Niagaran (Silurian) Trilobites from Ohio

A Thesis

Presented in Partial fulfillment of the requirements
for the degree Bachelor of Science
in Geological Sciences

by

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The Ohio State University
1993

Approved by

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ABSTRACT

For the most part, Silurian trilobites from Ohio have been poorly documented. This paper records taxa from the Niagaran Series. Specimens discussed here were collected from the southern and west-central areas of the state. Species reported here are *Arctinurus boltoni* (which is questionably recorded from Ohio), *Bumastus insignis, Cheirurus niagarensis, Flexicalymene celebra, Sphaerexochus romingeri, Trimerus delphinocephalus, Dalmanites brevicaudatus*, and *Dalmanites platycaudatus.* One species of *Calymene* is left in open nomenclature. During the deposition of the Niagaran in Ohio, trilobites lived in a variety of shallow marine environments, although most are associated with reef, inter-reef, and reef-flank lithofacies.

INTRODUCTION

Trilobites are a relatively small but persistent component of Silurian communities in Ohio. Despite numerous reports (Bowman, 1956; Hall and Whitfield, 1875; Meek, 1873, Shrake, 1990; LaRocque and Marple, 1955), typically of a few species each, there has been no comprehensive investigation of these fossils. This work involves the indentification of taxa from the Niagaran Series of Ohio, reporting known stratigraphic distributions of these taxa, and interpreting (to the extent possible) the life habits of these taxa.

BACKGROUND

Trilobites are not only one of the first, but also the most successful groups of arthropods from the early Paleozoic. The phylum Arthropoda itself is the single most successful animal phylum in the world. From their first appearance in the earliest Cambrian until the last species met with extinction near the end of the Permian, trilobites established a firm, albeit temporary foothold in the early seas. More than twenty thousand species and four thousand genera have been described to date (Babcock, 1993b), although these numbers represent a small fraction of the number of taxa that have been preserved.

The Cambrian saw not only the first appearance of trilobites, but also their greatest degree of diversity. The early success of trilobites is attributed partly to the arthropods' ability to quickly invade and adapt to new niche space. The hard, calcified exoskeleton, and the fact that trilobites frequently molted, made them good candidates for fossilization.

From about the middle of the Ordovician onward, trilobite diversity steadily declined until the Permian. Overall, the Silurian was a time of modest decline in trilobite diversity. Only three new families arose in the interval between the beginning of the Silurian and the end of the Permian (Robison, 1987). What is significant about the Silurian is that during this time, the rapid decline in diversity that began in the later stages of the Ordovician, leveled off and the number of trilobite genera actually saw a brief resurgence beginning in the late Silurian and on in to the Devonian.

During the Silurian, much of what is now North America was covered by a shallow, warm, cratonic sea. It was also during this time that large organic reef communities developed. We see this today in the large proportion of marine carbonate sediments in rocks of Silurian age. Paleogeographical as well as paleomagnetic and biogeographical data are evidence of an equatorial position for Laurentia, the North American-Greenland paleocontinent (Scotese et al., 1985).

Silurian rocks exposed at the surface in Ohio lie in the western half of the state along a narrow, north-south trending belt that widens in the middle of the state and extends westwardly to the Ohio-Indiana border (Fig. 1). Silurian marine rocks in Ohio are mostly dolomitized carbonates, with a few shales, terrigenous clays, and marine evaporites. Some of these strata are present only in the subsurface of the state in the eastern subsurface strata. Worldwide, the Silurian System is subdivided into the Llandoverian, Wenlockian, and Ludlovian stages. The Niagaran Series, as used in North America, extends from the late Llandoverian into the early Ludlovian. Silurian strata in Ohio averages 960 feet (317 m) in total thickness. Niagaran strata, which comprise most of the post-Brassfield Silurian section in Ohio, totals 230 feet (76 m) in average thickness. Generalized thicknesses of individual units are given in Figure 2.

In west-central Ohio, the stratigraphic subdivisions (Fig. 2) are in ascending order, the Dayton Formation, Osgood Formation, Laurel Formation (which includes the previously separate Massie Shale Member), Euphemia Dolomite, Springfield Dolomite, and the Cedarville Dolomite (see Kleffner and Ausich, 1988).

The Dayton Formation is generally a medium to coarse-grained, even-bedded dolostone. The unit is highly fossiliferous, with bryozoans, crinoids, corals, and cephalopods being the most common fossils. The Dayton is overlain conformably by the Osgood Formation. The Osgood consists of silty shales and interbedded dolomitic rocks. Echinoderms, pelecypods, and gastropods are common in the dolomite units, whereas trilobites, crinoids, bryozoans, brachiopods, and corals have been reported from the shales (Kleffner and Ausich, 1988). The Laurel Formation is also a dolomitic unit that includes some interbedded shales (Kleffner, 1988). Both the Laurel and Massie Shale are very fossiliferous, with crinoids, brachiopods, corals, gastropods, trilobites, and bryozoans being reported. The Euphemia Dolomite is a highly fossiliferous dolomite unit from which a large number of brachiopod species have been reported. The Springfield Dolomite has been described as sparsely fossiliferous, with a high quartz silt content in some areas (Kleffner, 1990). A few brachiopods and microfossils have been noted (Kleffner and Ausich, 1988). The Cedarville Dolomite is another fossiliferous unit. The Osgood and Laurel formations, including the Massie Shale Member of the Laurel, have been collectively referred to in past works as the Alger Formation (Bowman, 1956) It seems that Bowman (1956) used the name Alger to refer to the uppermost portion of the Estill Shale. This corresponds to the lower Osgood according to the stratigraphic correlation of Kleffner and Ausich (1988).

The Niagaran strata in the southern outcrop area of Ohio (Fig. 2) are subdivided into the Noland Formation, the Estill Shale, the Bisher Formation, the Lilley Formation, and the Peebles Dolomite (Kleffner and Ausich, 1988).

The Noland Formation correlates with the Dayton Formation and lies unconformably over the Brassfield. The Estill Shale, which lies unconformably over the Noland, is overlain unconformably by the Bisher Formation. The Estill Shale consists of shales with some arenaceous dolomitic lenses. Fossils are not common in this unit however, microfossils including conodonts, chitinozoans, and trilobites have been reported (Bowman, 1956).

The Bisher consists of alternating silty dolomites and silty shales at the base, with more massive dolostones at the top. Bowman (1956) divided the Bisher into four distinct lithofacies. In ascending order, they are the limestone lithofacies, the dolomitic shale lithofacies, the *Cryptothyrella* lithofacies, and the silty carbonate lithofacies. Brachiopods, corals, trilobites, and gastropods are common in all but the dolomitic shale lithofacies.

The Bisher is overlain conformably by the Lilley Formation. The Lilley is generally a fine-grained, argillaceous dolomite. Bowman (1956) subdivided the Lilley into three lithofacies. In ascending order, they are a dolomitic shale, argillaceous carbonate, and a crinoidal carbonate lithofacies. Bowman (1956) also reported reef structures from the the Lilley. Fossils are common in this unit (Bowman, 1956; Kleffner and Ausich, 1988).

Kleffner and Ausich (1988) described a transitional interval between the Lilley and the overlying Peebles, referred to as the Lilley-Peebles transition unit. This unit consists of a massive, argillaceous, and fine-grained dolostone. The Peebles Dolomite consists of fine-grained, massive dolostone beds. Vugs are common the lower part is fossiliferous.

STRATIGRAPHIC DISTRIBUTION

In Ohio, Silurian trilobites are mostly restricted to the rocks of the middle Silurian Niagaran dolostones (Table 1). In surrounding areas with similar depositional histories and stratigraphy, the stratigraphic ranges of the individual species are somewhat extended (Fig. 3). Exposed Silurian strata in Ohio consist of the early Silurian Brassfield Formation and middle

Silurian Niagaran units. The Brassfield and the Dayton Formations are separated by an erosional / non-depositional unconformity (Kleffner and Ausich, 1988) which may limit the ranges of taxa. Most of the post-Niagaran strata have been eroded as well, which again may limit the ranges of taxa.

Most of the trilobites occur within a number of highly fossiliferous units, primarily the Springfield and Cedarville dolomites in west-central Ohio; and the Bisher Formation, Lilley Formation, Lilley-Peebles transition unit, and Peebles Dolomite in western or southern Ohio.

PALEOECOLOGY

There has been no comprehensive work done concerning the paleoecology of Silurian trilobites in Ohio. Various investigations have been conducted on the lithostratigraphy and depositional history of the Ohio Silurian (e.g., Bowman, 1956; Kleffner and Ausich, 1988), and, using the results of these studies coupled with morphological comparisons and faunal associations, reasonable deductions concerning the general life mode of these species can be made.

Some of the discussed species possess morphological characteristics that seem to connote a particular life habit using criteria discussed by Fortey (1975) and Babcock (1993b). *Trimerus delphinocephalus* and *Bumastus insignis* are here interpreted to have been semi-infaunal burrowers. Their smooth, outer carapace, which would reduce friction against the sediment on the dorsal side, and large eyes are characteristics found on other genera such as *Illaenus,* which is occasionally found in partially buried living positions (Bergström, 1973). The convex, triangular cephalon of *Trimerus* is suggestive of a shovel used for digging. Furthermore, rounded genal angles in both species would further reduce sediment resistance dorsally. The terraced ridges or lines on the doublure of *Bumastus* may have been used to grip the substrate ventrally during burrowing or feeding (see Schmalfuss, 1975); this further suggests a semi-infaunal habit.

A strong anterior arch on the cephala of both taxa and, in the case of *Trimerus* , an upturned posterior end of the pygidium (Fig. 4.15), are all characters that would be conducive to a benthic, sediment-filtering mode of food gathering (see Babcock, 1993b). *Sphaerexochus romingeri* and *Cheirurus niagarensis* possess features thought to be indicative of a free-swimming or pelagic lifestyle. These two species have unusually inflated, forwardly expanding glabella, wide axial areas, and reduced pleural areas. These large glabellas may have served a flotation purpose or may have been a repository for fats which could have been used as a hedge against starvation (See (see Babcock, 1993b). *Sphaerexochus* had small eyes, which suggests a free-floating, possibly planktonic existence. *Dalmanites* has large, crescent-shaped eyes, wide pleural areas, and broad marginal spines. The wide pleural areas are suggestive that the animal was primarily benthic. The marginal spines (genal spines, medial-anterior cephalic spine, and medial-posterior pygidial spine) may have helped the animal to "float" on a soupy, fine-grained substrate. The purpose of the large eyes is unknown; perhaps they facilitated light collecting in a light-feeding predaceous trilobite (cf. Miller, 1976).

Encrinurus is morphologically similar to *Dalmanites*, and it too may have been a predominantly benthic trilobite. The more vaulted profile is evidence of a deposit-feeding habit. Large tubercles that cover much of the dorsal surface may have had a sensory function similar to that described in *Phacops* (Miller, 1976).

Arctinurus, like *Dalmanites*, was probably predominantly benthic. The large, flat exoskeleton, broad pleural spines, and flat, spinous pygidium are suggestive of a animal that "floated" on soupy substrates. The body type is suggestive of the flat, flounder-like fishes that live on or near the sea floor.

The relatively heavy, convex carapace of *Flexicalymene* suggests that this taxa were epifaunal, spending most of their time ploughing through the upper layers of sediment. The large anterior arch on the cephalon of Flexicalymene (Fig. 4.2) is typical of benthic, ploughing trilobites (Babcock, 1993b).

All described trilobite taxa are commonly found in association with brachiopods, crinoids, gastropods, stromatoporoids, and other invertebrate corals. Deposition of lower Niagaran strata in west-central and southern Ohio occurred during a transgressive event that eroded part of the underlying Brassfield. The result was the deposition of the clastic-carbonate Noland and Estill shales in the south and carbonate rocks of the Dayton Dolomite elsewhere (Kleffner and Ausich, 1988). Shallow seas were present in west-central Ohio during the remainder of Niagaran deposition. In southern areas of Ohio, eustatic sea level changes, coupled with the gradual tectonic rise of the Cincinnati Arch, were producing periods of intermittent transgressive-regressive depositional periods (Kleffner and Ausich, 1988). As a result, the "nose" of the Cincinnati Arch, dipped to the north, producing deeper, off-shore conditions during the time of Springfield and

Cedarville deposition. Southern Ohio was emergent by this time, resulting in a period of non-deposition.

Most Silurian trilobites are found in reef, inter-reef, or reef-flank lithofacies. The middle and Late Silurian were times of massive carbonate buildups, particularly in the Great Lakes area (Lowenstam, 1950). Mikulic (1981) divided the carbonate buildups in to two categories: the central core and the surrounding flank beds. He also categorized the typical trilobite taxa associated with each lithofacies type. The Ohio Silurian taxa coincide best with Mikulic's (1981) pelmatozoan-rich reef flank lithofacies, which seems to corroborate other evidence suggesting shallow reef and reef-flank conditions during the Silurian in Ohio. Trilobites reported here from siliciclastic lithofacies of Ohio are *Flexicalymene*, *Calymene*, *Dalmanites*, *Trimerus*, and *Encrinurus*.

SYSTEMATIC PALEONTOLOGY

Class TRILOBITA Walch, 1771

Family ENCRINURIDAE Angelin, 1854

Subfamily ENCRINURINAE Angelin, 1854

Genus ENCRINURUS Emmrich, 1844

ENCRINURUS ORNATUS Hall and Whitfield, 1875

Figures 4.10, 4.11

Cybele punctata Hall, 1852 (in part), p.297, pl. 66, figs. 1a-1.

Encrinurus punctatus Vogdes, 1907 (in part), p. 68-9, pl. I, fig. 5.

Encrinurus ornatus Hall and Whitfield, 1875, p. 154, pl. 6, fig. 16; Foerste, 1887, p.102; Raymond, 1916, p. 26; Foerste, 1919-24, p. 79-80, p. 18, figs. 9a, b, 10; Shimer and Shrock, 1944, p. 645, pl. 271, figs. 3-7; Best, 1961, p. 1029, pl. 124, figs. 1, 3, 6, 8, 10, 13; Armstrong, 1962, p. 24; La Rocque and Marple, 1977, p. 71, fig. 136; Ludvigsen, 1979, p. 63-64, fig. 41A-C; Babcock, 1993b, fig. 8-4.6.

Remarks- Cephalon arched, semi-circular in outline, with forwardly expanding glabella. Galbella is heavily tuberculate. Triangulate pygidium has distinct pleural furrows and mid-pleural axis is lined with tubercles. Two pygidia and one cephalon were observed.

Occurrence- Common in the Bisher and the Lilley Formations.

Family HOMALONOTIDAE Chapman, 1890

Subfamily HOMALONTINAE Chapman, 1890

Genus TRIMERUS Green, 1832

TRIMERUS DELPHINOCEPHALUS, Green, 1832

Figures 4.14, 4.15, 4.16

Trimerus delphinocephalus Green, 1832, p. 82, pl. 32, fig. 1; Shimer and Shrock, 1944, p. 654, pl. 272, fig 33; Levi-Setti, 1975, pl. 138; La Rocque and Marple, 1977, p. 71, fig. 140; Babcock, 1993, figs. 8-4.10, 4.11.

Homalonotus delphinocephalus (Green). Murchison, 1839, p. 651, pl. 7, figs. 1, 2; Hall, 1843, p.103, fig. 34; Salter, 1865, p. 113-115, pl. 11, figs. 1-11; Bassler, 1915, p. 632-633; Bowman, 1956, p. 290, pl. 10, figs. 20-28; Ludvigsen, 1979, p. 65, fig. 43A- C.

Remarks- Triangulate cephalon that narrows and tapers dorso-ventrally forward to a point. Axis of thorax is wide, with clear axial furrows. Pygidium is strongly convex, with wide doublure, and pointed posteriorly. Two fairly complete pygidia, six cephalons, and numerous fragmental portions of pygidia, cephalons, and thoracic segments were examined.

Occurrence- Found in the Bisher and Lilley formaitons.

Family DALMANITIDAE Vogdes, 1890

Subfamily DALMANITINAE Vogdes, 1890

Genus DALMANITES Barrande, 1852

DALMANITES BREVICAUDATUS Foerste, 1909

Figures 4.4, 4.5

Dalmanites limulurus brevidaudatus Foerste, 1909b, p. 35-36, pl. 2, figs. 20 a-c.

Dalmanites brevicaudatus Foerste, 1909, p. 61-107, pl. 1-4; Delo, 1940, p. 38, pl. 5, fig. 4; Babcock, 1993, figs. 8-3.14, 8-3.15.

Remarks- The sub-triangulate cephalon has a relatively flat glabella and distinct border. The eyes are large and distinctly crescent-shaped. The genal angles taper to short spines. The pygidium is also flattened and sub-triangulate, and has a distinct border that terminates posteriorly in a short, flat spine. Thirteen more or less complete specimens, and numerous fragmental portions examined.

Occurence- Found in the Bisher, Lilley, Osgood, Laurel, Euphemia, and Cedarville formations.

DALMANITES PLATYCAUDATUS, Weller, 1907

Figure 4.6

Dalmanites platycaudatus Weller, 1907, p. 272, pl. 2, figs. 3-5; Walter, 1927, p. 279, pl. 23, fig. 10; Delo, 1940, p. 48, pl. 3, figs. 14, 15; Armstrong, 1962, p. 34; Emielity, 1963, p. 17; Levi-Setti, 1975, pl. 96.

Remarks- A cranidium is not available, so the description is from figure in Levi-Setti (1975). Differs from *D. brevicaudatus* in that the glabella extends forward slightly more and genal spines are more pronounced. The pygidial spine is much longer and somewhat wider. One complete pygidium was examined.

Occurrence- From the Cedarville Dolostone.

Family ILLAENIDAE Hawle & Corda, 1847

Subfamily BUMASTINAE Raymond, 1916

Genus BUMASTUS Murchison, 1839

BUMASTUS INSIGNIS Hall, 1865

Figures 4.18, 4.19, 4.20

Bumastus insignis Hall, 1865; Shimer and Shrock, 1944, p.639, pl. 269, figs. 10-12; Armstrong, 1962, p. 11; Emielity, 1963, p. 14; Babcock, 1993b, figs. 8-4.7-8-4.9.

Remarks- The cephalon is strongly vaulted, convex, and smooth. The outline of the cephalon is semi-ovate. Pygidium is also very convex, and slightly more elongate than the cephalon. Three complete specimens, as well as one pygidium and one cranidium, were examined.

Occurrence- Found in the Bisher Formation, and the Springfield and Cedarville dolomites.

Family CHEIRURIDAE Salter, 1864

Family SPAEREXOCHINAE Öpik, 1937

Genus SPHAEREXOCHUS Beyrich, 1845

SPHAEREXOCHUS ROMINGERI Hall, 1867

Figures 4.8, 4.9

Sphaerexochus romingeri Hall, 1867; Shimer and Shrock, 1944, p. 653, pl. 272, figs. 17, 22; Armstrong, 1962, p. 31; Emielty, 1963, p. 21; Levi-Setti, 1975, pl. 111, 112; La Rocque and Marple, 1977, p.71, fig. 139; Ludvigsen, 1979, p. 70, fig. 48 A; Babcock, 1993b, figs. 8-4.4, 4.5

Remarks- An indentifiable thorax and pygidium are unavailable, so the description is modified from Babcock (1993b). The glabella is highly convex, inflated, and bulb-like. The eyes are small and holochroal. The thorax has ten segments and the axis is wider than pleural areas. The pygidium is moderately large, subelliptical, and has blunt marginal spines. Three cranidia and two pygidia were examined.

Occurrence- Found in the Springfield and the Cedarville dolomites.

Subfamily CHEIRURINAE Salter, 1864

Genus CHEIRURUS Beyrich, 1845

CHEIRURUS NIAGARENSIS Hall, 1867

Figure 4.7

Cheirurus niagarensis Hall, 1867, Shimer and Shrock, 1944, p. 641, pl. 272, fig. 13; Emielity, 1963, p. 23-4; La Rocque and Marple, 1977, p. 71, fig. 138; Ludvigsen, 1979, p. 70, fig. 47 A-D; Babcock, 1993b, fig. 8-3.8.

Remarks- A pygidium and thorax are unavailable, so the description is modified from Babcock (1993b). The cephalon is semi-circular, and the glabella expands forward to the anterior border. The lateral glabellar furrows are deep. Thoracic pleura are nearly straight. The pygidium is small, subtriangular, and has three marginal spines and one large medial spine. One cephalon was examined.

Occurrence- Found in the Springfield and the Cedarville dolomites.

Family LICHIDAE Hawle & Corda, 1847

Subfamily LICHINAE Hawle & Corda, 1847

Genus ARCTINURUS Castelnau, 1843

ARCTINURUS BOLTONI (Bigsby, 1825)

Figure 4.17

Paradoxus boltoni Bigsby, 1825, p. 365, pl. 23.

Arctinurus boltoni (Bigsby), Green, 1832, p. 560, pl. 14, fig. 5; Ludvigsen, 1979, p. 65, fig. 44, cover fig.; Morris and Fortey, 1985, p. 13, pl. 7, fig. 1, cover photo; Babcock, 1993a, p. 36

Remarks- A cranidium and thorax are unavailable, so the description is modified from Ludvigsen (1979). The cephalon is comparatively small and subelliptical in outline. The glabella is divided into three lobes by two deep, hook-shaped lateral glabellar furrows. The overall body is flattened and ovate. The pygidium is large, somewhat flattened and has three pairs of large, lobate spines.

Occurrence- The single available specimen (Fig. 4.17) is a plaster cast of a pygidium that is labeled as being from Ohio. Unequivocal evidence of this species from Ohio rocks is not yet available.

Family CALYMENIDAE Burmeister, 1843

Subfamily CALYMENINAE Burmeister, 1843

Genus FLEXICALYMENE Shirley, 1936

FLEXICALYMENE CELEBRA (Raymond, 1916)

Figures 4.1, 4.2, 4.3

Calymene celebra , Raymond, 1916, p.28-29, pl. 3, figs. 9, 10; Shirley, 1936, p. 390-92; Shimer and Shrock, 1944, p. 641, pl. 272, figs. 6, 7; Emielity, 1963, p. 18; Campbell, 1967, p. 27.

Flexicalymene celebra (Raymond), Whittington, 1971, p. 470, pl. 87, figs. 5, 9-13, pl. 88, figs. 1-10, pl. 89, 8, 11; Levi-Setti, 1975, 123, 130, 131; Babcock, 1993b, fig. 8-3.11, 8-4.1-4.3.

Remarks- Cephalon is sub-triangular, with prominent three-lobed glabella, defined by deep glabellar furrows. The eyes are small and holochroal. Thoracic pleura are thirteen number and are gently curving. The pygidium is comparatively small and subelliptical. Nine more or less complete specimens were examined.

Occurrence- Found in the Bisher, Springfield and Cedarville formations.

CALYMENE sp.

Figures 4.12, 4.13

Remarks- Two broken cranidia, unidentifiable to species, have been observed. The glabella is vaulted and has deep lateral glabellar furrows. A distinct protuberance between the first and second lateral glabellar lobes is more distinct than that of *Flexicalymene celebra.* The anterior border is moderately wide.

Occurrence- From the Niagaran Series of Ohio.

ACKNOWLEDGMENTS

For assistance with various aspects of this thesis work, I would like to thank Dr. Loren E. Babcock. For arranging loans of specimens, contributing specimens, or providing information pertinent to this work, I would like to thank Dale M. Gnidovec (Orton Geological Museum of The Ohio State University), Dr. William I. Ausich (The Ohio State University), Dr. Mark A. Kleffner (The Ohio State University, Lima campus), Dr. Jack Kovach (Muskingum College), Dr. David L. Meyer (University of Cincinnati), J. H. Marak (Miami University Geology Museum), Douglas L. Shrake (Ohio Division of Geological Survey), and Ray Meyer (Middleport, New York).

Photographic materials were purchased using funds from a University Seed Grant and a National Science Foundation grant through the University of Kansas, both to L. E. Babcock.

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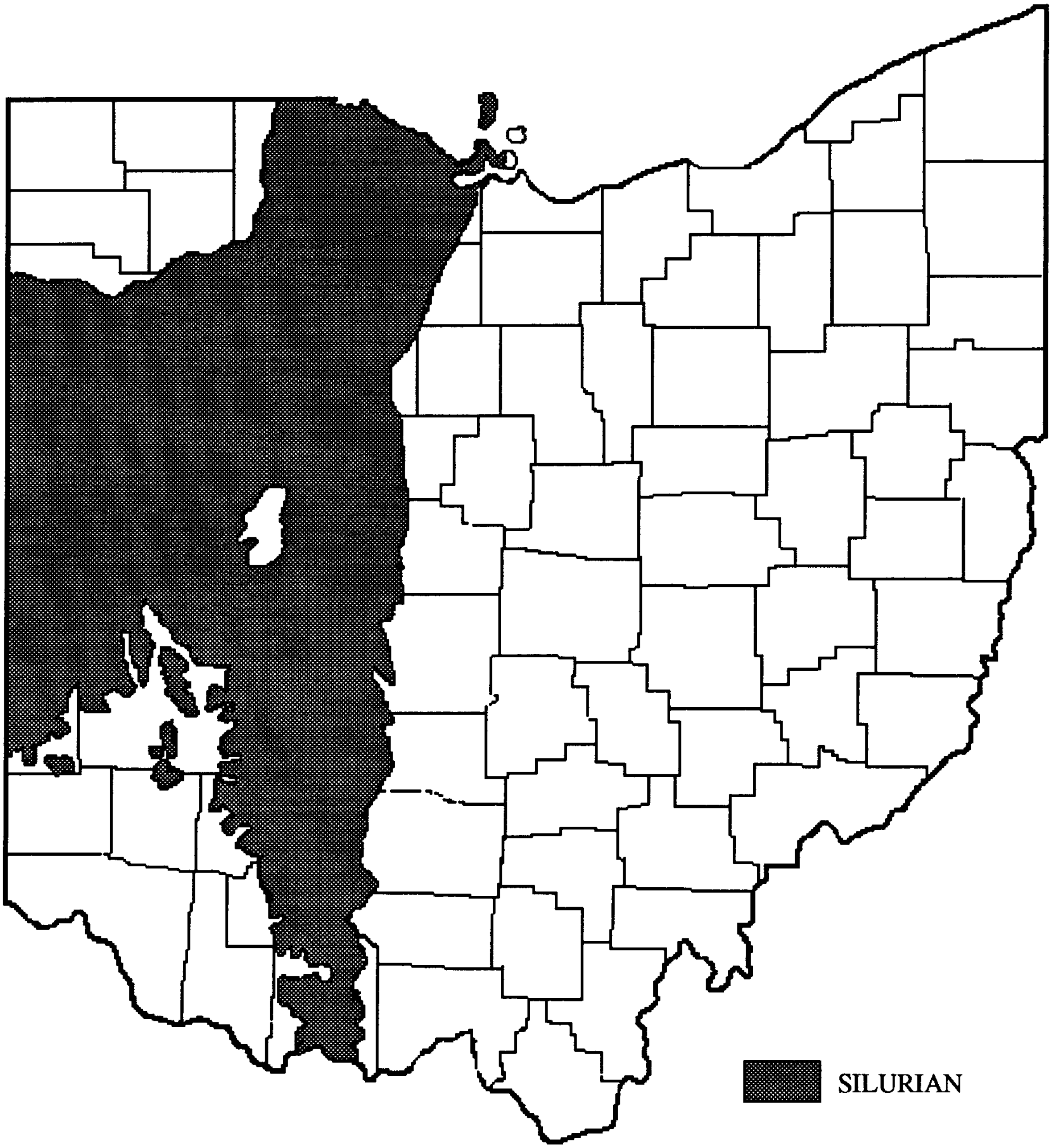
Figure 4. Post-Brassfield Silurian trilobites from Ohio. Specimens are deposited in the Orton Geology Museum of The Ohio State University (OSU), the Unversity of Cincinnati Geology Museum (UCGM), and the Miami University Geology Museum (MUGM).

1. *Flexicalymene celebra* (Raymond). Dorsal view of internal mold preserved in dolostone. Eaton, Ohio; Cedarville Dolostone; x1.25; UCGM 34570.
2. *Flexicalymene celebra* (Raymond). Anterior view of same specimen as in 4.1; x1.25; UCGM 34570.
3. *Flexicalymene celebra* (Raymond). Left lateral view of same specimen as in 4.1, 4.2; x1.25; UCGM 34570.
4. *Dalmanites brevicaudatus* Foerste. Dorsal view of internal mold of cephalon; x2, OSU unnumbered.
5. *Dalmanites brevicaudatus* Foerste. Internal mold of pygidium; x2; MUGM 6866.
6. *Dalmanites platycaudatus* Weller. Internal mold of pygidium; Cedarville Dolostone?; x3; Lewisburg, Ohio; OSU 22844.
7. *Cheirurus niagarensis* Hall. Internal mold of cranidium. Niagaran Series; Pontiac, Ohio; x1; UCGM 12975.
8. *Sphaerexochus romingeri* Hall. Dorsal view of internal mold of cranidium. Niagaran Series; Wilmington, Ohio; x1.5; OSU 7041.
9. *Sphaerexochus romingeri* Hall. Left lateral view of same specimen as in 4.8; x1.5; OSU 7041.
10. *Encrinurus ornatus* Hall and Whitfield. Partial cephalon preserved as internal mold. Niagaran Series; Lewisburg, Ohio; x3; OSU 22843.
11. *Encrinurus ornatus* Hall and Whitfield. Internal mold of pygidium. Niagaran Series, Lewisburg, Ohio; x3; OSU 22843.
12. *Calymene* sp. ; partial cephalon; Niagaran Series; location unkown; x2; OSU 20675-76
13. *Calymene* sp. ; partial cephalon; Niagaran Series; location unknown; x3; OSU unnumbered.
14. *Trimerus delphinocephalus* Green. Internal mold of cephalon and separate thoracic segment. Bisher Formation; near North Uniontown, Ohio; x1; OSU 20693.
15. *Trimerus delphinocephalus* Green. Incomplete pygidium preserved as internal mold, left lateral view. Bisher Formation; near Harriet, Ohio; x1.5; OSU 20691.
16. *Trimerus delphinocephalus* Green. Same specimen as in 4.15; dorsal view; x1.5; OSU 20691.
17. *Arctinurus boltoni* (Bigsby). Cast of partial pygidium. Niagaran Series; Rockford, Ohio; x1; OSU 18588.
18. *Bumastus insignis* Hall. Internal mold of exoskeleton preserved in dolostone. Niagaran Series; Springfield, Ohio; x1.5; OSU 3329.
19. *Bumastus insignis* Hall. Weathered internal mold of exoskeleton preserved in dolostone. Niagaran Series, Eaton, Ohio; x2; OSU 11943.
20. *Bumastus insignis* Hall. Same specimen as in 4.19; right lateral view. Niagaran Series, Eaton, Ohio; x2; OSU 11943.



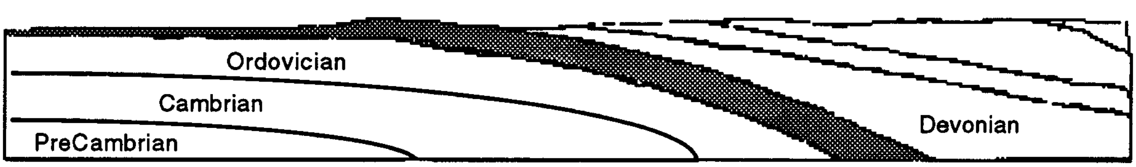


Figure 1. Silurian outcrop belt in Ohio. Modified from Geologic Map and Cross-section of Ohio published by Ohio Division of Geologic Survey.

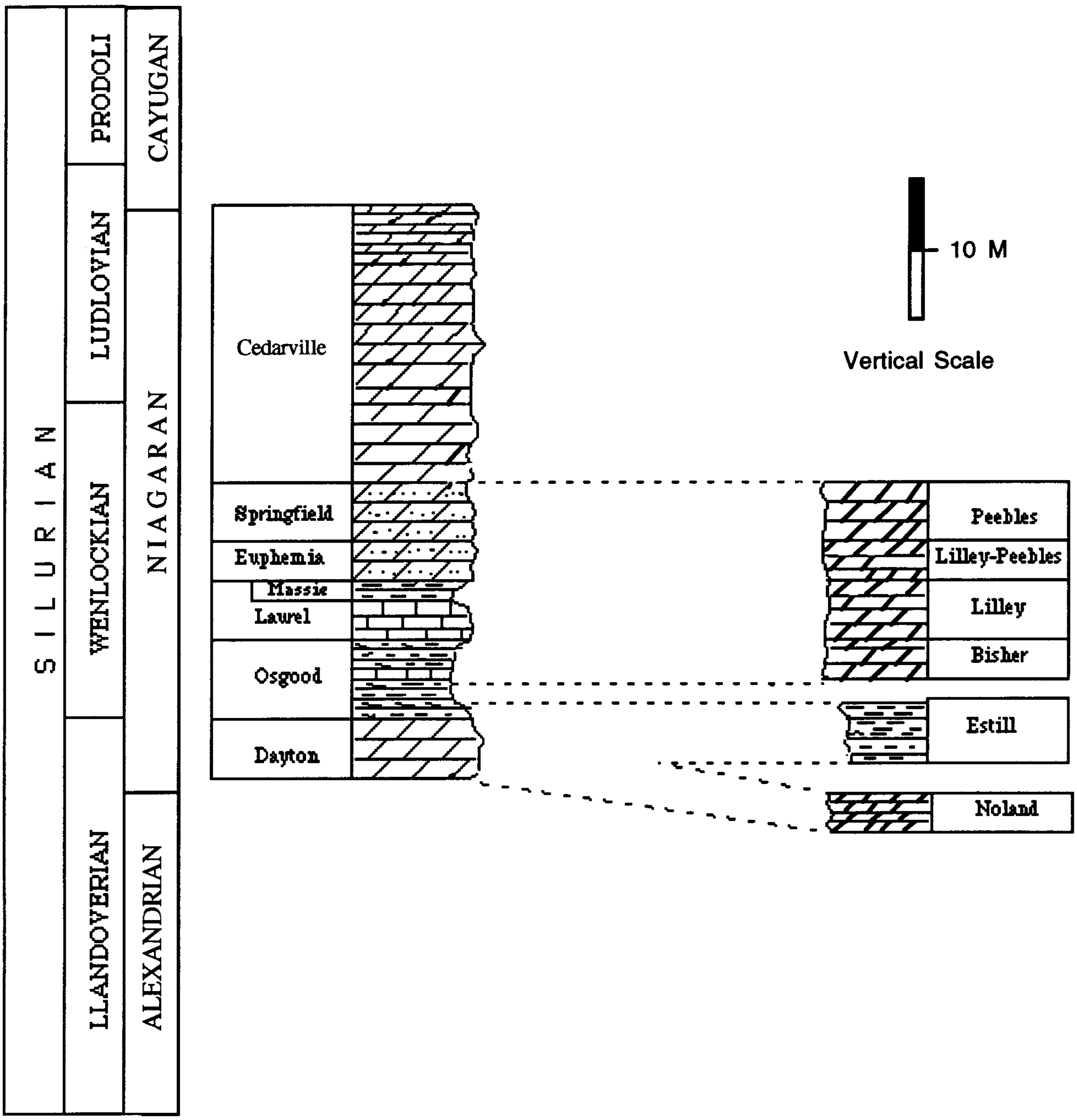


Figure 2. Generalized stratigraphic correlation of Niagaran (Silurian) sections from west-central (left) and southern Ohio (right). Modified from Kleffner (1990).

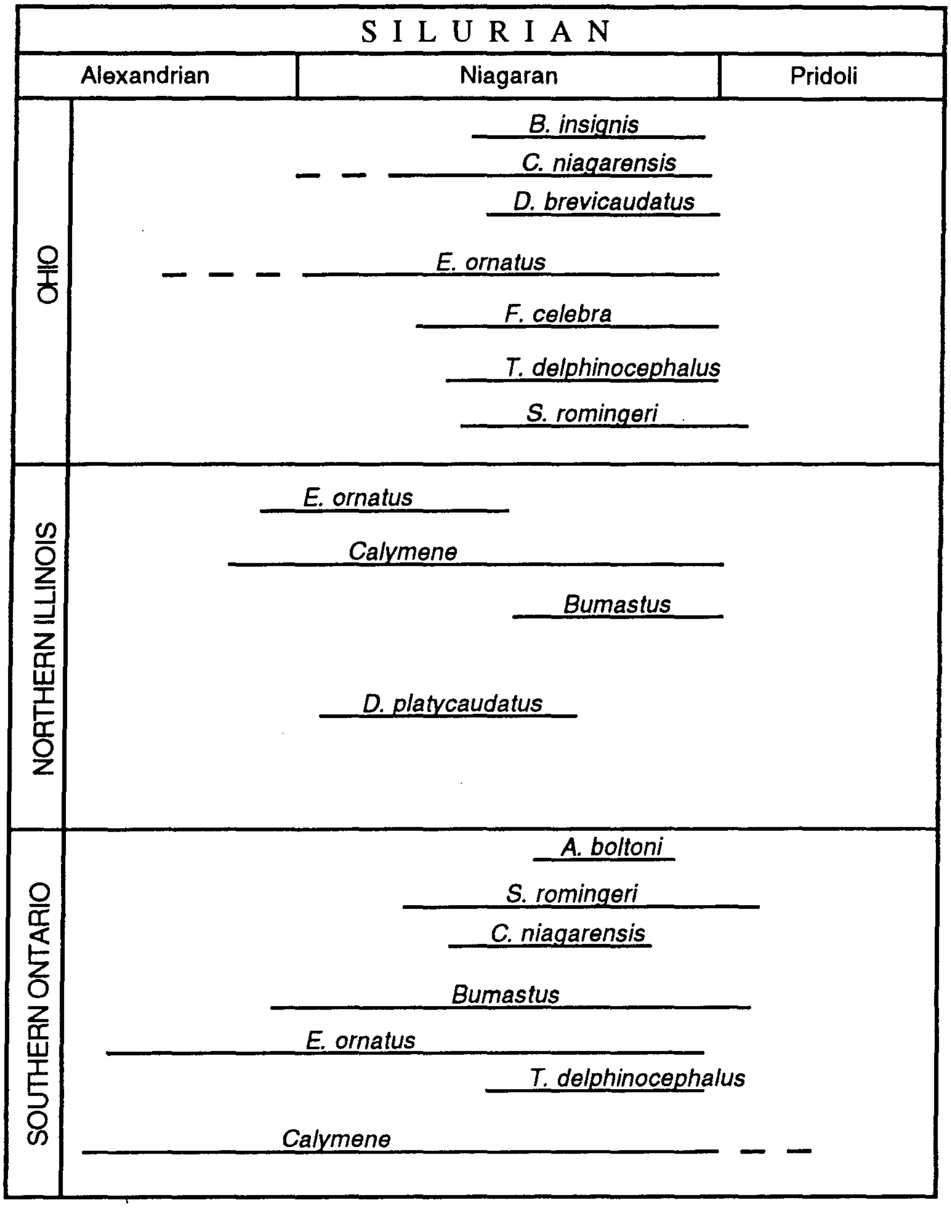
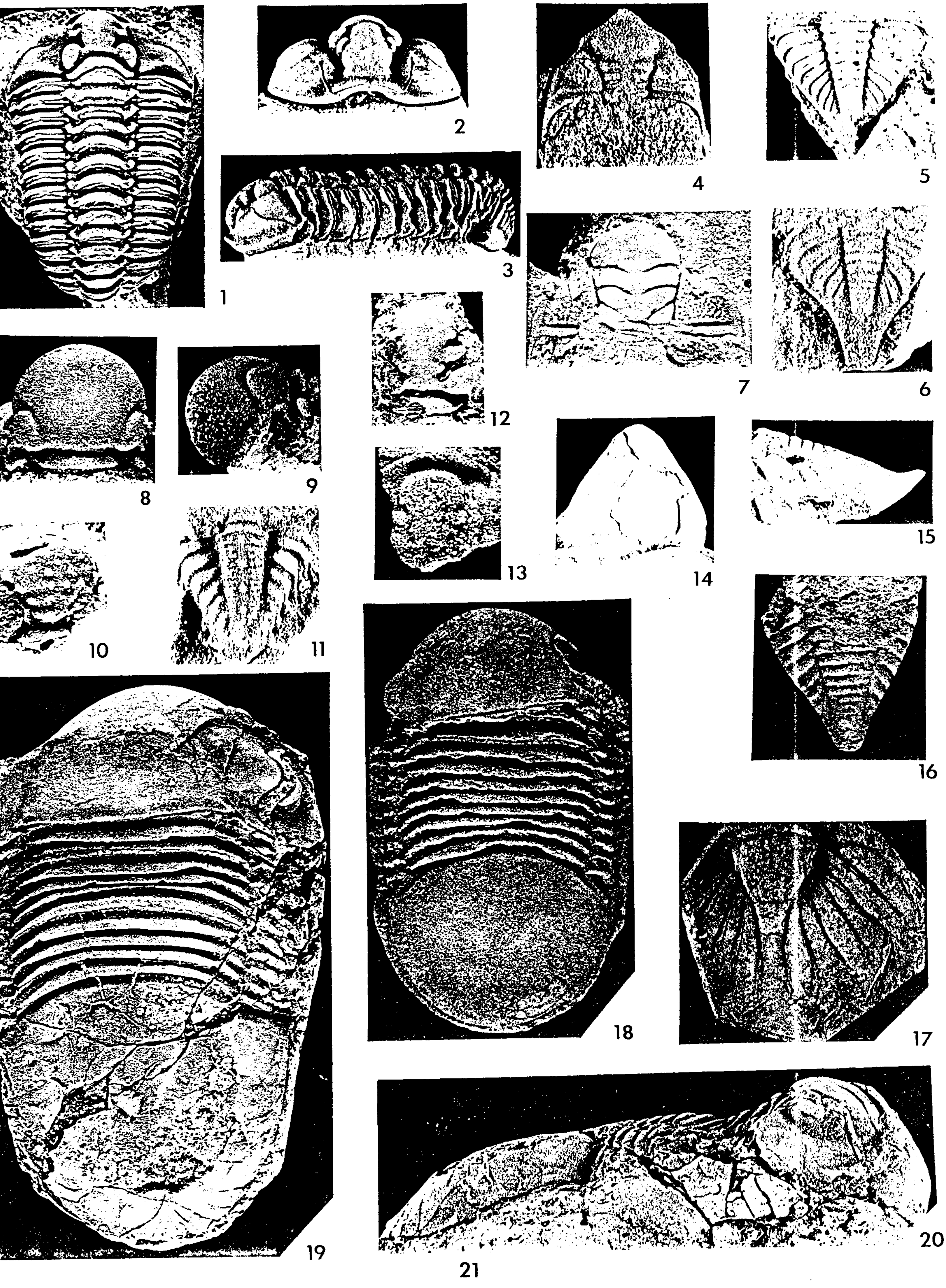


Figure 3. Generalized, observed stratigraphic ranges of some Silurian trilobites from Ohio and surrounding areas. Ranges of Illinois trilobites are from Armstrong (1962). Ranges of trilobites from Ontario are from Ludvigsen (1979).

NIAGARAN (SILURIAN) TRILOBITES FROM SOUTHERN OHIO								
	Noland Fm.	Estill Sh.	Bisher Fm.	Lilley Fm.	Peebles Dol.	"Niagaran"		
Arctinurus boltoni						X		
Bumastus insignis			X					
Cheirurus niagarensis								
Dalmanites brevicaudatus		X	X	X				
Encrinurus ornatus			X	X				
Flexicalymene celebra			X					
Sphaeroxochus romingeri								
Dalamianites platycaudatus								
Trimerus delphinocephalus			X	X				

NIAGARAN (SILURIAN) TRILOBITES FROM WEST-CENTRAL OHIO								
	Dayton Fm.	Osgood Sh.	Laurel Ls.	Massie Sh.	Euphemia Dol.	Springfield Dol.	Cedarville Dol.	"Niagaran"
Arctinurus boltoni								X
Bumastus insignis						X	X	
Cheirurus niagarensis						X		
Dalmanites brevicaudatus		X	X	X	X		X	
Encrinurus ornatus								
Flexicalymene celebra						X	X	
Sphaeroxochus romingeri						X	X	
Trimerus delphinocephalus								
Dalmanites platycaudatus							X	

Table 1. Chart showing observed, generalized stratigraphic ranges of Niagaran Series trilobites of southern Ohio (top chart), and west-central Ohio (bottom chart).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