10 Middle Silurian Rochester Shale of Western New York, USA, and Southern Ontario, Canada

WENDY L. TAYLOR AND CARLTON E. BRETT

A LONG HISTORY OF COLLECTING

Extraordinary assemblages of echinoderms and trilobites are preserved in the Rochester Shale of western New York and southern Ontario, Canada. Aside from being one of the first formally designated formations in North America, the Rochester Shale is also noted for its exceptional fossils. Outcrops around the city of Lockport, New York, were famous for their well-preserved crinoids and cystoids as early as the 1820s. Excavations were carried out by the Lockport physician Eugene Ringueberg (1890) and later continued by Frederick Braun (1911, 1914), who was employed by Frank Springer. The specimens are now housed in the Springer Collection of the National Museum of Natural History. These sites have produced an astonishing array of intact crinoids, cystoids, asterozoans and edrioasteroids. More recent study by the authors of this chapter at a commercial quarry run by the Caleb family in Middleport, New York (Fig. 101), and several other localities continues to produce rare echinoderms and spectacular trilobites.

The Rochester Shale, Upper Clinton Group (Wenlockian), crops out along the east–west-trending Niagara Escarpment in western New York and southern Ontario and is composed of Middle Silurian age (Late Sheinwoodian to Homerian) calcareous shales and limestones, deposited about 415 million years before present (Fig. 101). The major intervals of echinoderm *Lagerstätten* (*Homocrinus* Beds) occur in the Lower Rochester Shale or Lewiston Member, with only a few sporadic occurrences of well-preserved fossils noted in the upper, dominantly unfossiliferous Burleigh Hill Member (Brett & Eckert 1982; Brett 1983; Taylor & Brett 1996; Brett & Taylor 1997).

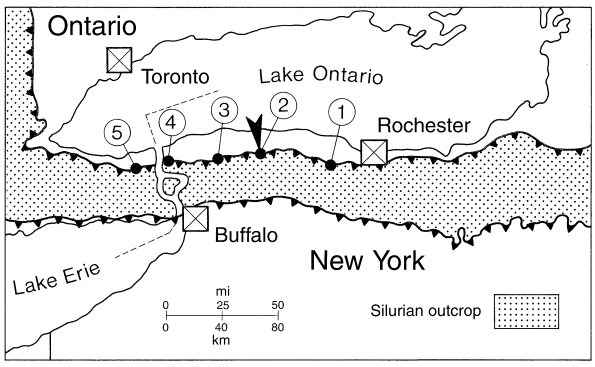

Fig. 101. Crinoid *Lagerstätten* horizons (*Homocrinus* Beds) from the Rochester Shale occur in western New York State and southern Ontario, Canada, along the Silurian outcrop belt (stippled) and bounded by the Niagara (north) and Onondaga (south) Escarpments, shown as toothed lines. Locations are as follows: (1) Wegman's Plaza, Brockport, N.Y.; (2) Jeddo Creek tributary, Middleport, N.Y. (arrow); (3) Lockport, N.Y.; (4) Niagara Gorge, Lewiston, N.Y.; (5) Welland Canal, Thorold, Ontario, Canada. (After Taylor & Brett 1996.)

Hans Hess, William I. Ausich, Carlton E. Brett, and Michael J. Simms, eds., *Fossil Crinoids*.

BARREN SHALES WITH HORIZONS OF EXQUISITE FOSSILS

The Rochester Shale consists of up to 40–45 m of medium grey calcareous shale and mudstone with interbedded limestones. Fossil content is variable, ranging from nearly barren shales and limestones to highly fossiliferous skeletal limestones with pelmatozoans and bryozoan debris.

Sedimentological and taphonomic evidence indicates that benthic communities were rapidly buried by storm-generated siliciclastic muds and carbonate silts. The resulting rapid burial produced horizons with well-preserved invertebrate fossils, intact crinoids, cystoids and trilobites. In addition to the taphonomic evidence for rapid burial, scanning electron microscopy of the burial muds indicates that these sediments were deposited as aggregate particles of flocculated silt and clay (O'Brien *et al.* 1994). The mudstones generally lack internal lamination and good fissility and, in most cases, overlie shell accumulations of variable thickness. Carbonate silt deposits show a characteristic set of sedimentary structures. These indicate rapid deposition, including planar- to cross-lamination or small-scale hummocky cross-stratification, normal grading, basal scour marks and obliquely embedded pelmatozoans and trilobites.

Fossils present in the Rochester mudstones vary greatly in their preservation, ranging from totally disarticulated long-term background accumulations during periods of slow sedimentation, to well-preserved, smothered bottom assemblages that exhibit signs of slight disturbance and current alignment (Fig. 106). Calcitic skeletons are recrystallized with a variable degree of flattening. The *Lagerstätten*, several so-called *Homocrinus* Beds, are outstanding for their intact crinoids, cystoids and edrioasteroids, frequently preserved in life position (Fig. 102). Camerate crinoids (*Dimerocrinites*, *Macrostylocrinus*), disparids (*Homocrinus*, *Crinobrachiatus*), cladids (*Dendrocrinus*) and the rhombiferan cystoid *Caryocrinites* occur within the lower 1–2 cm of mudstone, commonly with stems attached to the underlying shell debris. In certain horizons, the flexible *Asaphocrinus* is abundant and anchored to the brachiopod *Striispirifer* or to a branching (ramose) bryozoan colony (Fig. 103). Embedded in thicker burial muds are the remains of free-living echinoderms such as asteroids and ophiuroids, commonly preserved in contorted, possibly escape positions. Complete trilobites (*Dalmanites*, *Bumastus*, *Arctinurus*) also occur within the mudstones in clusters, commonly inverted with the dorsal surface down. In certain horizons, the large lichiid *Arctinurus* may carry extraordinary microcommunities of encrusting brachiopods, bryozoans and worm tubes on the dorsal shield.

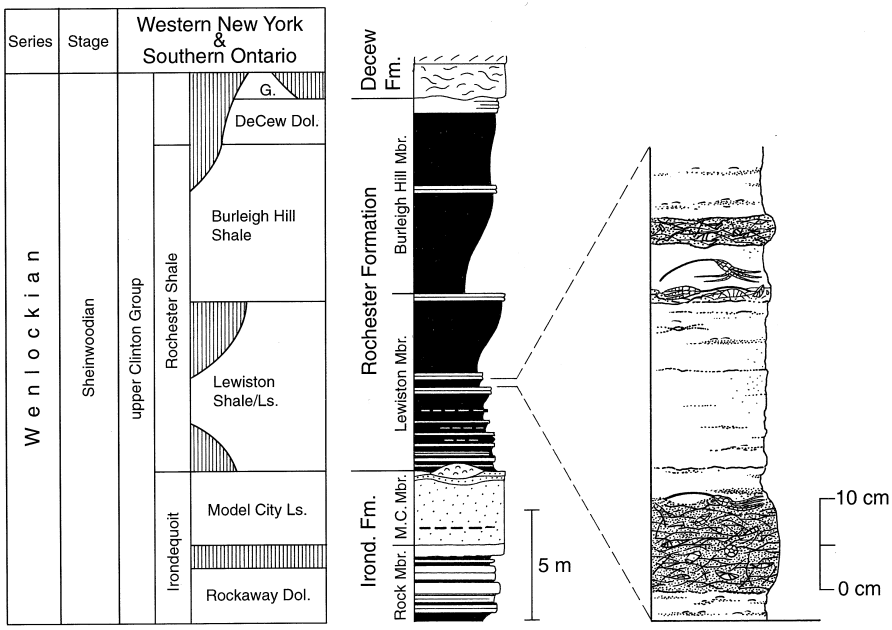

Fig. 102. Chronostratigraphic and generalized stratigraphic column of the Rochester Shale. Key: G, Glenmark Shale; Irond., Irondequoit; Rock, Rockway; M.C. Model City; Ls., limestone; Dol., dolomite. Note the smothered crinoid assemblages in the Lewiston Member. Black indicates dark grey shale; ledges indicate tabular thin carbonate layers; stipple indicates shell-rich units.

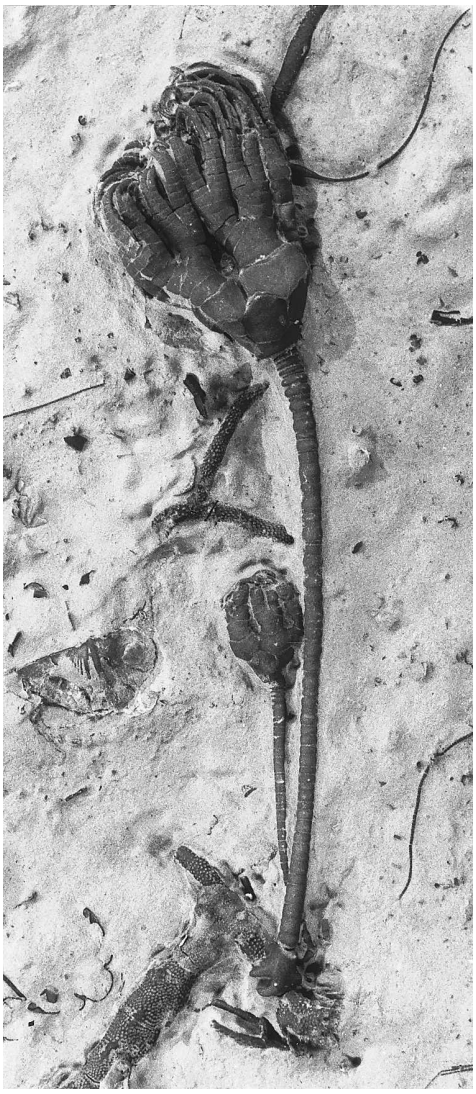

Fig. 103. Two intact individuals (adult and juvenile) of the flexible crinoid *Asaphocrinus ornatus* attached to a branching bryozoan. Note the brachiopod *Striispirifer* (left) and string-like stems of *Homocrinus*. *Homocrinus* Beds, Lewiston Member of the Rochester Shale, Lockport, N.Y. (National Museum of Natural History, Washington, D.C.) ×1.

The preservation of free-living ophiuroids and trilobites, as well as of extremely fragile, sedentary crinoids and cystoids, is dramatic evidence of rapid and deep burial of benthic communities. The burial layers themselves are composed of fine-grained, siliciclastic muds and carbonate silts that were transported into the basin by way of storm-generated sediment flows. Rare evidence of the activity of burrowing organisms can be seen in the occasional disruption of the delicate arms of crinoids, as noted in the arms of the camerate *Macrostylocrinus* (Fig. 104).

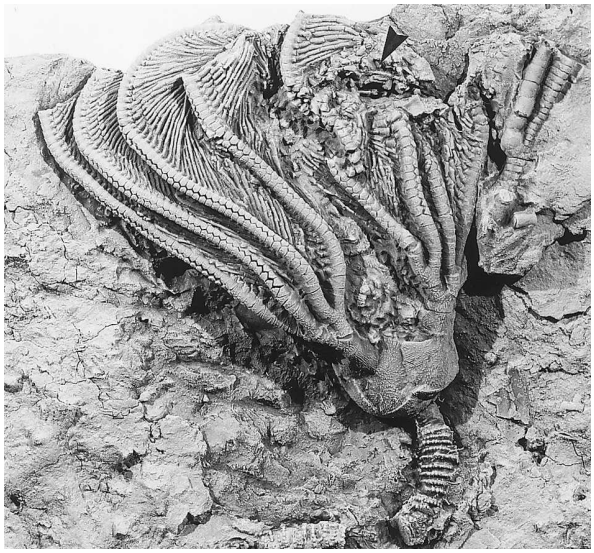

Fig. 104. Complete crown of the camerate *Macrostylocrinus ornatus*. Note the bioturbated arms on upper right (arrow). *Homocrinus* Beds, Lewiston Member of the Rochester Shale, Lockport, N.Y. (National Museum of Natural History, Washington, D.C.) ×1.6.

A MUD-BOTTOM FAUNA OF BRACHIOPODS, BRYOZOANS, TRILOBITES AND ECHINODERMS

More than 200 species of invertebrate fossils are known from the Rochester Shale in New York and southern Ontario. A significant proportion of species are represented by brachiopods, including the spiriferids *Striispirifer* and *Eospirifer*, the rhynchonellids *Stegerhynchus* and *Rhynchotetra*, the strophomenids *Leptaena*, *Coolinia* and *Amphistrophia* and the orthids *Dalejina* (now *Mendacella*) and *Resserella*. The ramose bryozoan *Cheilotrypa* and the fenestrate and encrusting forms *Fenestella* and *Lichenalia*, respectively, are also abundant in some horizons, and may form local thickets associated with the pelmatozoans *Caryocrinites*, *Crinobrachiatus* and *Stephanocrinus*. The trilobites *Dalmanites*, *Calymene*, *Bumastus* and *Arctinurus* commonly occur as disarticulated material; however, in rapid-burial beds they may be exceptionally well preserved.

A variety of echinoderm groups are present and include crinoids, cystoids, asterozoans and edrioasteroids. Crinoids are represented by a diversity of forms, including the camerates *Macrostylocrinus*, *Dimerocrinites*, *Saccocrinus* and *Eucalyptocrinites* (Figs. 105, 106). Cladids are represented by the long-stemmed *Dendrocrinus* with its tall anal sac and highly branched, non-pinnulate arms. Disparids occur as the tiny *Homocrinus*, recumbent

calceocrinids (*Calceocrinus*) and the coiled, bilaterally symmetric *Crinobrachiatus*. Flexible crinoids are also present, with *Asaphocrinus*, *Icthyocrinus* and *Lecanocrinus*. In addition, the rhombiferan cystoid *Caryocrinites* is very common in most beds both as disarticulated material and as intact, even-rooted specimens, which in many cases formed clusters associated with bryozoan thickets. The edrioasteroid *Hemicystites* occurs in certain burial layers (*Homocrinus* Beds) attached to *Striispirifer* valves, and recent excavations have produced rare stalked edrioasteroids, part of a group of extinct multiplated echinoderms popularly known as seated stars.

The Rochester Shale communities were dominated by suspension-feeding organisms such as brachiopods, bryozoans, crinoids and cystoids. These tiered or vertically stratified communities were composed of organisms feeding at different levels. Low levels, several centimeters above the bottom, were occupied by brachiopods, calceocrinids, *Asaphocrinus* and encrusting bryozoans. Branching bryozoans, most crinoids and cystoids exploited higher levels, from 5 cm to more than 1 m above the sea floor; they include *Dendrocrinus*, *Dimerocrinites*, *Icthyocrinus* and *Saccocrinus*. Several species (*Caryocrinites*, *Crinobrachiatus*) favoured the bryozoan thickets, commonly perching on the bryozoan colonies (Fig. 107).

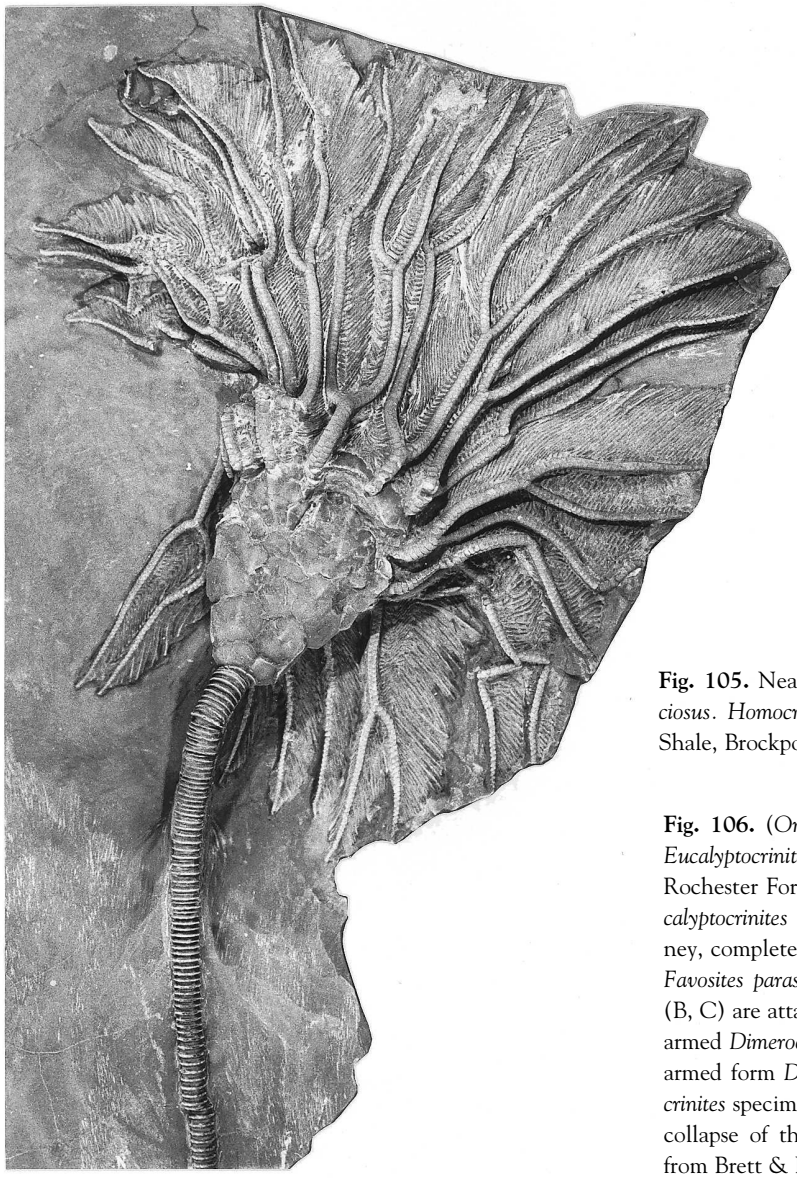

Fig. 105. Nearly complete camerate crinoid, *Saccocrinus speciosus*. *Homocrinus* Beds, Lewiston Member of the Rochester Shale, Brockport, N.Y. (New York State Museum.) ×1.3.

Fig. 106. (*On facing page*) Part of a slab with specimens of *Eucalyptocrinites caelatus* and *Dimerocrinites* spp. from the Rochester Formation of Lockport, New York. The larger *Eucalyptocrinites* specimen (A) exhibits an elongate anal chimney, complete stem and radicular holdfast. The tabulate coral *Favosites parasiticus* and several small dimerocrinitid crinoids (B, C) are attached to the stem of this individual. B is the 10-armed *Dimerocrinites* cf. *liliiformis* and C is an undescribed 20-armed form *Dimerocrinites* (?) species. The smaller *Eucalyptocrinites* specimen (D) shows imperfect preservation and partial collapse of the stem. (Royal Museum of Ontario, Toronto; from Brett & Eckert 1982.) ×1.5.


D
A
C
B

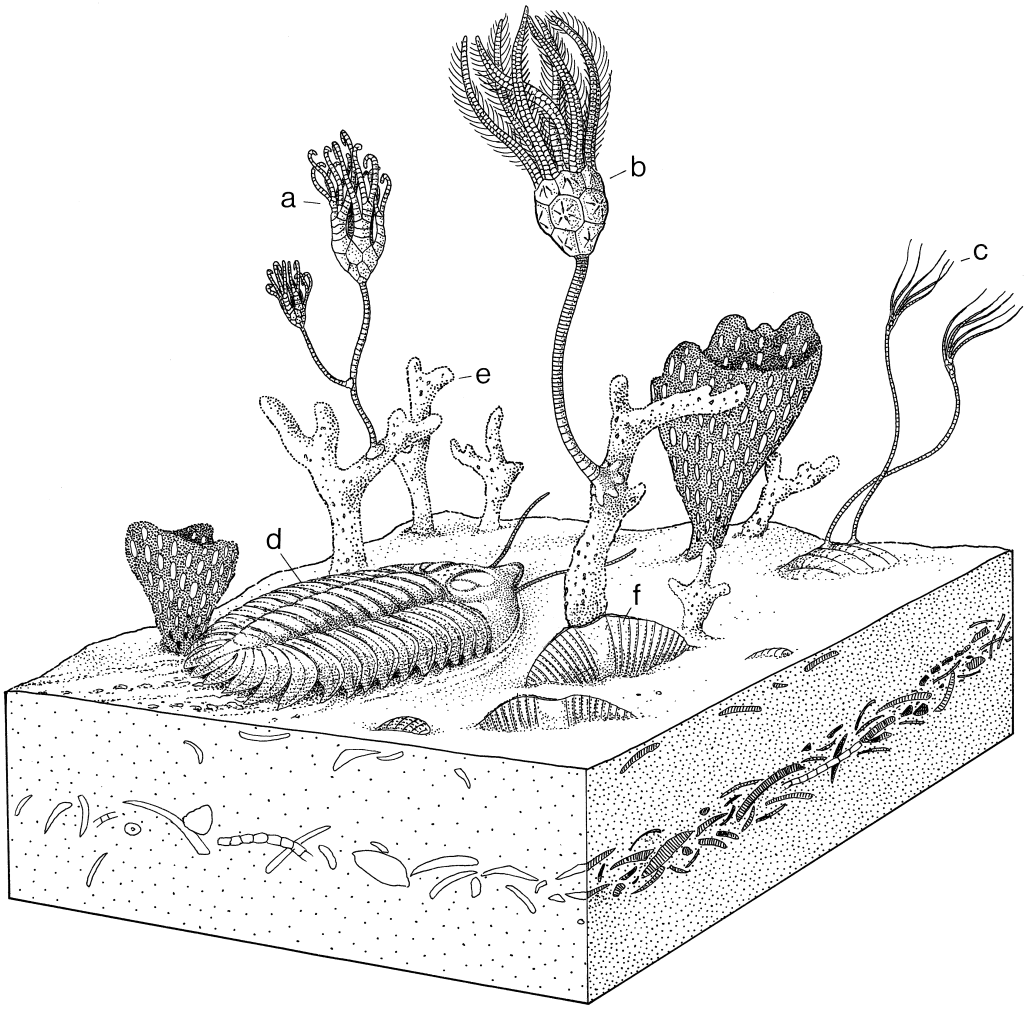

Fig. 107. Reconstruction of the Rochester Shale community from *Homocrinus* Beds. Crinoids: (a) *Asaphocrinus ornatus*; (c) *Homocrinus parvus*. Rhombiferan cystoid: (b) *Caryocrinites ornatus*. Also figured: (d) *Arctinurus* (trilobite); (e) *Cheilotrypa* (ramose bryozoan); (f) *Striispirifer* (brachiopod). A fenestrate bryozoan is between crinoids b and c.

Sediments of the Rochester Shale accumulated in a shallow, subtropical, muddy sea approximately 15–20° south of the palaeoequator. Siliciclastic muds were derived from the erosion of the Taconic highlands to the southeast of New York State and deposited into the Appalachian Foreland Basin. In addition, carbonate silt was transported into the basin from a carbonate platform – crinoidal shoal complex (Wiarton Shoal) to the northwest. Faunal and sedimentological evidence, as well as the presence of endolithic algal borings from Rochester Shale fossils, indicates a normal marine setting of these platform sediments below storm wave base. The finest preservation occurs within rapidly buried mudstone and calcisiltite beds of the Lower Rochester Shale, which record the episodic events of storms within a relatively shallow (50–100 m) subtropical continental sea.

IMPORTANT COLLECTIONS IN NORTH AMERICA

Buffalo Museum, Buffalo, N.Y.
New York State Museum, Albany
Rochester Museum and Science Center, Rochester, N.Y.
Paleontological Research Institution of the University of Rochester, Rochester, N.Y.
Royal Ontario Museum, Toronto, Canada
Springer Collection of the National Museum of Natural History, Smithsonian Institution, Washington, D.C.