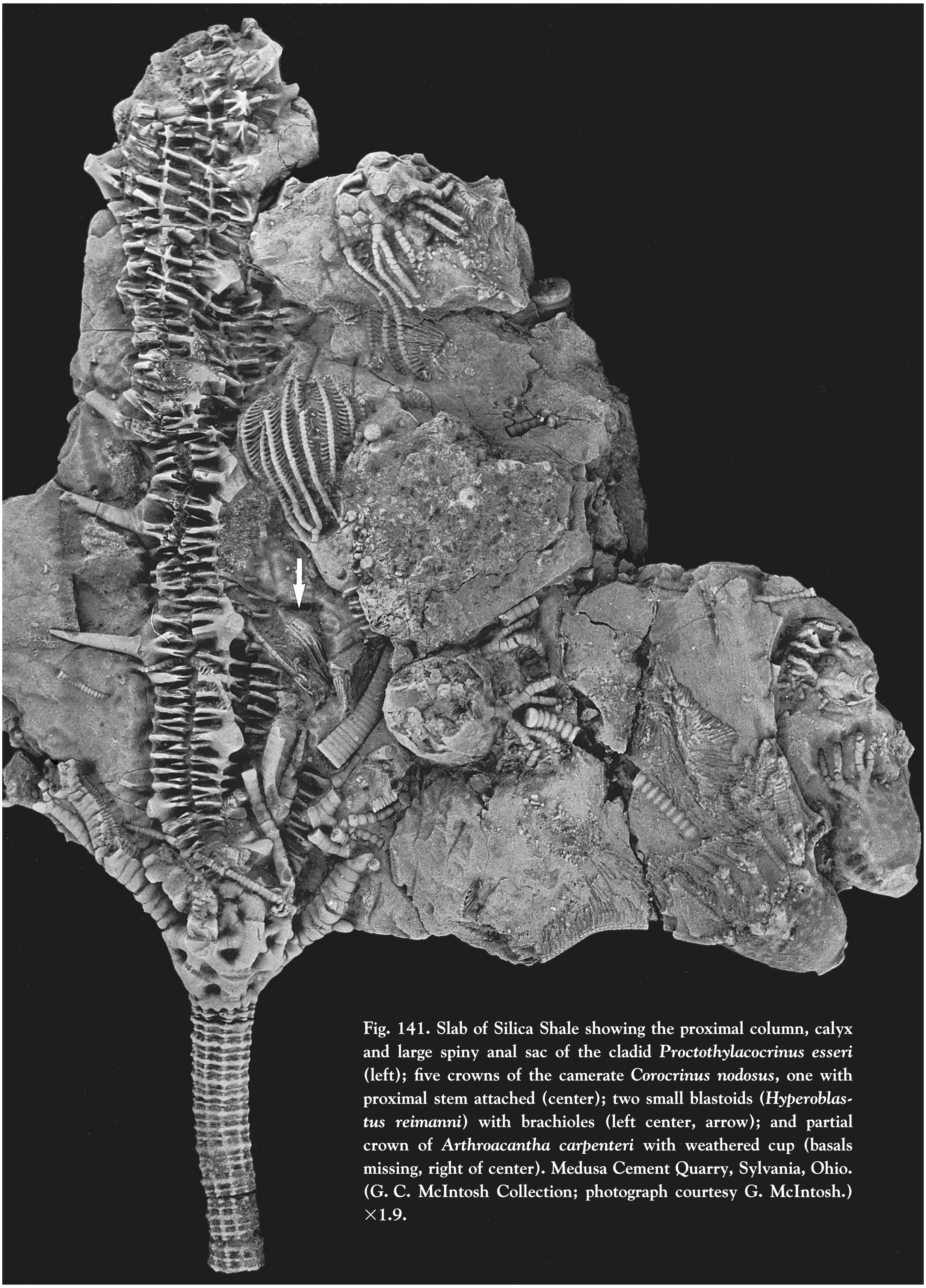

Fig. 141. Slab of Silica Shale showing the proximal column, calyx and large spiny anal sac of the cladid *Proctothylacocrinus esseri* (left); five crowns of the camerate *Corocrinus nodosus*, one with proximal stem attached (center); two small blastoids (*Hyperoblastus reimanni*) with brachioles (left center, arrow); and partial crown of *Arthroacantha carpenteri* with weathered cup (basals missing, right of center). Medusa Cement Quarry, Sylvania, Ohio. (G. C. McIntosh Collection; photograph courtesy G. McIntosh.) ×1.9.

mensal platyceratid gastropods. In the Arkona and Silica Shales another camerate crinoid, *Corocrinus nodosus*, is abundant in certain assemblages (Fig. 141) and, again, commonly has attached platyceratid snails. Associated specimens of the small cladid *Decadocrinus*, *Proctothylacocrinus esseri* (Fig. 141) and the flexible *Synaptocrinus* are also found. The blastoid *Hyperoblastus* is commonly associated with the crinoids at Sylvania, Ohio, and is typically preserved with stems and brachioles (Fig. 141).

A MUDDY SEA FLOOR

Both the Arkona and Silica Shales were deposited in relatively offshore, deeper water, characterized by muddy bottoms. Some evidence of winnowing and fragmentation of fragile fossils and of erosive sole marks on the bases of some coarsely skeletal limestone lenses suggests intermittent activity of storm-generated currents on the sea bottom. However, the crinoids lived predominantly below the effect of storm waves. Clays deposited in this offshore setting were ultimately derived from the erosion of eastern siliciclastic sources, uplifted in the Acadian orogenic belt along the present eastern seaboard of North America. The sparsely fossiliferous nature of most of the mudstone suggests rather inhospitable conditions associated with a soft, possibly soupy substrate; and the occurrence of a diminutive, pyritized fossil in some of these shales indicates low-oxygen conditions at least at and below the surface of the sediment. During most of the time, relatively little sediment accumulated. However, considerable mud was deposited during brief pulses associated with the development of mud-rich slurries, possibly winnowed from upslope areas of flocculated clays by storm waves and transported into this setting by storm generated gradient currents.

Most of the benthic organisms in these assemblages were apparently adapted to soft-substrate attachment or support. The brachiopods, for example, display large bearing surfaces or elongate ski-like wings in the *Mucrospirifer* brachiopods. The crinoids such as *Arthroacantha* possessed flexible radicular cirri that may have permitted either attachment to other objects (including other crinoids) or temporary anchoring to soft substrate. *Gilbertsocrinus* was tethered by a distal coil that could be wrapped around bryozoan stalks, other crinoids or positioned on the sea floor in a series of coils resembling a coiled snake. In this crinoid, and perhaps in *Arthroacantha*, a portion of the stem may have been borne horizontally as a runner on the sea bottom, as is noted for some modern isocrinids (see Chapter 29). Blastoids and some associated small crinoids were anchored to thickets of bryozoans by either coils or small discoidal holdfasts. The occurrence of crinoids and other animals preferentially around pods of skeletal debris suggests a process of taphonomic feedback in which an armouring of crinoidal skeletal material from the sea bed permitted attachment of new types of epifaunal organisms in a tiered ecological succession. However, it is clear that most of the crinoids could anchor in soft muds as well as attach themselves to loose piles of skeletal debris.

IMPORTANT COLLECTION IN THE UNITED STATES

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