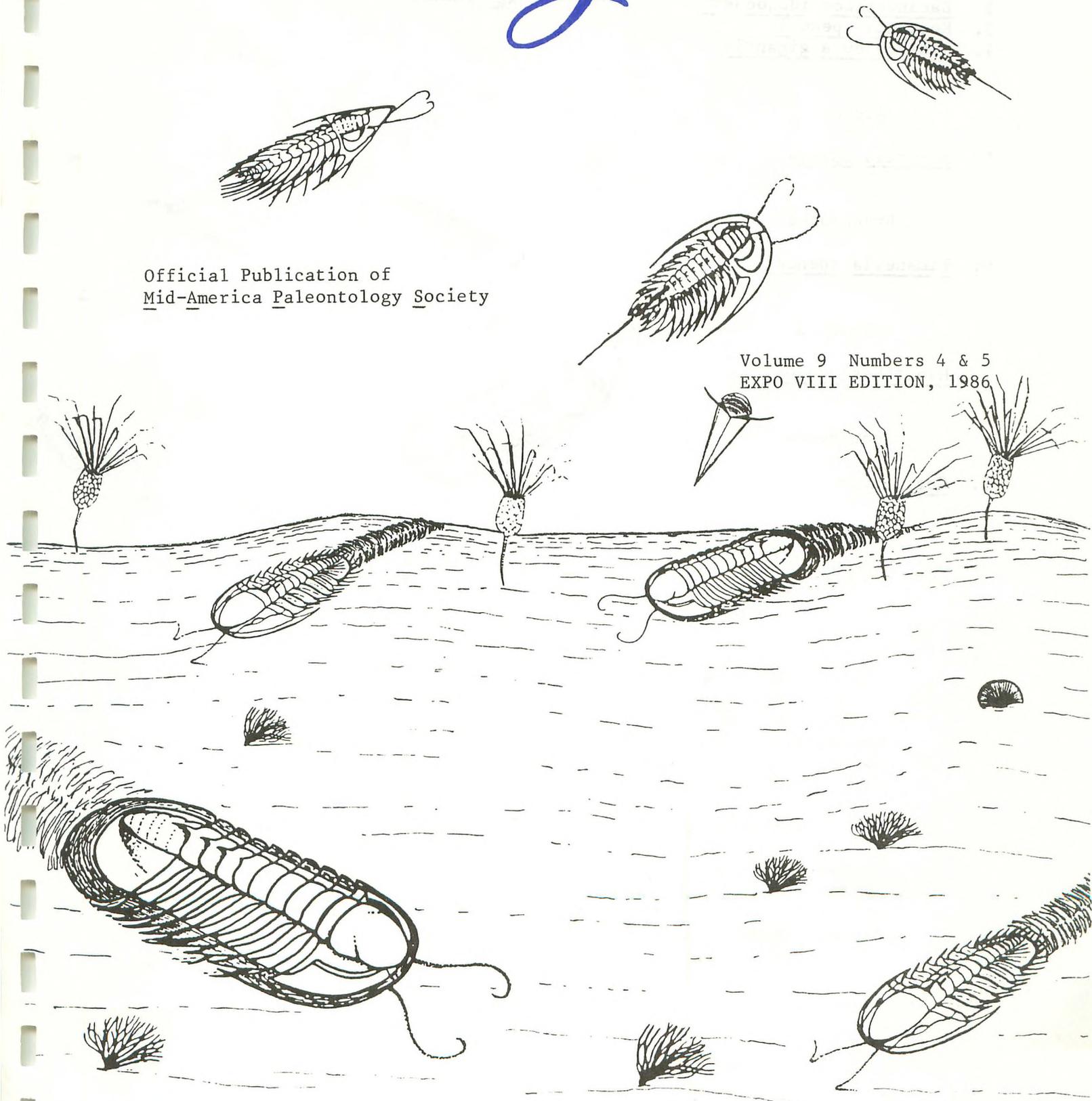


M.A.P.S *Digest*

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FRONT COVER SPECIMENS,
SPENCE SHALE

M.A.P.S *Digest*

Trilobites

1. Zacanthoides grabau
2. Zacanthoides idahoensis
3. Kootenia spencei
4. Glossopleura gigantia

Algae

5. Marpolia spissa

Brachiopod

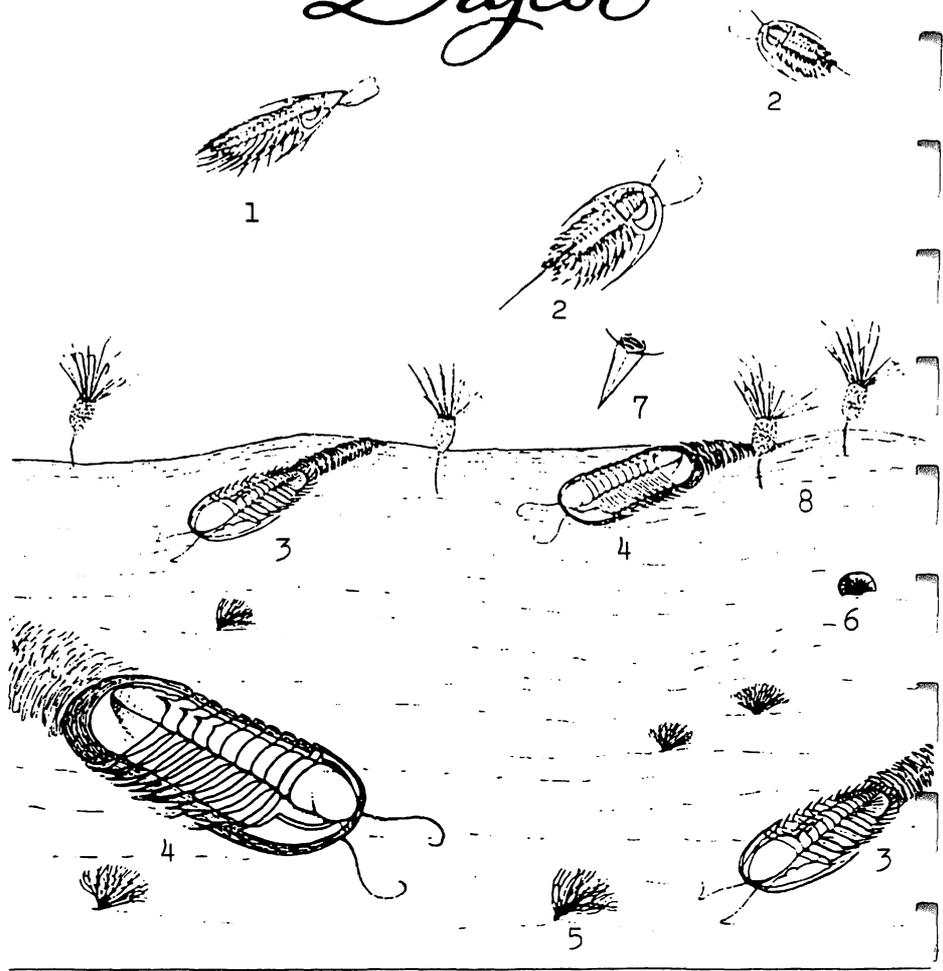
6. Wimanelia spencei

Hyalolithid

7. Hyalolithes cecrops

Eocrinoids

8. Gogia n.sp.



We take this opportunity to recognize those who have made this issue of the Digest possible. Their special interest in trilobites, their curiosity, their ability to never stop questioning, their wisdom born of years of collecting, reading, researching, and comparing gives them expertise which they have generously shared.

They are highly motivated, they are competitive, but share a mutual respect for each other. In some instances they volunteered, in others they were approached.

The fruits of their labors is found on the following pages. It is, indeed, a generous gift.

SPENCE SHALE -- It's Fossil Flora & Fauna

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The Spence Shale of Utah and Idaho was named by Charles D. Walcott in honor of Robert S. Spence of Garden City, Utah, who in 1896 sent some well preserved fossils to him at the U.S. National Museum.

Spence was an enthusiastic amateur fossil collector and his discoveries prompted Walcott to visit his collecting sites in Utah and Idaho and make collections and studies of these Lower Middle Cambrian outcrops.

Sediments in this ancient Cambrian sea represented by the Spence Shale were deposited in what is referred to as the outer detrital belt or far shore environment where the continental shelf slopes more steeply toward the open sea. This deeper water area was less subject to wave action and strong currents and as the result many of the fossils were preserved entirely or in an articulated condition.

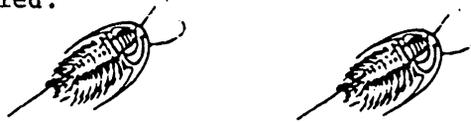
Numerous Spence Shale outcrops occur in northern Utah and southern Idaho especially in the Bear River and Wasatch Ranges. It is richly fossiliferous and ranks in fossil abundance close to the Wheeler and Marjum formations of the House Range and the Drum Mountains of west central Utah. The Spence is also somewhat older in age, more closely to the famous Burgess Shale of British Columbia, Canada. The Burgess and Spence shales have many fossil genera in common.

A great variety of fossil forms are to be found in these laminated shales. The number of new species is steadily growing as further collections and studies are being made.

Because trilobites are generally better suited for preservation, they often appear to dominate the animal life present. Approximately 100 species of trilobites have so far been discovered in these Spence Shale outcrops, although not all have been formally described as yet. A few of these are illustrated on the cover page. One of these trilobites is a very large crawler, Glossopleura gigantea, which often grew over 6 inches in length. This is the largest of the Spence Shale trilobites. Two others, believed to be swimmers are shown, Zacanthoides idahoensis, and the more rare form, Z. grabau. Although not illustrated, other representative genera of the Spence include Alokistocare, Alokistocarella, Athabaskia, Bathyriscus, Bythicheilus, Dorypyge, Chancia, Achlysopsis, Caborcella, Elrathina, Kochina, Kootenia, Ogygopsis, Olenoides, Oraspis, Oryctocare, Oraspis, Oryctocephalus, Pachyaspis, Peronsosis, Prohedina, Pagetia, Poliella, Palmerella, Spencia, Thoracare, Utia, etc.

Although the number and variety of trilobites is impressive, they may not have been that dominant when compared to other animals associated with them. Many of the soft-bodied animals did not preserve well and therefore do not show up as well in the fossil record. Here there are many that do show up and give evidence that they were an important part of the total fauna. Phyllocarids, meristomes and other trilobitomorphs as well as other soft-bodied arthropods are present. Echinoderms are abundant in certain layers. Several species of

eocrinoids of the genus Gogia are present in different zones. Some of these occur in "gardens" with hundreds present on a single slab. Ctenocystoids are also common. Brachiopods, both articulate and inarticulate are abundant, especially the latter. Hyolithids are present and oftentimes preserved with their "helens" or swimming appendages attached. Sponges, Choia and Protospongia, occur in the lower zones. Worms are common though rarely preserved well enough to show details, but trails and burrows are common. Algal seaweeds are common both green and blue-green forms. A few inigmatic fossils have also been found that are yet to be identified.



AGNOSTOIDS: A NEGLECTED GROUP OF TRILOBITES

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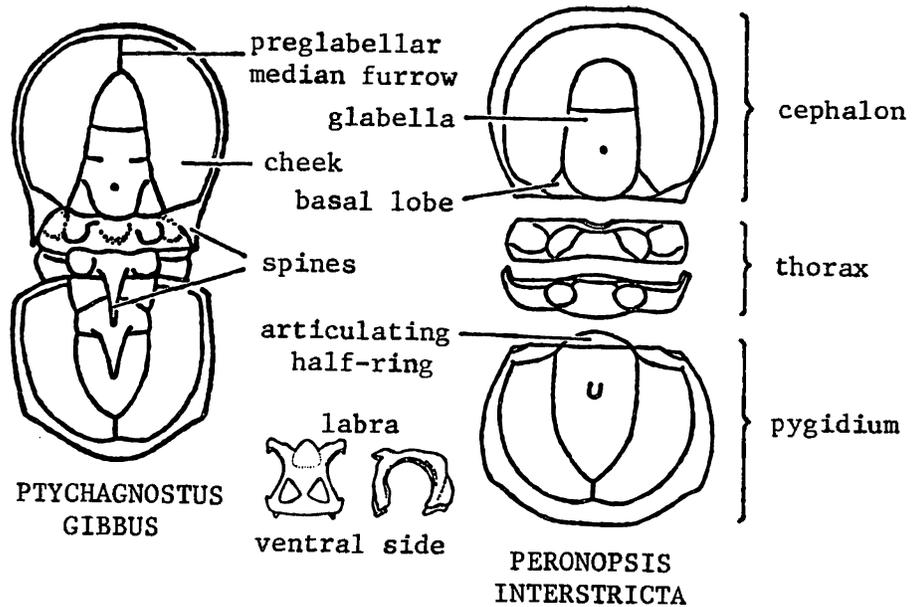
Trilobites can be divided into two distinctive, but disproportionate groups-- Polymeroids and agnostoids. Circumstantial evidence suggests that the striking differences between the groups in form and average size are the result of adaptations to quite different modes of life. The larger polymeroids, which make up about 95 percent of described trilobite genera, were mostly sea-bottom, detritus feeders. The smaller agnostoids, which make up only about 5 percent of described genera, were probably floating or swimming, suspension feeders. Observed geographic distribution patterns are in accord with these inferred modes of life. Polymeroid genera commonly are restricted to the margins of single Paleozoic continents, whereas most agnostoid genera and many species are cosmopolitan.

Agnostoids are small, eyeless trilobites characterized by having only two segments in the thorax and by the nearly equal size and similar shape of the cephalon and pygidium (see figure). Adult length averages about a quarter inch and rarely exceeds half an inch. Other differential features include a pair of triangular basal lobes flanking the back of the glabella, a unique labrum (ventral plate covering the mouth), and a non-overlapping hinge between the cephalon and thorax. The pygidium can be distinguished from the cephalon by an absence of basal lobes and by the presence of an articulating half-ring. The latter is a convex flange that projects beneath the back edge of the next-forward segment and functions as a hinge during enrollment. When outstretched, a complete agnostoid resembles a dumbbell in outline. Agnostoids have a stratigraphic range from the Lower Cambrian to the Upper Ordovician. Specimens tend to be most abundant in open-shelf Middle and Upper Cambrian deposits.

Until recently, agnostoids have received little scientific study. Contributing factors may be their small size and an apparent simplicity. Because the zonal subdivision of Cambrian rocks has been preponderantly based on polymeroid trilobites, which have very limited geographic ranges, age correlations between continents have been difficult and lacking in precision. Recent studies of some agnostoid species have documented rapid rates of evolution in combination with wide geographic distributions. These attributes now are making possible quite exact dating of rocks that contain these species from widely separated parts of the world, especially for Middle and Upper Cambrian rocks.

Several evolutionary trends are apparent among agnostoids. Some of the more easily recognized were the smoothing out of dorsal furrows or development of variously positioned spines, a preglabellar median furrow, or radial grooves on the cheeks. Each of these trends was repeated in more than one agnostoid lineage and at different times, resulting in numerous look-alikes. The common effacement of dorsal furrows in various lineages has resulted in several smooth forms that may be especially difficult to differentiate.

In terms of practical geological applications, the recent studies of agnostoid trilobites once again are proving that "bigger is not necessarily better." These small, easily overlooked fossils hold much potential for improving the dating of Cambrian rocks.



THE TRILOBITES OF NEW YORK STATE

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New York State (NYS) has a valid claim to the title of the "homeland of American invertebrate paleontology". This, of course, includes trilobites among the other paleozoic fossils first recognized and described from NYS. Perhaps the earliest reference to American trilobites, not confused with European species, are the *Isotelus gigas* (Dekay 1824) and the *Arctinurus boltoni* (Bigsby 1825). In 1832 Joshua Green, a physician in Philadelphia, published his "A Monograph of Trilobites of North America" which described 33 different? trilobites from 23 collections in the north-east and Ohio. Of these trilobites twenty six were from NYS.

It is not too surprising that material from New York dominated these collections. NYS was in a period of intense westward expansion triggered by the agricultural wealth of western New York and the abundant water power throughout the length of the state. The Erie Canal was completed in 1825 from Albany to Buffalo through rich Paleozoic formations. Construction of canal locks, permanent buildings, mill races etc. required the quarrying of large amounts of stone with the inevitable disclosure of Paleozoic fossils in abundance. Early collections were, without doubt, made up of material from chance disclosure and did not represent any systematic approach to collecting and classification. This was not the case after 1834. In this year NYS authorized a natural history survey of the state. This monumental undertaking was done in sections by some of the most prominent scientist/naturalists of the day. In 1836 Part IV: Geology, in Four Parts, was authorized and funded. James Hall was a young (25) naturalist who participated in some of the initial activities and in a reorganization of the Geology Survey in 1837 he was assigned the Fourth District which now was all counties west of Cayuga Lake.

James Hall deserves particular attention as he, more than anyone else, established invertebrate paleontology as a systematic science in NYS and indeed North America. The Geology of the Fourth District was published in 1843 illustrated with numerous fossil plates all done by Mrs. Hall. Twelve of the more common trilobites from the Silurian and Middle Devonian are included in these plates. Hall was appointed State Geologist in 1843 and soon was deep into the Paleontology volumes of the Survey of Natural History. In 1848 the first volume was published on "The Organic Remains of the Lower Division of the New-York System". We now call this the Ordovician but at that time there was a hot debate among the English geologists whether to call these rocks lower Silurian or separate them out. This volume illustrates as many as 23 trilobites, some for the first time. Volume 2 in 1852 was devoted to the Middle Silurian and has illustrated 15 trilobites. Similarly Volume 3 on the Lower Devonian contains 13 trilobites. After Volume 3 Hall changed the format of the paleontology section because of the vast amounts of Middle Devonian fossils and started devoting entire volumes to one phylum. Thus the next trilobites are in Volume 7 which is "solely" the crustacea of the Middle Devonian and describes and illustrates 98 species. Not all of these are from NYS and at least 15 are not Middle Devonian. Also Hall was assisted in Volume 7 by James Clarke who rightly is a co-author on the trilobites described in this volume.

It is unfortunate that one cannot go to the NYS Museum and see all this spectacular material. The practice of the day was for the collector to keep, legitimately, one-half of what he collected. The remainder was the property of the state. Hall regularly sold off his collections to finance further collecting. The New York State Museum has at least half his material but the rest is scattered. The American Museum of Natural History in New York City has a great deal of his Lower Devonian trilobites but I do not know the location of any Ordovician or Silurian trilobites from his earlier collecting.

If one wishes to examine NYS trilobites the first place to go is the New York State Museum in Albany. Their collections are the most complete although not always the best material available. Significant material is in the Smithsonian, United States National Museum of Natural History, including Cambrian material from the Taconic sequence of New York collected by F. Rasetti. There are a considerable number of other NYS trilobites in the Smithsonian but collections of the Cambrian of New York are rare. The British Museum (Natural History) does have a purchased collection of NYS Cambrian trilobites. The Harvard museum of Comparative Zoology has the outstanding Ordovician trilobites collected by C. D. Walcott as a young man and the Chazy trilobites collected by P. E. Raymond.

H. B. Whittington has material at both Harvard and Yale. Yale also has the Triarthrus eatoni with appendages, discovered by Valiant and described by Beecher. As noted earlier the American Museum of Natural History has early Hall material. Other museums to note are the Buffalo Museum of Natural History and the Carnegie Institute in Pittsburg.

This paper will make no effort to locate specific collecting sites in NYS as they are often well known and if one wishes to collect it is best to contact someone or a club directly to select sites which match their interests and collecting abilities. The map however should give one some idea of the generalities of New York paleontology.

Cambrian sites are mostly east of the Hudson River with most of the described sites within about 30-40 miles of Albany.

The Ordovician is much more complex. The Chazy sites are all immediately west of and bordering Lake Champlain. Trenton sites are known from Albany and Hudson Falls in the east to Rome in the west. Important sites are also known in the Watertown area and adjacent to the Chazy locations in extreme north-eastern NYS. There are Ordovician exposures all along Lake Ontario but I know of no significant fossil locations.

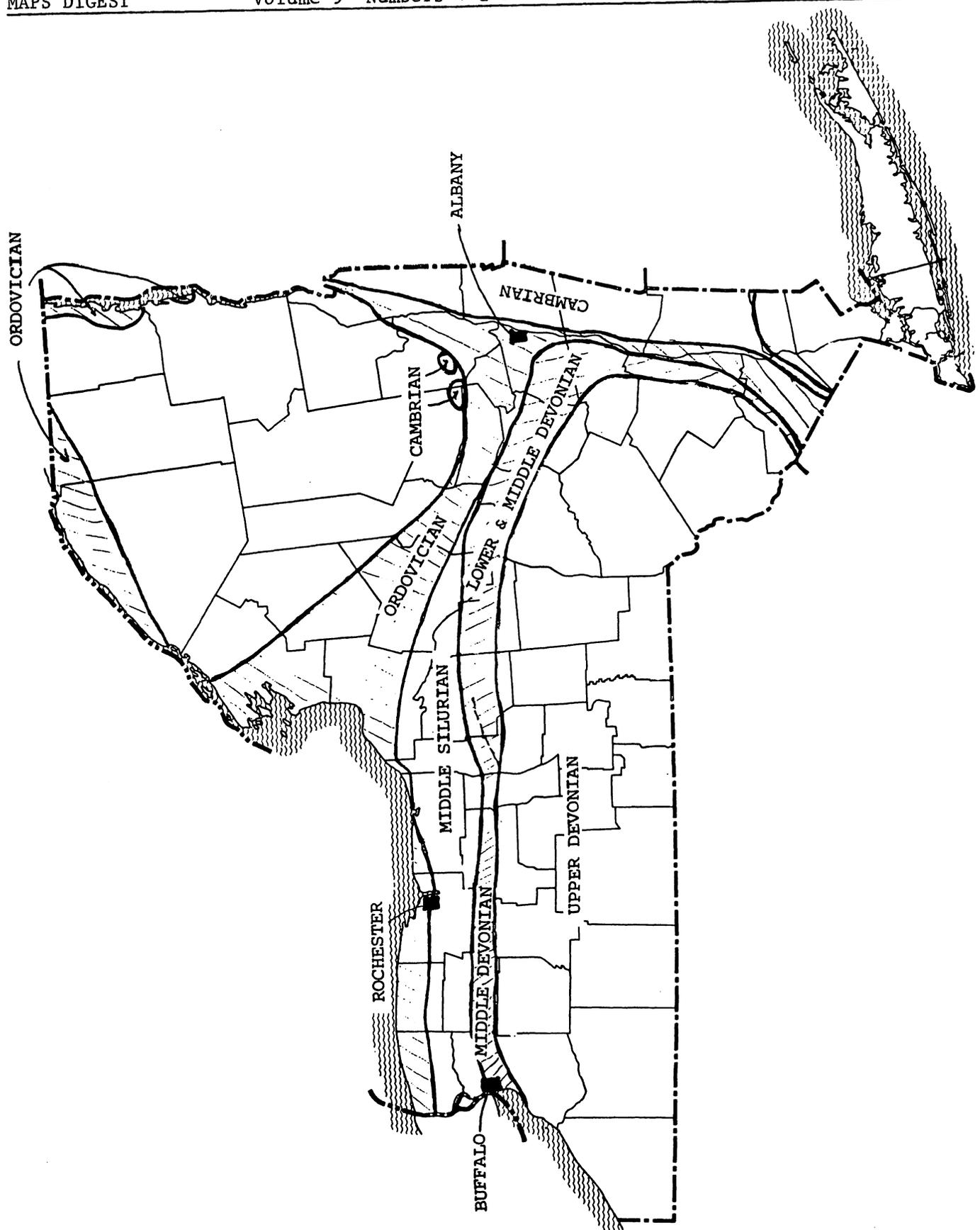
Silurian trilobites are found all along the band of Middle Silurian rocks from Utica to Buffalo. Most of the current collecting is confined to the Rochester Shale from the Sodus Bay area to Buffalo.

The Lower Devonian rocks are essentially in the Helderberg Mountains south and west of Albany, the Schoharie area. There are quarries with Lower Devonian material up to the area south of Utica but they are not common or productive.

The Middle Devonian rocks best represented by the Onondaga Limestone and the Hamilton Formation feature far and above the most productive locations for trilobite collecting. There are Onondaga quarries all across the state, paralleling the NYS thruway, with numerous trilobites. Unfortunately this limestone has all the characteristics of reinforced concrete and is not a favorite collecting formation. The overlying members of the Hamilton formations are much more exploited as these shales and limestones are easy to work and the trilobites are often exceptionally well preserved. There are useful sites in all the western counties, in which the Middle Devonian is exposed, up to Cayuga Lake. There are also a few specific sites east of there, particularly for Dipleura dekayi.

The Upper Devonian is prominently exposed clear across the southern part of NYS. It is very poor trilobite collecting and not worth much attention except to the specialist.

The tables list, organized by era, name and family, all the NYS trilobites known to the author. There are undoubtedly errors of nomenclature and I would appreciate them being called to my attention, with literature references where available.



UPPER CAMBRIAN

Apatokephaloides sp.
 Aphelaspis sp.
 Cameraspis cushingi (Ruedemann)
 Cameraspis ruedemanni (Resser)
 Cheilocethalus sp.
 Dicerellocephalus hartti
 Dunderbergia sp.
 Elvinia ruedemanni Resser
 Glyptomtopis (?) sp.
 Idionesus sp.
 Keithia sp.
 Kingstonia seelyi (Walcott)
 Lonchocephalus catciferous
 Lotagnostus sp.
 Phoreotropis sp.
 Plethopeltis granulosa Resser
 Plethopeltis saratogensis (Walcott)
 Plethopeltis walcotti Raymond
 Prosaukia eboracensis (Resser)
 Prosaukia tribulis (Walcott)
 Pseudagnostus communis (Hall and Whitfield)
 Richardsonella sp.
 Theodenisia sp.

LOWER CAMBRIAN

Acidiscus birdi Rasetti
 Acidiscus hexacanthus Rasetti
 Acimetopus bilobatus Rasetti
 Agraulos saratogensis Walcott
 Analox bipunctata Rasetti
 Analox obtusa Rasetti
 Bathydiscus dolichometopus Rasetti
 Bolboparia sp.
 Bonnia sp.
 Calodiscus lobatus (Hall)
 Calodiscus walcotti Rasetti
 Chelediscus chathamensis Rasetti
 Conocoryphe trilineata (Emmons)
 Elliptocephala asaphoides Emmons
 Hebediscus marginatus Rasetti
 Leptochilodiscus punctulatus Rasetti
 Microdiscus (Eodiscus) connexus Walcott
 Microdiscus (Eodiscus) beeki Ford
 Microdiscus schucherti Walcott
 Microdiscus speciosus Ford
 Neopagetides sp.
 Neopagetina taconica Rasetti
 Olenellus sp.
 Olenoides fordi Walcott
 Oodiscus sp.
 Paedeumias sp.
 Pagetia bigranulosa Rasetti
 Pagetia cyttioides Rasetti
 Pagetia erratica Rasetti
 Pagetia laevis Rasetti
 Pagetides amplifrons Rasetti
 Pagetides elegans Rasetti
 Pagetides leiopygus Rasetti
 Pagetides minutus Rasetti
 Pagetides rupestris Rasetti
 Prototypus sp.
 Protozacanthoides sp.
 Prozacanthoides sp.
 Serrodiscus grswoldi Rasetti
 Serrodiscus latus Rasetti
 Serrodiscus speciosus (Ford)
 Serrodiscus spinulosus Rasetti
 Solenopleura nana Ford
 Stigmadiscus stenometopus Rasetti

MIDDLE CAMBRIAN

Athabaskiella cf. proba (Walcott)
 Athabaskiella sp.
 Atops trilineatus Emmons
 Baltagnostus angustilobus Rasetti
 Baltagnostus sp.
 Baltagnostus stockportensis Rasetti
 Bathyriscidella cf. socialis Rasetti
 Bathyriscidella sp.
 Bathyriscus cf. fibriatus Robison
 Bathyriscus eboracensis Rasetti
 Bathyriscus sp.
 Bolaspidella fisheri Rasetti
 Bolaspidella sp.
 Centropleuria sp.
 Corynexochides ? expansus Rasetti
 Corynexochides ? sp.
 Elrathia ? sp.
 Elrathina ? sp.
 Goniagnostus sp.
 Grandagnostus ? sp.
 Hemirhodon sp.
 Hypagnostus parvifrons (Linnarsson)
 Komaspidella seelyi
 Kootenia sp.
 Leiopyge ? sp.
 Leiopyge cf. calva Robison
 Lonchocephalus minutus
 Meneviella sp.
 Modocia punctata Rasetti
 Ogygopsis sp.
 Olenoides sp.
 Olenoides stockportensis Rasetti
 Oryctocephalus sp.
 Pagetia sp.
 Peronopsis sp.
 Ptychagnostus cf. elegans (Tullberg)
 Ptychagnostus gibbus (Linnarsson)
 Ptychagnostus punctuosus (Angelin)
 Ptychopariacea sp.
 Rimauskia typica Resser
 Zacanthoides sp.

Dolichometopidae
 Dolichometopidae
 Conocoryphidae
 Diplagnostidae
 Spinagnostidae
 Diplagnostidae
 Dolichometopidae
 Dolichometopidae
 Dolichometopidae
 Dolichometopidae
 Dolichometopidae
 Menomoniidae
 Menomoniidae
 Centropleuridae
 Corynexochidae
 Dolichometopidae
 Alokistocaridae
 Alokistocaridae
 Agnostidae
 Diplagnostidae
 Dolichometopidae
 Agnostidae
 Leiestegiidae
 Dorypygidae
 Agnostidae

Lonchocephalidae
 Conocoryphidae
 Marjumiidae
 Ogygopsidae
 Dorypygidae
 Dorypygidae
 Dorypygidae
 Oryctocephalidae
 Pagetiidae
 Agnostidae
 Hastagnostidae
 Agnostidae
 Agnostidae
 Ptychopariidae
 Zacanthoididae

MIDDLE ORDOVICIAN

| | | | |
|---|------------------|--|------------------|
| Acanthoparypha ? sp | Cheiruridae | Hibbertia valcourensis Shaw | Harpidae |
| Acidaspis trentonensis Walcott | Odontopleuridae | Homalonotus trentonensis Simpson | Homalonotidae |
| Amphilichas conifrons Ruedemann | Lichidae | Hyboaspis depressa Raymond | Asaphidae |
| Amphilichas cornutus (Clarke) | Lichidae | Hygodicranotus striatulus (Walcott) | Remopleurididae |
| Amphilichas inaequalis Raymond | Lichidae | Iliaenus americanus Billings | Iliaenidae |
| Amphilichas wiganensis (Billings) | Lichidae | Iliaenus arcturus Hall | Iliaenidae |
| Apianurus narrawayi (Raymond) | Odontopleuridae | Iliaenus crassicauda (Hall) | Iliaenidae |
| Arctinurus trentonensis (Hall) | Lichidae | Iliaenus sp | Iliaenidae |
| Basilicus (Basilicella) whittingtoni Shaw | Asaphidae | Isotelus (Onchometopus) obtusus (Hall) | Asaphidae |
| Basilicus romingeri (Walcott) | Asaphidae | Isotelus gigas | Asaphidae |
| Basilicus sp | Asaphidae | Isotelus harrisi Raymond | Asaphidae |
| Basilicella barrandei (Hall) | Asaphidae | Isotelus iowensis Owen | Asaphidae |
| Bathyropsis longispina (Walcott) | Bathyruridae | Isotelus sp | Asaphidae |
| Bathyropsis schucherti (Clarke) | Bathyruridae | Isotelus sp | Asaphidae |
| Bathyrurus (?) levis Cleland | Bathyruridae | Isotelus walcotti Ulrich | Asaphidae |
| Bathyrurus concinus Billings, Whitfield | Bathyruridae | Kawina ? chazyensis (Raymond) | Cheiruridae |
| Bathyrurus ellipticus Cleland | Bathyruridae | Kawina ? sp | Cheiruridae |
| Bathyrurus extans Hall | Bathyruridae | Leonaspis trentonensis (Hall) | Odontopleuridae |
| Bathyrurus johnsoni Raymond | Bathyruridae | Lichas (Conolichas) cornutus Clarke | Lichidae |
| Bathyrurus spiniger (Hall) | Bathyruridae | Lonchodomas chaziensis Shaw | Raphiophoridae |
| Bathyrurus superbus | Bathyruridae | Lonchodomas halli (Billings) | Raphiophoridae |
| Bathyrurus taurifrons Dwight | Bathyruridae | Lonchodomas hastatus (Ruedemann) | Raphiophoridae |
| Bellefontia sp | Asaphidae | Nanillaenus ? punctatus (Raymond) | Iliaenidae |
| Bumastoides aplatys (Raymond) | Iliaenidae | Nanillaenus raymondi Shaw | Iliaenidae |
| Bumastoides gardenensis Shaw | Iliaenidae | Nieszowskaia ? satyrus (Billings) | Cheiruridae |
| Bumastoides milleri | Iliaenidae | Niloides perkinsi Raymond | Asaphidae |
| Bumastus bellewillensis Raymond, Narraway | Iliaenidae | Odontopleura ceralepta (Anthony) | Odontopleuridae |
| Bumastus decensegaentus Ulrich | Iliaenidae | Odontopleura cf crosota (Locke) | Odontopleuridae |
| Bumastus globosus (Billings) | Iliaenidae | Odontopleura trentonensis (Hall) | Odontopleuridae |
| Bumastus holei Foerste | Iliaenidae | Olenus undulostriatus Hall | Olenidae |
| Bumastus indeterminatus (Walcott) | Iliaenidae | Onchometopus sp | Asaphidae |
| Bumastus porrectus Raymond | Iliaenidae | Otarion hudsonica (Ruedemann) | Otarionidae |
| Bumastus trentonensis (Emmons) | Iliaenidae | Otarion matutina (Ruedemann) | Otarionidae |
| Calliops callicephalus (Hall) | Pterygomotopidae | Otarion spinicaudatum Shaw | Otarionidae |
| Calyptaulax annulata (Raymond) | Pterygomotopidae | Paraceraurus ruedemanni (Raymond) | Cheiruridae |
| Calyptaulax callicephalus (Hall) | Pterygomotopidae | Platillaenus erastusi (Raymond) | Iliaenidae |
| Calyptaulax eboraceus (Clarke) | Pterygomotopidae | Platillaenus liabatus (Raymond) | Iliaenidae |
| Carrickia setoni Shaw | Konaspidae | Platylichas inconspicuus Raymond | Lichidae |
| Ceratocephala triacanthus Whitt. & Evitt | Odontopleuridae | Pliomerops canadensis (Billings) | Pliomeridae |
| Ceraurinaella latipyge Shaw | Cheiruridae | Primaspis crossotus (Locke) | Odontopleuridae |
| Ceraurinus artisculatus Ulrich | Cheiruridae | Proetus clelandi Raymond | Proetidae |
| Ceraurinus marginatus (Barton) | Cheiruridae | Proetus parviusculus Hall | Proetidae |
| Ceraurinus scofieldi (Clarke) | Cheiruridae | Proetus undulostriatus (Hall) | Proetidae |
| Ceraurus dentatus Raymond & Barton | Cheiruridae | Pseudogygites latimarginatus (Hall) | Asaphidae |
| Ceraurus granulatus | Cheiruridae | Pseudosphaerexochus approximatus Raymond | Cheiruridae |
| Ceraurus hudsoni Raymond | Cheiruridae | Pseudosphaerexochus trentonensis Clarke | Cheiruridae |
| Ceraurus pleurexanthemus Green | Cheiruridae | Pterygomotopus achetella | Pterygomotopidae |
| Ceraurus pleurexanthemus montyensis | Cheiruridae | Pterygomotopus callicephalus (Hall) | Pterygomotopidae |
| Chasops bambryx (Billings) | Pterygomotopidae | Raymondites ingalli (Raymond) | Bathyruridae |
| Cheirurus mars Hudson | Cheiruridae | Raymondites longispinus (Walcott) | Bathyruridae |
| Cornuproetus beecheri Ruedemann | Proetidae | Raymondites sp | Bathyruridae |
| Cryptolithus lorettensis Foerste | Trinucleidae | Remopleurides canadensis Billings | Remopleuridae |
| Cryptolithus quadrilineus | Trinucleidae | Sphaerexochus parvus Billings | Cheiruridae |
| Cryptolithus tessellatus | Trinucleidae | Sphaerocoryphe goodnovi Raymond | Cheiruridae |
| Cybeloides prima (Raymond) | Encrinuridae | Sphaerocoryphe robusta Walcott | Cheiruridae |
| Dicanthaspis parvula (Walcott) | Odontopleuridae | Symphysurina sp | Asaphidae |
| Dicanthaspis sp | Odontopleuridae | Tetralichas trentonensis (Conrad) | Lichidae |
| Dimeropyge clintonensis Shaw | Odontopleuridae | Thaleops longispina Shaw | Iliaenidae |
| Dolichoharpes sp | Dimeropygidae | Thaleops ovata Conrad | Iliaenidae |
| Encrinuroides insularis Shaw | Harpidae | Tretaspis reticulata Ruedemann | Trinucleidae |
| Encrinurus cybeleformis Raymond | Encrinuridae | Triarthrus beckii | Olenidae |
| Encrinurus trentonensis Walcott | Encrinuridae | Triarthrus cf canadensis Smith | Olenidae |
| Encrinurus vigilans Hall | Encrinuridae | Triarthrus eatoni | Olenidae |
| Eobronteus sp | Scutellulidae | Triarthrus huguesensis Foerste | Olenidae |
| Eoharpes antiquatus (Billings) | Harpidae | Triarthrus spinosus Billings | Olenidae |
| Eoharpes ottawaensis (Billings) | Harpidae | Trochurus wesenbergensis Paulianus | Lichidae |
| Flexicalymene senaria | Calymenidae | Uromystrum brevispinum (Raymond) | Bathyruridae |
| Flexicalymene senaria magnotuberculata | Calymenidae | Uromystrum minor (Raymond) | Bathyruridae |
| Flexicalymene sp | Asaphidae | Vogdesia ? obtusus (Hall) | Asaphidae |
| Gerasaphus ulrichiana Clarke | Glaphuridae | Vogdesia bearsi (Raymond) | Asaphidae |
| Glaphurus laottensis Ulrich | Glaphuridae | | |
| Glaphurus pustulosus (Walcott) | Glaphuridae | | |
| Gravicalymene sp. | Calymenidae | | |
| Helioneroides akocephala Shaw | Encrinuridae | | |
| Hemiarges paulianus (Clarke) | Lichidae | | |
| Hibbertia sp | Harpidae | | |

LOWER ORDOVICIAN

Asaphellus gyracanthus Raymond
 Bathyrurus ? perkinsi
 Bolbocephalus seelyi (Whitfield)
 Clelandia parabola (Cleland)
 Cryptolithus bellulus
 Harpes ? cassinesis
 Hystricurus conicus
 Hystricurus crotalifrons (Dwight)
 Hystricurus ellipticus (Cleland)
 Isoteloides whitfieldi
 Paraplethopeltis sp.
 Scutellum lunatus (Billings)
 Shumardia pusilla (Sars)
 Symphysurus convexus (Cleland)

Asaphidae
 Bathyridae
 Bathyridae
 Trinucleidae
 Harpidae
 Solenopleuridae
 Solenopleuridae
 Solenopleuridae
 Asaphidae
 Plethopeltidae
 Thysanopeltidae
 Shumardidae
 Nileidae

UPPER ORDOVICIAN

Cryptolithus lorrainensis Ruedemann
 Flexicalymene granulosa
 Flexicalymene neeki
 Homotelus stegops
 Isotelus maxiaus
 Isotelus pulaskiensis Ulrich
 Triarthrus cf glaber

Trinucleidae
 Calymenidae
 Calymenidae
 Asaphidae
 Asaphidae
 Asaphidae
 Olenidae

"ORDOVICIAN"

Apyx (Lonchodomas) hastatus Ruedemann
 Aparchites minutissimus var robustus
 Calymene multicoستا Hall
 Eoharpes pustulosus (Hall)
 Eomonorachus convexus Ulrich & Delo
 Illaenus cf conradi Billings
 Remopleurides (Caphyra) linguatus Rued.
 Remopleurides tumidus Ruedemann
 Sceptaspis lincolnensis
 Sphaerocoryphe major Ruedemann
 Tretaspis diademata Ruedemann

Rhaphiophoridae
 Calymenidae
 Harpidae
 Pterygometopidae
 Illaenidae
 Remopleurididae
 Remopleurididae
 Cheiruridae
 Trinucleidae

MIDDLE SILURIAN

Scutellum niagarensis (Hall)
 Arctinurus boltoni Bigsby
 Arctinurus nereus (Hall)
 Bumastus ioxus
 Calymene camerata Conrad
 Calymene conradi
 Calymene crespensis Prouty
 Calymene niagarensis
 Calymene senaria
 Calymenella rostata
 Cheirurus niagarensis
 Cheirurus welleri Raymond
 Dalmanites linulurus
 Dalmanites linulurus lunatus
 Dicranopeltis fragosa Raymond
 Encrinurus ornatus Hall & Whitfield
 Lichas (Trochurus) ptyonurus Hall
 Liocalymene clintoni
 Odontopleura sp
 Phacops trisulcatus
 Proetus corycoeus
 Proetus stokesii
 Triaerus delphinocephalus
 Trochurus phlyctainoides (Green)

Thysanopeltidae
 Lichidae
 Lichidae
 Illaenidae
 Calymenidae
 Calymenidae
 Calymenidae
 Calymenidae
 Calymenidae
 Calymenidae
 Cheiruridae
 Cheiruridae
 Dalmanitidae
 Dalmanitidae
 Lichidae
 Encrinuridae
 Lichidae
 Calymenidae
 Odontopleuridae
 Phacopidae
 Proetidae
 Proetidae
 Homalonotidae
 Lichidae

THE ORDOVICIAN TRILOBITES OF SWATARA GAP

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Swatara Gap in Lebanon County, Pennsylvania, is a renowned locality for collecting Ordovician trilobites. The collecting area is about two miles north of the village of Lickdale where the Swatara Creek cuts a gap through Blue Mountain. The collecting site consists of two areas. The original collecting area is a small borrow pit immediately adjacent to Route 72 and under the northbound overpass lane of Interstate 81. The second collecting area is in the roadcut made for the southbound lane of Interstate 81, just west of the original area and at a slightly higher elevation.

The fossils occur in the Martinsburg Formation as casts and molds in fine grained olive to black shales, representative of quiet environmental conditions, and, in coarser sandy turbidite beds representative of more turbulent conditions. The beds have been tilted to a near vertical position so a wide time interval is exposed on the rock face. The southern exposure of the Martinsburg is relatively younger and more fossiliferous than the older northern exposure. Further north, the barren coarse sandstones and conglomerates of the early Silurian age Tuscarora Formation are encountered.

The rocks of the Martinsburg Formation at Swatara Gap were formed when conditions were favorable for marine life. As a result, they contain a diverse fauna with more than seventy genera reported. Ten trilobites can be found, and are sufficiently well preserved, and distinctive, so they can be identified by even casual inspection. As is frequently the case, there is occasional disagreement about identification and, from time to time, other identifications are proposed, especially species assignment.

Acidaspis cincinattiensis Meek
Cryptolithus bellulus (Ulrich)
Dicanthaspis sp.
Flexicalymene granulosa (Foerste)
Homotelus stegops (Green)
Mesotaphraspis parva
Platylichas sp.
Pterygometapus (Achatella) achates Billings
Proetus paraviscus Hall
Triarthrus beckii Green

The most frequently found trilobite, and the one for which the locality is best known, is the Cryptolithus. (Fig. 1) Cephalons of this trilobite are abundant in both the shales and the turbidite beds. In common with most trilobites from this locality, detail is excellent, and, the orange iron stained surface of the trilobite provides a pleasing contrast to the matrix and a generally attractive appearance. Complete specimens, particularly those with one, or both, of the elongated genal spines are found less frequently but a day's diligent digging

will usually turn up one or two. These are usually flat, outstretched, averaging about 3/4". Enrolled specimens are also frequently encountered.

Although not as abundant as the Cryptolithus, the Flexicalymene (Fig. 2) is commonly found in the shales either flat, outstretched or in the enrolled position. Overall length of about 1" is representative.

The remaining eight trilobites are considerably more rare than the Cryptolithus and Flexicalymene. Most are found only after persistent searching over extended periods of time. Among these latter is the Triarthrus (Fig. 3) which is occasionally found as partials and less frequently, complete in the flat, outstretched position. These are usually quite small, about 1/2" overall.

Mesotaphrasis (Fig. 4) is another of the smaller trilobites, usually about 1/8" in length but specimens up to 3/8" have been reported. Because of its small size, and low contrast with the matrix, keen eyesight and thorough inspection of all material examined is needed to win a specimen. As with the other trilobites from this locality, they are usually found singly but at least one specimen has been found with six individuals clustered together. Although some published data suggests they are only found in the sandy turbidite beds, personal experience has demonstrated they are also found in the shales. Proetus paraviscus is another of the small trilobites both small, relatively rare, and difficult to detect.

Unquestionably, one of the most prized trilobites at Swatara Gap is the rare Acidaspis (Fig. 5) This highly ornamental trilobite is distinguished by its very spiny nature, with cephalon, thorax, and pygidium all generously endowed. Partial (cephalons) are rarely found and complete specimens even more rarely. They occur in both the shales and turbidite beds with lengths of 3/4" to 1" being representative.

Another highly prized ornamental trilobite, Dicanthaspis, closely resembles the Acidaspis but is smaller in size with thicker spines arranged differently, particularly those on the cephalon.

Homotelus (Fig. 6) is the largest trilobite found at Swatara Gap. Specimens up to 6" have been reported although a 3" length is probably more representative. This trilobite, found in the shales, is distinctive, not only due to its size, but also by its elegant simplicity. It is relatively broad and cephalon, thorax, and pygidium are essentially proportionate. Its smooth surface is devoid of prominent ornamentation, but its very simplicity and large size make it one of the more desirable trilobites from Swatara Gap.

Pterygometapus (Fig. 7) is another of the rarer trilobites found in both the shales and turbidite beds. Complete specimens are very rarely found but the distinctive cephalons are occasionally encountered. Overall length of 1 1/4" can be considered representative for a complete specimen. This trilobite is readily identified by its distinctively shaped cephalon decorated by many pustules (pimple like spots). The large, many faceted eyes are also diagnostic.

Possibly the rarest of the Swatara Gap trilobites is the Platylichas which reportedly only occurs in the turbidite beds. With a broad flat body, few thoracic segments, and distinctive pygidium, it is one of the trilobites whose identity is questioned. Hopefully, future finds will provide adequate material to resolve the issue.

Finally, a word on the collecting situation. The area is small and not suited for large groups nor is it suited for youngsters due to real hazards. The lower borrow pit has very limited parking space and that is on a blind curve of heavily travelled Route 72. The upper area is immediately adjacent to Interstate 81 and is subject to the usual parking and safety considerations of all interstate routes. State police patrol the road constantly and take varying degrees of tolerance toward collecting.

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- Moore, R. C. 1959 Treatise on Invertebrate Paleontology, Part O, Arthropoda 1, Geological Society of America and University of Kansas Press.

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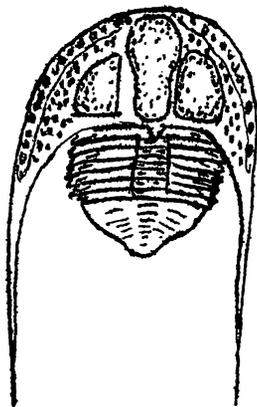


Figure 1
Cryptolithus bellulus
X2

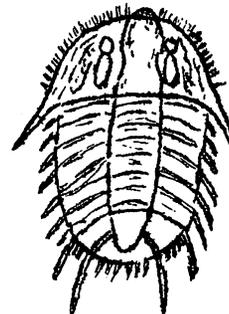


Figure 5
Acidaspis cincinnatiensis
X1.5

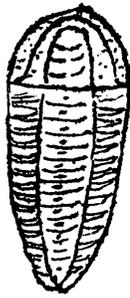


Figure 3
Triarthrus beckii
X5

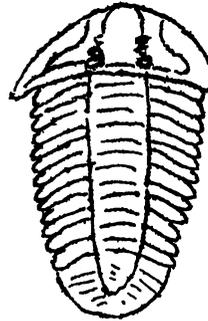


Figure 2
Flexicalymene granulosa
X1.2

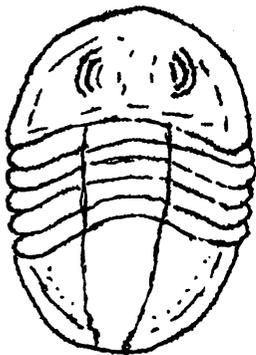


Figure 6
Homotelus stegops
X0.5

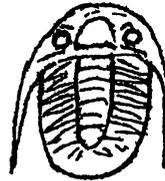
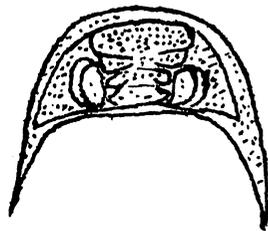


Figure 4
Mesotaphraspis parva
X7



(a) cephalon
X2



(b) eye
X4

Figure 7
Pterygometapus (Achatella) achates

MIDDLE ORDOVICIAN TRILOBITES OF SOUTHERN ONTARIO - AN OVERVIEW

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228 Livingston Road
West Hill, Ontario, CANADA M1E 1L7

Following a neglect of at least 30 to 40 years, the paleontology of Southern Ontario is regaining its popularity. This renewed interest is being focused, in part, on a re-evaluation and re-interpretation of the geology and paleontology of the Simcoe group in Southern Ontario (see fig. 1). However rare some of its faunal elements, the high quality of preservation, in turn, play a major role in the excitement of their rediscovery. Fossils from these formations account for some of the best specimens ever found in the Ordovician of North America.

The reader may already be familiar with some of these frequently well preserved fossils such as Ceraurus and Isotelus from the Lindsay formation, Pseudogygites and Triarthrus from the Whitby and the exquisite echinoderms (various crinoids, starfish, cystoids, edrios...) from the Bobcaygeon formation (Kirkfield fauna). The Verulam formation itself offers the greatest faunal diversity, not only for trilobites, but also for most of the other fossil groups (see fig. 2). However, due to its present lack of exposure, little is being obtained from it at this time. In general this is the case not only for the Verulam but also for most of the other formations above and below it. This unfortunate state of affairs is largely the result of a persistent covering of Quaternary deposit throughout Southern Ontario, limiting access to actual bedrock. This then limits the collector to a handful of localities (mainly quarries) which are then regularly visited.

In spite of these drawbacks, persistent inquiry into the geology of Southern Ontario has yielded, over time, the depositional sequence shown in Fig. 1. These formations in turn are interpreted as standing monuments to ancient oceanic systems which once offered scenarios of clear, well oxygenated, normal tropical marine environments. The bottom of these then supported a profuse and varied shelly fauna as witnessed by present day faunal elements in these formations.

Each of these formations being different lithologically (rock type) and paleontologically (faunal content), are interpreted as having different origins. Past interpretations, however, have not always emphasized the relationship these formations might have. For example, it has been customary to interpret each one of these as the product of a single marine invasion. That is, any number of them in the sequence would be the product of cyclic transgression-regression events, each cycle being responsible for a given formation which was laid down according to the then prevailing physical and biological conditions. Necessarily then, the lower rocks in the sequence would be the oldest and the upper ones the youngest. Time itself would progress upward and evolutionary events expected in that direction. Unfortunately, very little in the way of evolution has been observed, even with trilobites which are now under the scrutiny of the paleontologist in Ontario and elsewhere. Most trilobites seem to appear abruptly, with very little to suggest any ancestry, making any interpretation highly speculative.

More recent studies of the geology of Southern Ontario and surrounding area may actually shed some light on this and other problems. Accumulation of data seem to favor a view first proposed by Winder (1960) which interprets this series of formations as being a sequence representing the different marine environments of

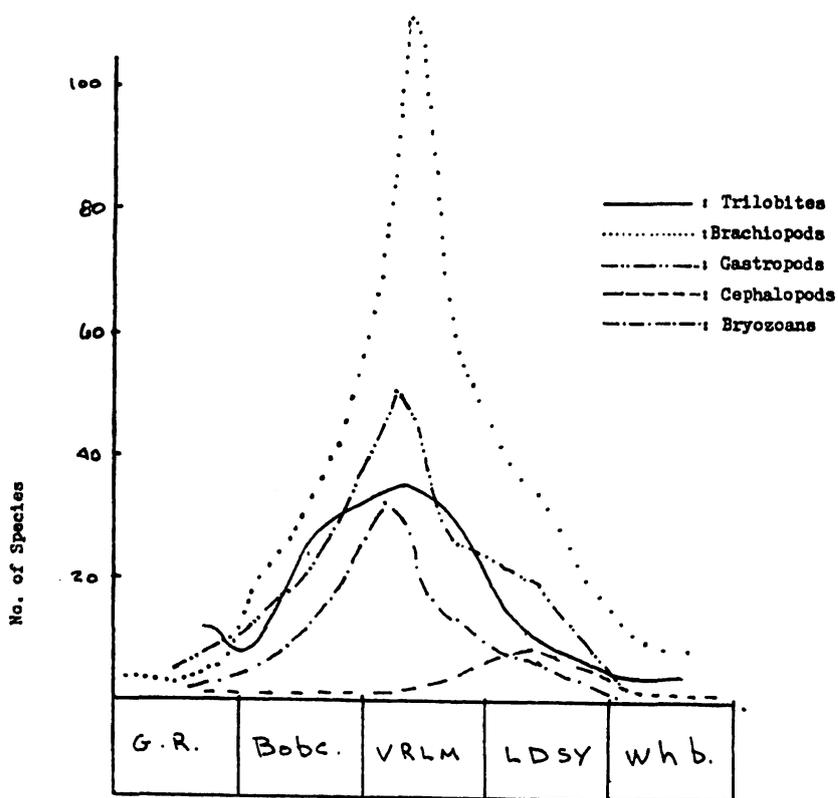


Fig. 2: Relative Abundance of Selected Groups

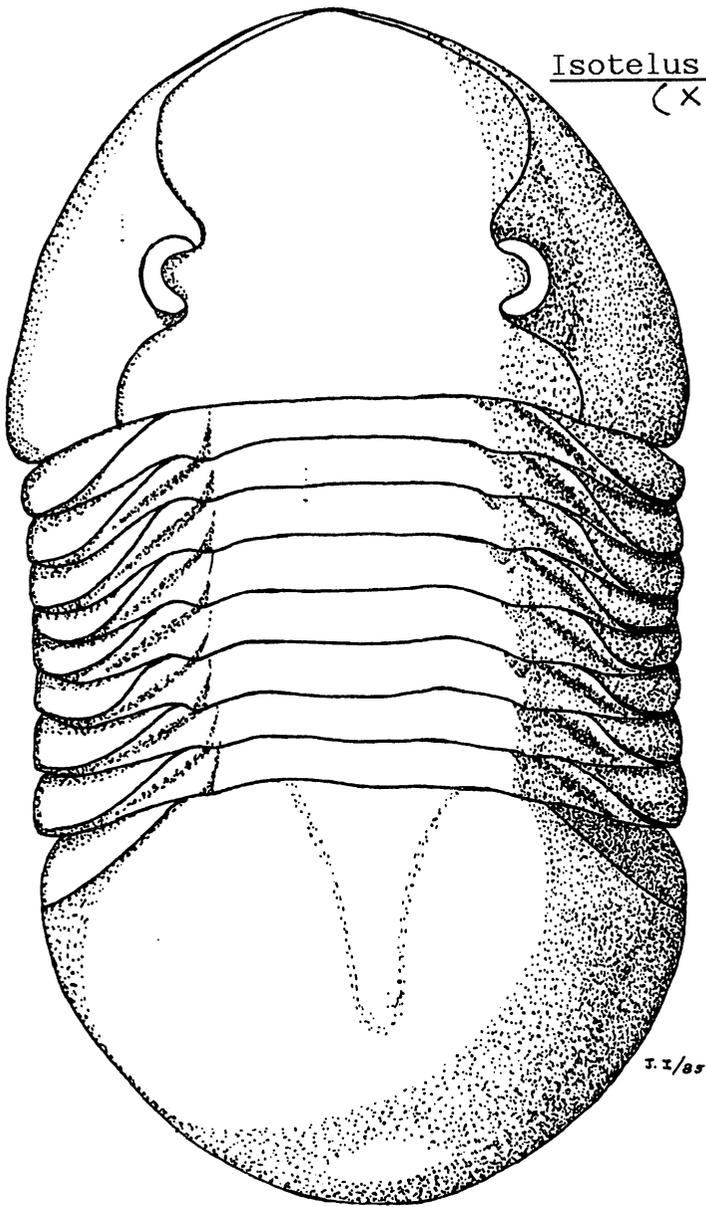
| | G.R. | BOBC. | VRLM | LDSY | WHB |
|----------------|------|-------|------|------|-----|
| BATHYURUS | X | | | | |
| THALEOPS | X | X | * | | |
| RAYMONDITES | X | X | * | | |
| CYBELOIDES | * | X | * | | |
| BUMASTOIDES | X | X | X | | |
| FAILLEANA | * | * | * | * | |
| CALYPTAULAX | M | X | X | | |
| NANILLAENUS | X | * | X | X | |
| ISOTELUS | M | X | M | M | |
| CERAURUS | | M | X | M | |
| ENCRINUROIDES | | X | X | * | |
| ACHATELLA | | * | X | | |
| SCEPTASPIS | | X | X | | |
| FLEXICALYMENE | | X | M | X | * |
| CYPHOPROETUS | | * | * | | |
| ISOTOLOIDES | | X | | | |
| XYLABION | | X | | | |
| PRIMASPIS | | * | * | | |
| ROMONORACHUS | | X | * | | |
| SPHAEROCORYPHE | | * | * | | |
| DOLICHOHARPES | | * | * | * | |
| DIMEROPYGE | | * | * | | |
| HYPODICRANOTUS | | | X | * | |
| EOBRONITEUS | | | * | | |
| HEMIARGES | | X | X | | |
| AMPHILICHAS | | * | * | | |
| CERAURINUS | | | | X | |
| CERAURINELLA | | | | * | |
| PSEUDOCYGITES | | | | X | M |
| TRIARTHURUS | | | | | M |

Fig. 3: Middle Ordovician Trilobites of S.W. Ontario

* : Minor Elements
 X : Well Represented
 M : Major Trilobite

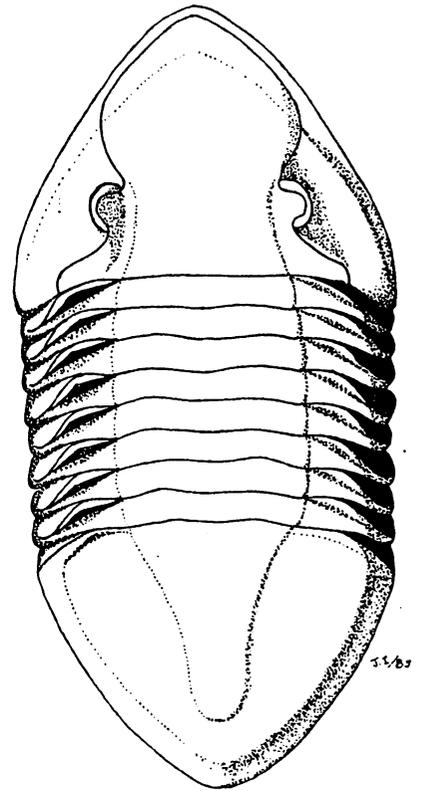
| | Formations | Lithology |
|--------------|-----------------------|---|
| SIMCOE GROUP | WHITBY (Lower member) | Black Shales |
| | LINDSAY | Lithographic Limestones |
| | VERULAM | Interbedded Limestones with Shales |
| | BOBCAYGEON | Calcarinites & sublithographic Limestones |
| | GULL RIVER | Dolomitic & Lithographic Limestone |
| | SHADOW LAKE | Shales & Sandstones |

Fig. 1: Middle Ordovician Table of formations of S.W. Ontario



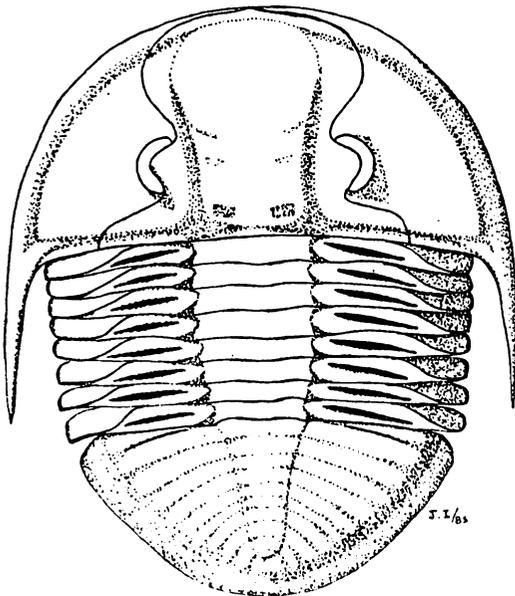
Isotelus latus
(X .75)

J. I. / 85



J. I. / 85

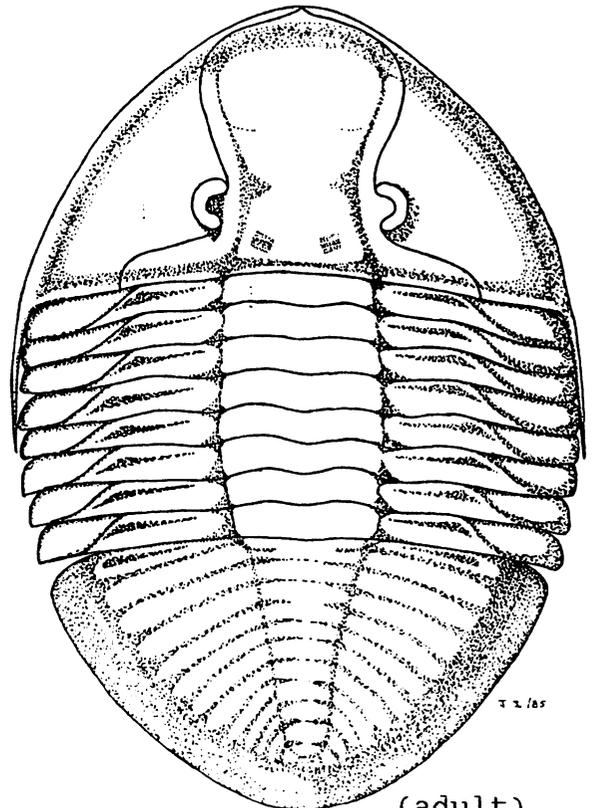
Isotelus gigas (X 1)



J. I. / 85

(juvenile)
(X 6)

Pseudogygites latimarginatus



J. I. / 85

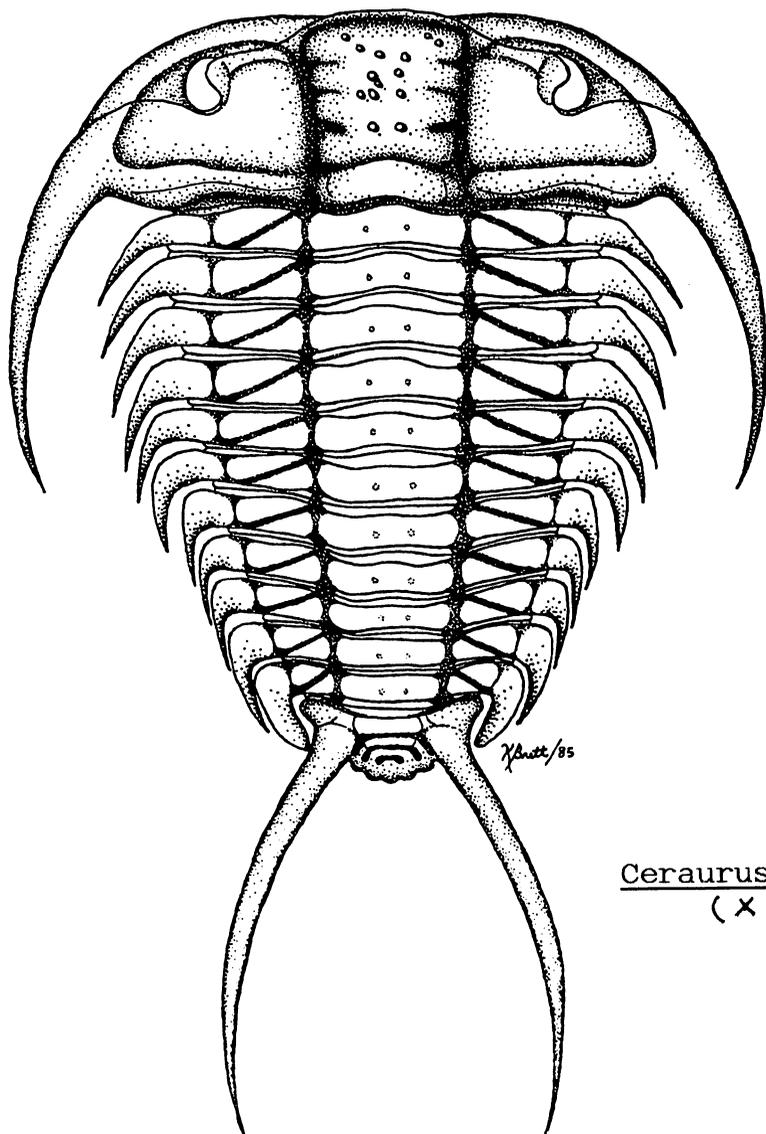
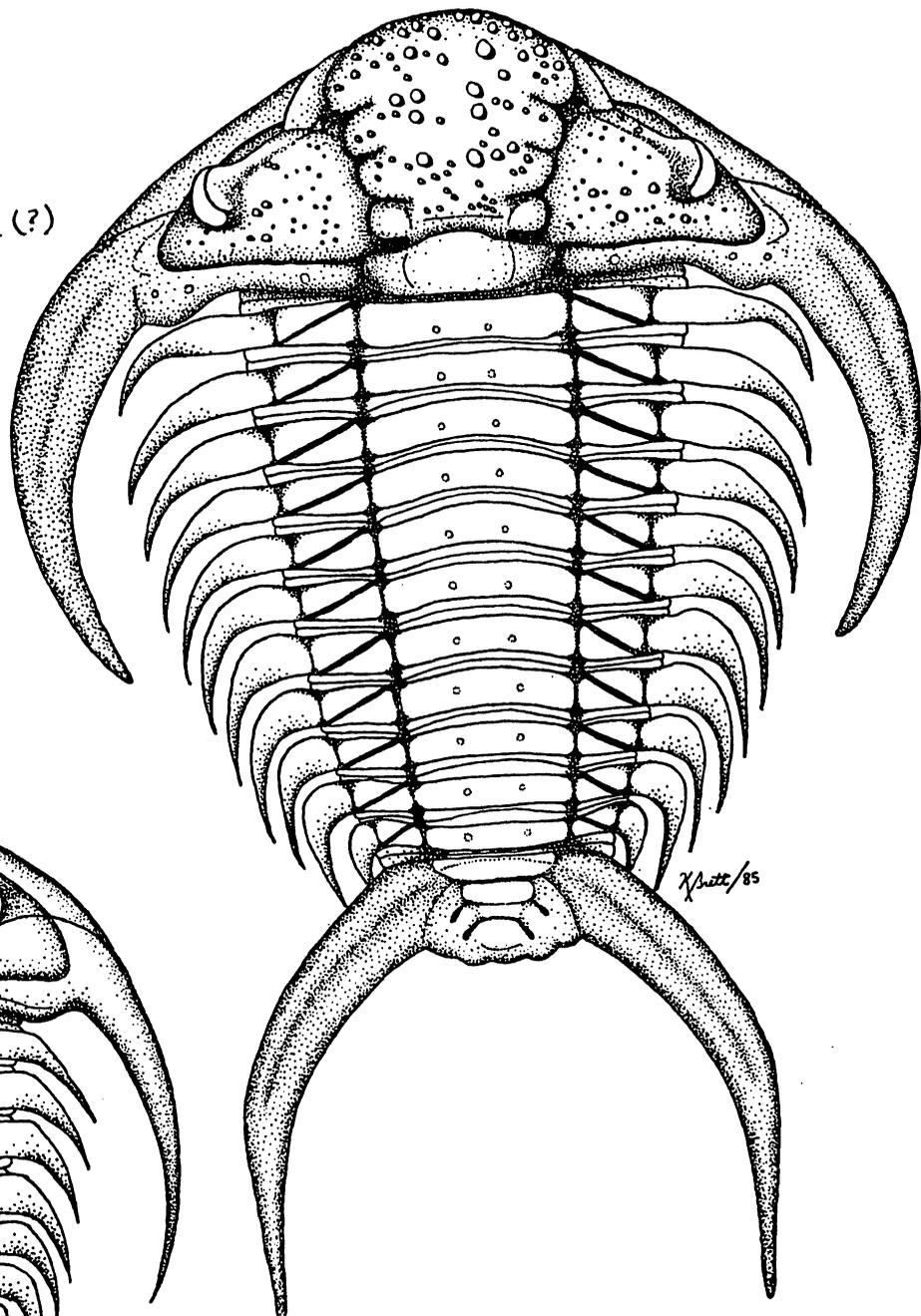
(adult)
(X 1.1)

a transgressive sea that overtook the Precambrian shield during the Middle Ordovician. However simplistic this view might originally have seemed, it nevertheless offers a plausible profile for the sequence as a whole: it is general in character and does not pretend to explain details (like the Plate Tectonic Theory for example). It views the sequence as a final product of a series of pulses (sometimes regressive in nature)--depicting oscillatory conditions--that eventually resulted in a net transgression.

The required mechanics of deposition responsible for this interpretation first involves the recognition of marine environments with their own specific depositional characteristics. These usually range from shore and nearshore (littoral zone) to deep shelf or basinal environments with a spectrum of different zones in between (lagoonal, reefal, shoals...). One expects to find sandstones or reworked sediments in shore environments, for example with possibly finer shale (sometimes black) deposits in deeper shelf areas with carbonate deposits in between. Now, the sequence in Fig. 1 seems to represent this very scenario. Starting with the Shadow Lake Formation, its lithology represents, in part, reworked Precambrian shield material deposited as the sea overtook it. The transgressive nature of this formation along with the Gull River formation (both making up the Black River stage in southwestern Ontario) have been established not only in Ontario but also in equivalent rocks in New York State. The latter represents deposition in a quiet lagoonal environment deepening away from shore. The lithology of the Bobcaygeon formation, with its rich fauna indicates shallowing conditions, possibly an offshore shoal facies. Its lower member grades evenly and gradually into the underlying Gull River. This lack of unconformity along with the evidence for continuous sedimentation between these two formations supports the idea that they were both laid down simultaneously, side by side in a transgressive sea. Again, the lithology and fauna of the Verulam indicate deposition in deep water (a deep offshore shelf facies) while those of the Lindsay suggest deeper water still. The stable and consistent nature of the Lindsay further suggests deposition in very deep waters where conditions are usually quiet. The lower Whitby again grades conformably with the underlying Lindsay (in spite of localized evidence of altered sedimentation conditions), in places so gradually that it is very easy to consider it a sub-facies of the Lindsay. The trilobite *Pseudogygites* so characteristic of the lower Whitby (and restricted there), is also found in the Lindsay, further supporting their relatedness. The exact reconstruction of this member has always been a matter of controversy, but a poorly oxygenated deep basinal facies is supported here.

From this perspective then, our list of formations becomes the various lateral facies of a marine system that eventually piled up over one another as ~~the~~ transgressed upward on higher landmasses. In a given vertical section, across several formations, the lower stratas are obviously older than the top ones but this is not necessarily so for the formations as a whole: these were deposited simultaneously and hence are of the same age. A vertical cut through such a section would not only represent travelling through time but also through the different marine environments as represented by the different formations. The real-time direction itself would be on a line parallel to the formational boundaries and in the direction of the motion of the paleo-shoreline up the Precambrian shield. A 30-foot section, presently being studied in the Bobcaygeon, for example, represents very little time as compared with its 100 miles (at least) in lateral extent (with an average dip of 20 ft/mile). The time it took the paleoshore to "climb" this 100 miles, upward on the Precambrian shield, is the time of interest in studying any evolutionary event of both the physical environments and their contained communities. Rocks under this 30-foot section do not contain ancestral forms

Ceraurus Pleurexanthemus (?)
(x 2.8)



Ceraurus sp. nova
(x 6)

to the communities found above them, but one expects them down the time-line described above. Also, one should not necessarily look for ancestral forms of organisms contained in one formation in the one below it. This so far seems to be the case for most (if not all) forms in the Ordovician of Southern Ontario, including the trilobites.

Investigations are still in progress and I am personally convinced that this paleoecological model (or one derived from it) will, in time, find its way into future consideration of this problem.

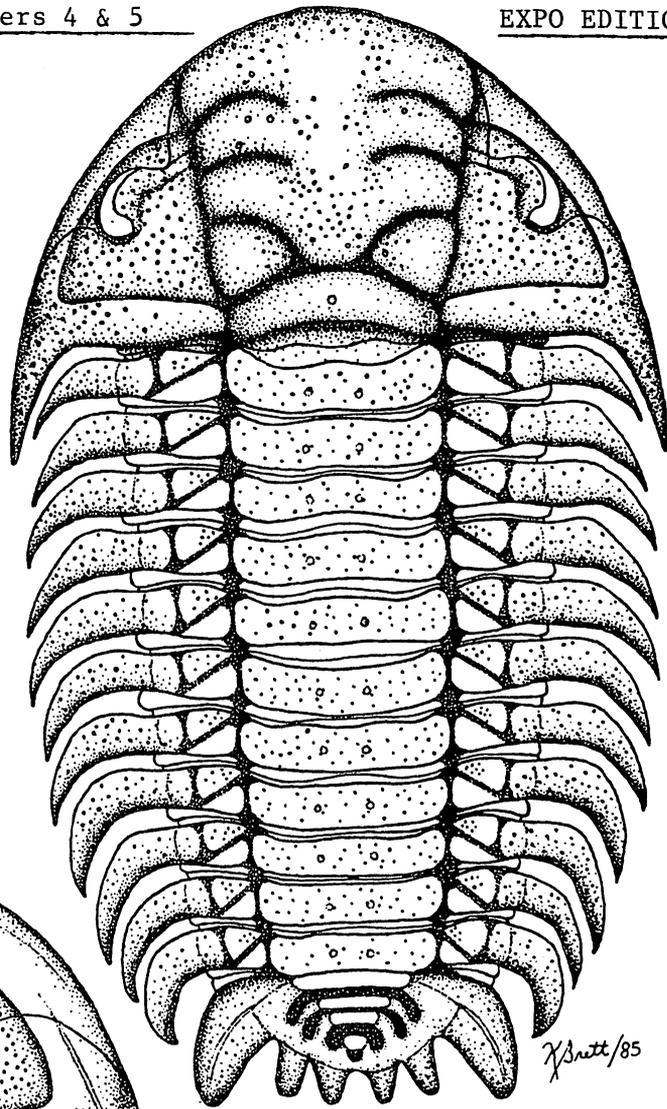
For the section described above, the trilobites themselves are essentially a heterogeneous group with a set of highly diversified morphological features. These are in fact, varied enough, that in between groups they often have very little in common. It is difficult, for example, to see what the Cheirurids may have in common with, say, the Asaphids or the Illaenids (at least in the adult stages) other than the fact that they all are trilobites. This lack of similarity no doubt reflects different ancestries, as each group evolved to adapt in different geographical and ecological environments. Since the majority of the Cambrian trilobites became extinct by the end of that period, the Lower Ordovician must have been a crucial time for the diversification and subsequent stabilization for our Middle Ordovician trilobites. Whereas in the Cambrian the trilobites were dominant, here the Ordovician trilobites shared their communities with other successful invertebrates (brachiopods, bryozoans, echinoderms...) which helped in shaping their environments.

The open shelf environment (represented here mostly by the Verulam) may have contained the highest diversity because of its larger area, increasing the potential number of habitats. Ecologically, competition is usually minimized, between species, by the tendency towards specialization to different niches. Here, with the trilobites, this is reflected by a recognized finer subdivision of habitats as opposed to an increase in diversity within habitats. All trilobites, including the specialized ones (i.e. apparently restricted), are found to be components of faunal aggregates or communities, which as a whole better define their environments. (Here in Ontario, these communities are often ill-defined and need further research). Trilobites with wide geographical extent are interpreted as generalists (in habitat and resources) and were probably among the first ones to invade new environments as they became available through time.

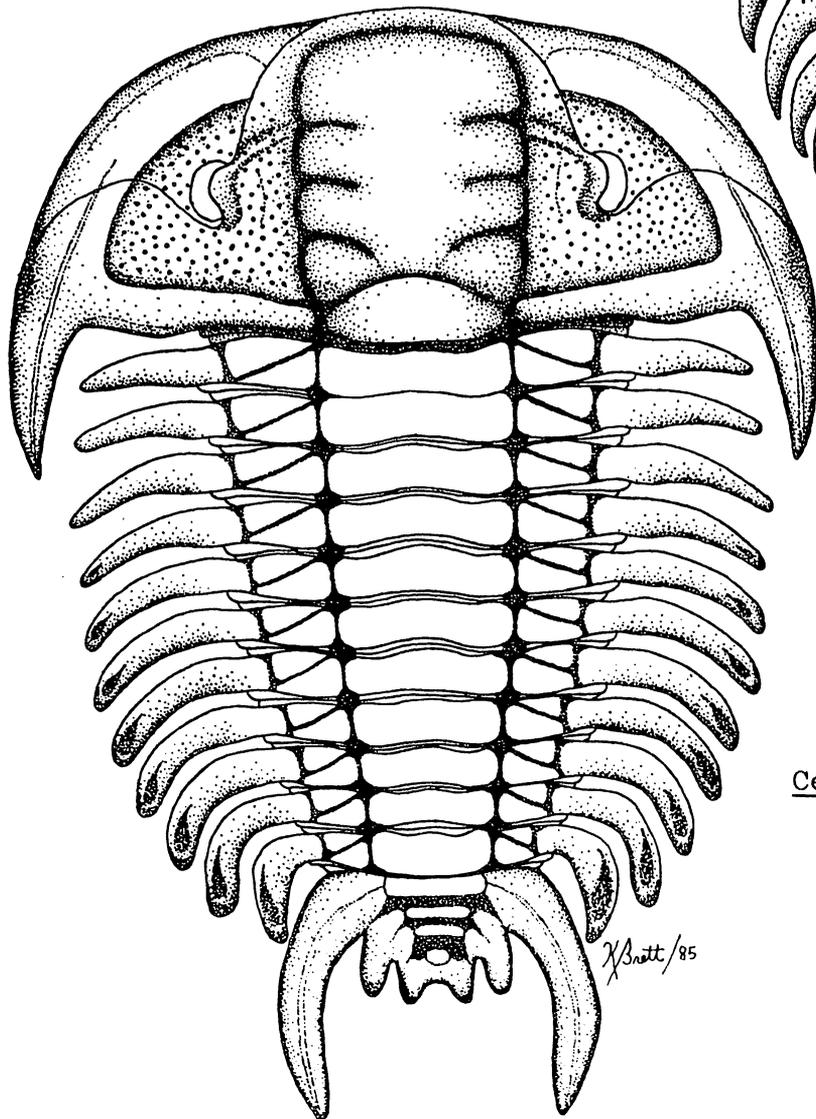
The natural pressures responsible for the apparently adaptive morphologies of these trilobites are not always clear as the fossil record offers but a blurred picture of the world these organisms lived in. Ways to protect from predators are not likely to be the whole answer, for these are rarely important faunal members of trilobite communities. Unless other predators (soft bodied ones) existed but did not preserve in the fossil record, cephalopods are the only known potential trilobite enemies. It is more likely that specialization and subsequent isolation (both, behavioural and geographical) are more important factors responsible for this trilobite diversity that lived in a transgressive sea.

What follows now, is a brief account of selected trilobite groups (families) found in the Middle Ordovician of S. Ontario.

Xylabion sp. (x. 2.8)



XSnitt/85



XSnitt/85

Ceraurinus Marginatus
(x 2.4)

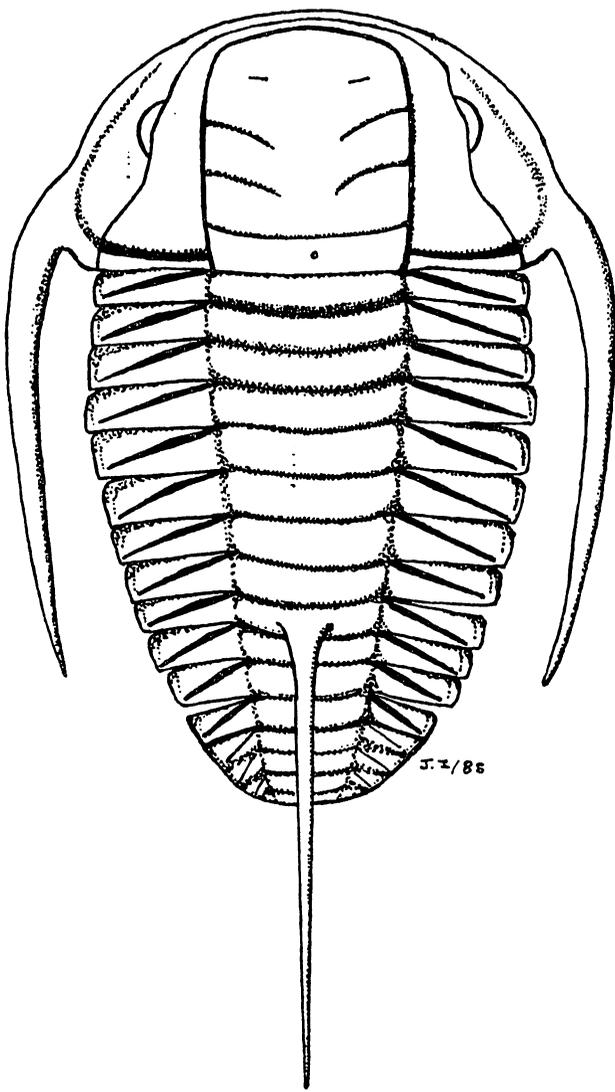
The Asaphids are represented by the genera Isotelus, Pseudogygites and possibly by 3 other minor genera. Isotelus is by far the most generalized (apparently in habitat and resource utilization) as seen in the widespread I. gigas. This model comes with optional genal spines, having them in apparently higher overall diversity environments. Its broad outline and elevated eyes suggest a partly buried existence on muddy bottoms in which it apparently fed. This lifestyle might also have predisposed it to quick burial at the time of death, explaining in part its relative abundance. Isotelus latus is a monster among trilobites reaching lengths of at least 2 feet. A complete 14" specimen is known as well as a few other 10-12" ones. For some reason with this species, smaller ones, less than 3", are extremely rare. Pseudogygites, typical of black shale facies, is also found in the Lindsay. Here it is quite three-dimensional and looks very much like I. gigas to which it is no doubt closely related. A new Asaphid form, Isotelus-like, pitted, with a pronounced posterior pointed border, both, with and without genal spines and temporarily termed "Isotoloides" has been found in the Bobcaygeon Formation.

The Cheirurids are represented by at least 4 genera, Ceraurus being the most common and most widespread. Their light build and spinosity suggest a pelagic (open water) lifestyle. Ceraurus is itself found in several types of environments perhaps attesting its non-specialized way of life while reflecting its pelagic nature. 5 Species of this genus might exist, all perhaps geographical variants. Ceraurinus on the other hand is much more restricted and is usually found in the more argillaceous layers of the Lindsay. Here it coexists with Ceraurus where it is outnumbered by the latter by a factor of at least 5 to 1. It can grow up to 5" whereas Ceraurus seems to be restricted to 3". Xylabion is a recent addition to the Cheirurids of S. Ontario, previously only known from the Ordovician of W. Europe. Its resemblance to the English Cheirurus there is remarkable. Ceraurinella, a beautiful Cheirurid, is reported but unfortunately almost non-existent in our strata. Meraspid of any Cheirurid are also unfortunately unknown in S. Ontario

Pterygometopids are conspicuous among other trilobites, being represented here by at least 4 genera Calyptaulax (see drawing) however, is the only one commonly found complete, although parts of other genera, in this family frequently display beautiful preservation among which are the typical eyes so characteristic of the Dalmanitids. The Illaenids are represented by Nanillaenus, Bumastoides and 3 other genera. Their typically smooth exoskeletons were an ideal design for burrowing, offering them protection and possibly camouflage as they lived and fed in their benthic environment. Triarthrus is the only Olenid trilobite found in our sequence. Although 10 species are reported in this genera, only 2 are commonly found here. T. eatoni here is contrasted with T. rougensis (found in Ontario but not in the sequence described above), these being quite similar except for the set of spines in the latter (see drawing).

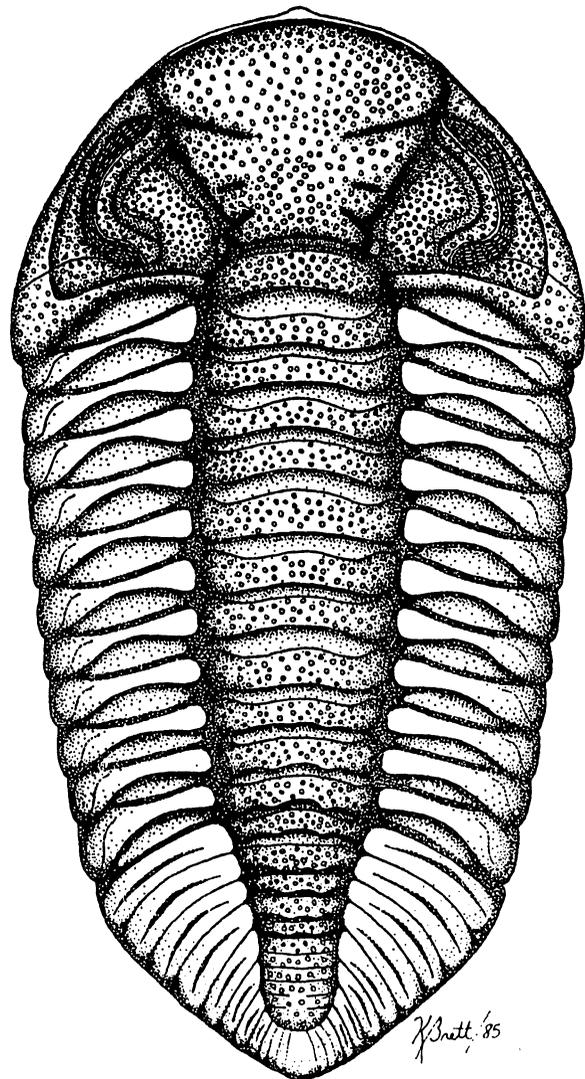
The remaining trilobites in the faunal list (Fig. 3) now play but a minor role, as members of their communities, mainly because of their scarcity. Future collecting however, will no doubt help in elucidating their true nature as these will add to the exciting world of the trilobites.

As a general reference on the trilobites of Ontario I recommend Fossils of Ontario: Part 1: The Trilobites by R. Ludvigsen--a Royal Ontario Museum publication (1979). C. Winder's article can be found in Intern. Geo. Congr. Pt. 7 Sec. 7 pp 18-27,



Triarthrus rougensis
(X 5.5)

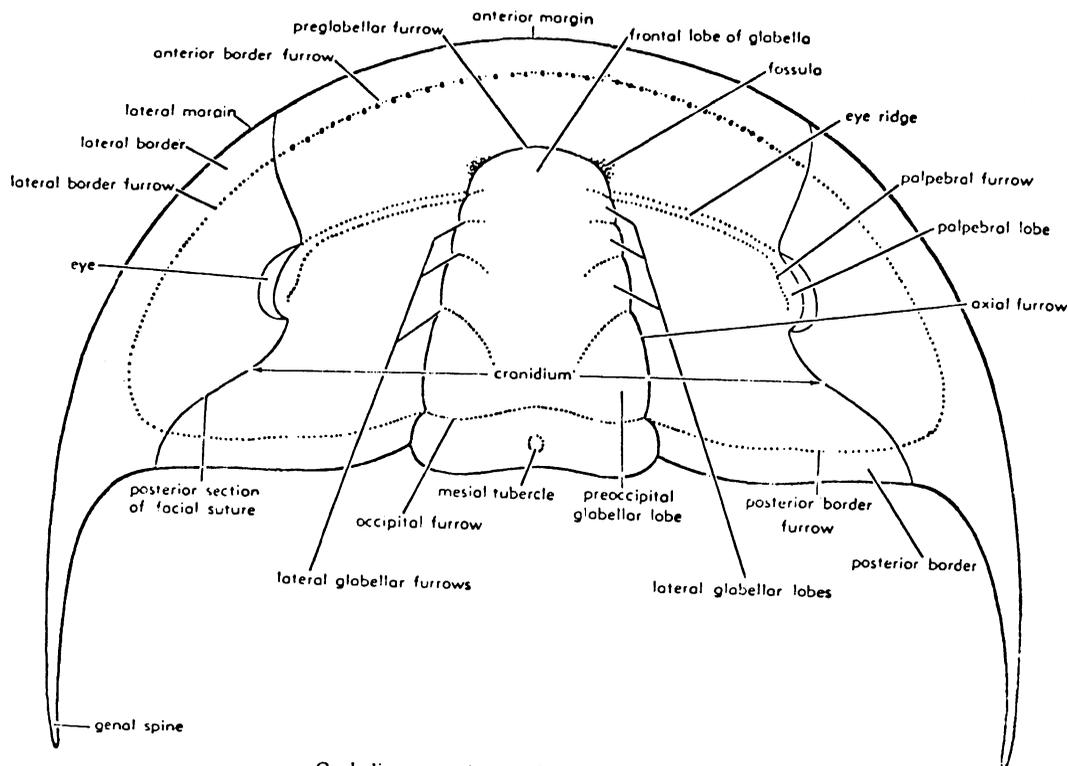
Calyptaulax callicephalus
(X 5.5)



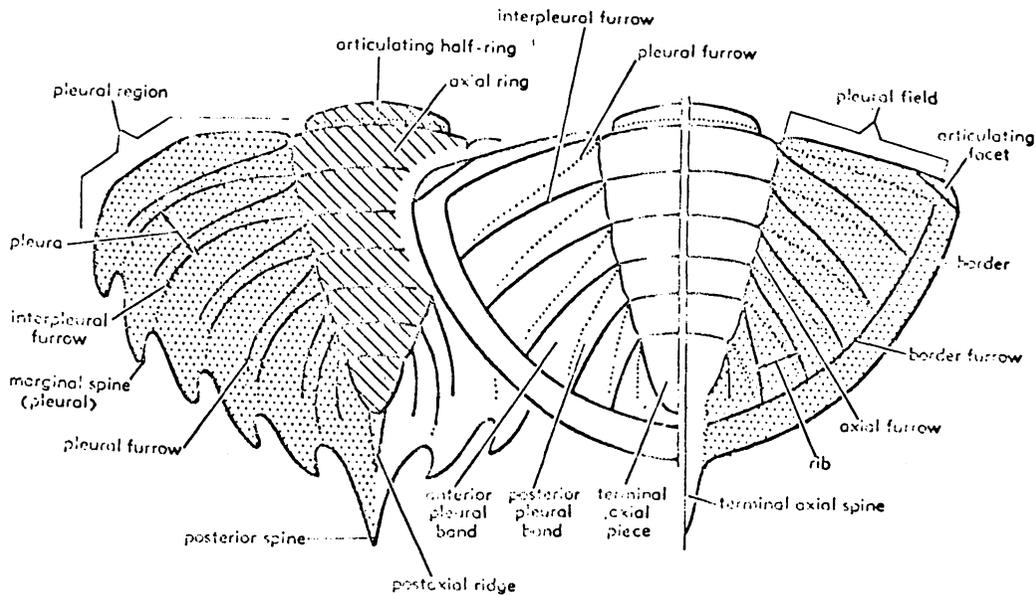
as black carbon films. It is very unusual to find anything but an occasional Flexicalymene out of their expected horizons but several of the other species are best found in pockets. Finding a single Primaspis can take years although Bill and Bob White have found small crinoidal pockets containing hundreds of complete specimens. The same thing is true of Ceraurus. A complete Ceraurus is one of the rarest of our Cincinnati trilobites, yet Steve Felton found a Glyptocrinus pocket with close to a hundred complete Ceraurus. This pocket was one of the most unusual assemblages of trilobites I have ever seen.

The Waynesville Formation is famous for its beautiful Flexicalymene and without doubt the best trilobite beds in Cincinnati. Although there are fewer trilobites in the Corryville, the size and quality of the Flexicalymene are unmatched. I personally enjoy collecting the Fairmount for trilobites. I have one site I collect where I have found complete Flexicalymene meeki, Isotelus maximus, Isotelus gigas, Proetus spurlocki, and Primaspis crossota. Also I have found 30 cephalon of Achetella with beautiful compound eyes, hundreds of Ceraurus cephalons with hypostoma, several Asidaspis, Amphilichas, and Primaspis cephalons and pygidia. This is 9 different species in about 3 feet of strata.

Trilobitomorpha—Trilobita



Cephalic nomenclature of a typical ptychopariid trilobite.



Pygidial nomenclature.

Artinurus harrisi

Very similar to Amphilichas shideleri. No ~~known~~ complete specimen. Like all Lichae, the Cincinnati material needs further study.

Platycoryphe cristyi

Elongate glabella, trapezoidal in outline. 3 pairs of lateral furrows and relatively short preglabellar area. The thoracic axis appears to taper gradually posteriorly. Distally, the pleural ribs of the pygidium are impressed by interpleural furrows. Species possesses 13 thoracic segments.

This trilobite is easily mistaken for the more common Flexicalymene which adds to its very rarely reported occurrences.

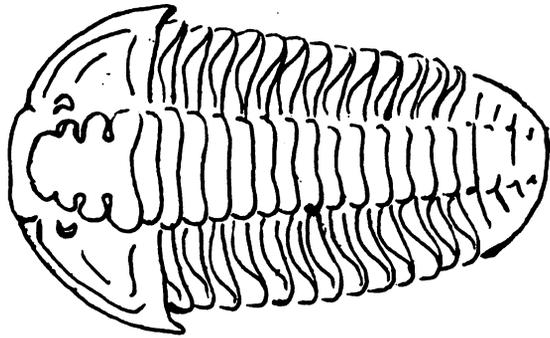
Platylichas halli

very similar to Amphilichas halli. I know of no complete Cincinnati specimen. More work needs to be done on the Lichidae family.

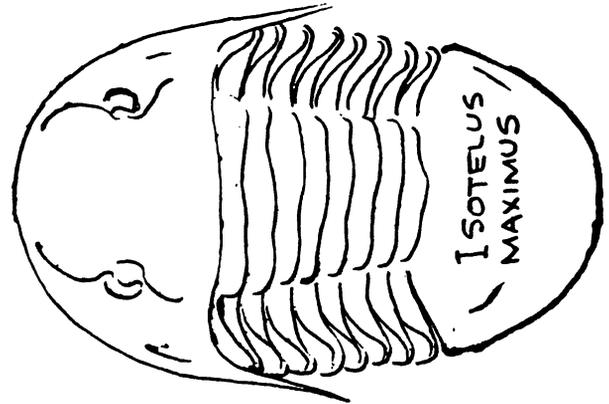
CINCINNATIAN TRILOBITES AMENDED LLOYD CRAWLEY LIST

FORMATION

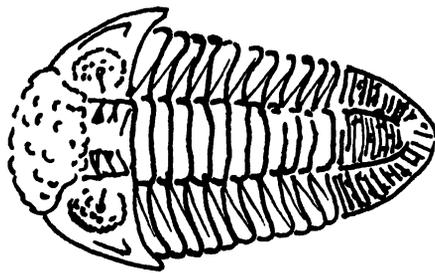
| TRILOBITES | FULTON BEDS | ECONOMY | SOUTHGATE | MC MICKEN | MT. HOPE | FAIRMOUNT | BELLEVUE | CORREYVILLE | MT. AUBURN | ARNHEIM | WAYNESVILLE | LIBERTY | WHITEWATER | ELKHORN | MAXIMUM SIZE | COMPLETE SPECIMEN COLLECTED |
|---------------------------|-------------|---------|-----------|-----------|----------|-----------|----------|-------------|------------|---------|-------------|---------|------------|---------|--------------|-----------------------------|
| ACHATELLA CARLEYI | | | | | | X | | | | | | | | | 3/4 | 4 |
| ACIDASPIS CINCINNATIENSIS | | | X | | | X | | | | | | | | | 3/4 | 5 |
| A. O'NEALLI | | | | | | | | X | | | X | | | | 3/4 | 5 |
| AMPHILICHAS SHIDLERI | | | | | | | | | | | | | | | 4" | 6 |
| ARTINURUS HARRISI | | | | | | | | | | | | | | | 4" | 1 |
| CERAURINUS ICARUS | | | | | | | | | | | | X | X | | 1 1/2 | 5 |
| CERAURUS MILLERANUS | | | | | | X | | | | | | | | | 2 | 150 |
| CHASMOPS BREVICEPS | | | | | | | | | | | | | X | | 1/2 | 15 |
| CRYPTOLITHUS TESSELLATUS | X | | X | | | X | | | | | | | | | 3/4 | 20 |
| FLEXICALYMENE MEEKI | | | | X | X | X | X | X | | X | X | X | X | | 2 1/4 | 10,000 |
| FLEXICALYMENE RETRORSA | | | | | | | | | | X | | | | | 1 3/4 | 10,000 |
| FLEXICALYMENE GRANULOSA | | | | | | | | | | | | | | | 1 1/2 | 250 |
| ISOTELUS BRACHYCEPHALUS | | | | | | | | | | | | X | | | 18" | 5 |
| I. GIGAS | | | | | | | | | | X | X | | | | 8"+ | 20 |
| I. MAXIMUS | | | | | | | | X | | X | X | | | | 18"+ | 1,000 |
| PLATYCORYPHE CRISTYI | | | | | | | | | | | X | | | | 1 1/2 | 5 |
| PLATYLICHAS HALLI | | | | | | X | X | X | | | | | | | 4" | 1 |
| PRIMASPIS CROSSOTA | X | X | X | | | | | | | | | | | | 1/2 | 500 |
| PROETUS SPURLOCKI | | | | | | X | | | | | | | | | 3/4 | 10 |
| TRIARTHURUS EATON I | X | | | | | | | | | | | | | | 1 | 100 |



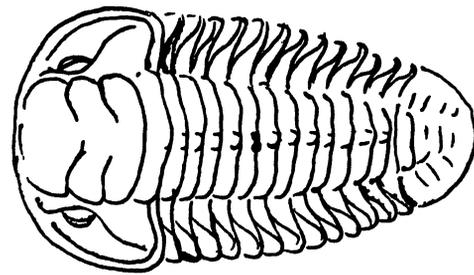
FLEXILYMENE
MEEKI



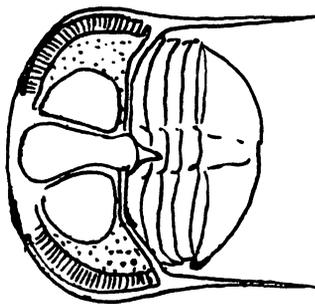
ISOTELUS
MAXIMUS



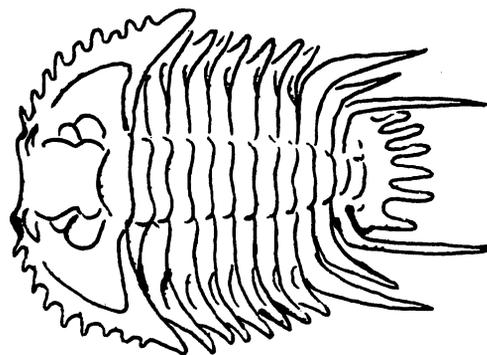
CHASMOPS
BREVICEPS



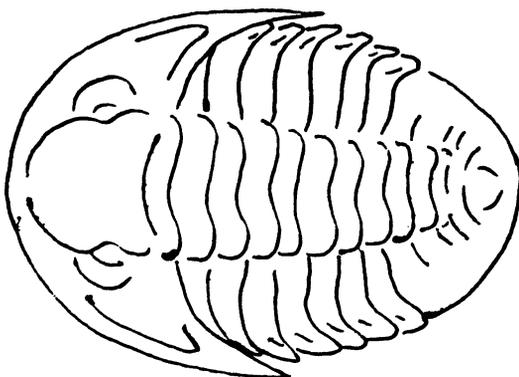
TRIARTHURUS
EATONI



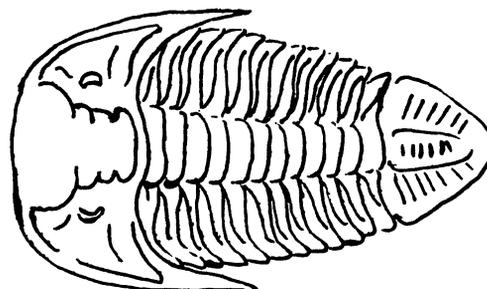
CRYPTOLITHUS
TESSELLATUS



PRIMASPIS
CROSSOTA



PROETUS
SPURLOCKI



ACHATELLA
CARLEYI

Proetus spurlocki

Cephalon vaulted; exterior border convex; border furrow sharp; no preglabellar field; glabella large, suboval to rectangular, glabellar region in front of 3P furrows short, similar to length of 1P glabellar lobes; anterior sections of facial sutures slightly diverging; librigenae with genal angles with short spines. Thorax with 10 segments, ends truncate, axis as wide or wider than pleurae. Pygidium vaulted, semicircular, entire axis broad, with 6 to 9 rings; 5 to 7 ribs, nearly parallel, slightly curved backward.

Very rarely found complete, even fragments are difficult to find. Several known specimens are very thin and not well preserved.

Crytolithus tessellatus

Cephalic fringe broad, sloping outward, Bilaminar, with numerous opposed pits on external surfaces extending posterolaterally somewhat behind rest of cephalon; convex occipital ring with one spine, occipital furrow with deep apopemal pit; glabella expanding forward, reaching to inner margin of fringe, deep anterior pits at extremities of axial furrows; genae subtriangular in outline; without eye tubercles and faint eye ridges; lower lamellae of fringe bearing genal spines. Thorax with 6 segments. Pygidium triangular; axis with many rings.

Nicknamed the "lace collar" trilobite for its obvious appearance, cephalons are very abundant in some beds making it difficult not to take back slabs of these. The body is very frail and even when a complete one is found, it is not very distinct.

Chasmops breviceps

Cephalon semicircular, ogival transversely subrectangular or subpentangular; glabella with frontal lobe inflated, anterior slope steep or overhanging, posterior part fused with central area; anterior corners tending to indent posterior margin of frontal lobe, posterior part reaching far backward so as to compress remnants of 2P lobes and even 1P lobes toward sagittal line of glabella; eyes moderately to very high and ranging from small to large; genal spines generally present and fairly long. Pygidium with long axis containing 6 to 20 rings; distal parts of pleural lobes steeply sloping or vertical with 6 to 20 pairs of ribs; border indistinctly marked; posterior margin rounded.

This trilobite has beautiful eyes very similar to a Phacops. If not for the Ceasar's Creek Spillway, specimen would be virtually unknown.

Flexicalymene meeki

Glabella with 3 pairs of lateral lobes; axial furrows contracted slightly opposite 1P and 2P lateral furrows; preglabellar furrow broad. Pygidium with deep pleural furrows and shallow interpleural grooves extending to margins of pleural regions.

By far the most well known Cincinnati trilobite, this trilobite can be found anywhere in the Cincinnati strata. The largest are found in the Corryville with prominent genal spines.

Achatella carleyi

Exoskeleton rather flat. Cephalon semicircular to transversely subrectangular; axial furrows divergent; frontal lobe of glabella transversely elongate elliptical, 3P lateral glabellar lobes larger than 1P and 2P lobes, which are subequal in size; occipital ring broad, elevated; eyes relatively small, highly elevated, near center of genae; genal spines well developed. Pygidium triangular to subtriangular; with 9 to 13 rings and 8 to 13 pairs of ribs distinct.

One of the most rare of Cincinnati trilobites, it has very high prominent compound eyes and the appearance of Palmanites. One prone specimen 3/4" long and nearly complete was found by Bob White. Lloyd Crawley found 2 nice enrolled specimens from a Fairmount exposure.

Primaspis crossota

Glabella with small 3P lateral lobes; occipital ring not greatly lengthened or inflated, small occipital lobes with paired occipital spines. Eye lobes opposite basal glabellar lobes and about halfway across genal regions; librigenal spines broad at base, adjoining short lateral cephalic spines. Thorax with 10 segments; posterior pleural bands inflated at fulcra, stout posterior pleural spines, small anterior pleural spines.

Another beautiful trilobite, normally rare, they are occasionally found in pockets with crinoidal material. Bill and Bob White collected two pockets of Primaspis with over 500 specimens in each pocket. The pockets also contained Ectinocrinus calyx and starfish.

Triarthrus eatoni

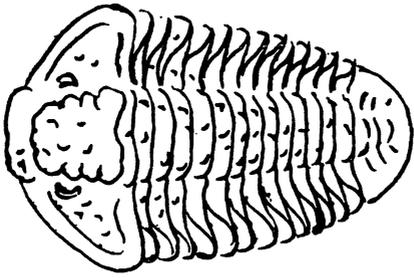
Cephalon semicircular; glabella considerably wider than posterior areas of fixigenae, separated from front border by anterior border furrow or by short preglabellar field, with 2 to 4 pairs of lateral furrows, usually 1 or 2 anterior pairs separated from axial furrows; fixigenae very narrow, anterior sections of facial sutures converging from eyes to front border; librigenae extremely narrow. Thorax composed of 13 to 16 segments, with axis wider than pleural regions; fulcrum placed very close to axis. Pygidium small with 3 to 5 axial rings and entire, evenly rounded posterolateral margin.

This trilobite is fairly uncommon due mainly to the lack of exposures of strata they are found in. Molts are commonly found with complete specimen uncommon. Bill White dug a site several years ago containing close to 100 complete specimens along the Ohio River

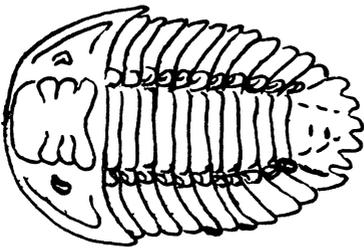
Isotelus maximus

Cephalon and pygidium with poorly defined flattened border. Frontal area moderately long, cephalic axis ill defined, slightly expanding in front of eyes of medium size. Cephalon with no posterior border furrow possessing long genal spines. Thoracic axis considerably broader than pleurae. Pygidial axis broad, poorly defined faintly ribbed. Having 8 thoracic segments.

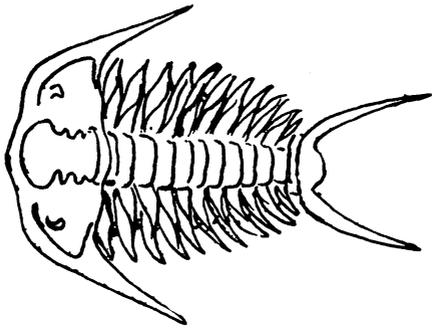
One of the more desirable Cincinnati trilobites, this genus is by far the largest with known specimen 16" in length. Pieces of this trilobite are found throughout the Cincinnati with complete specimens uncommon. Occasional enrolled specimens are collected but prone specimens are virtually unknown collected complete.



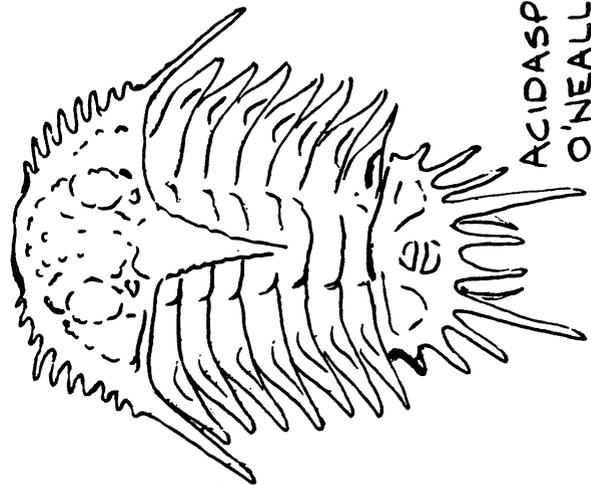
FLEXICALYMENE
GRANULOSA



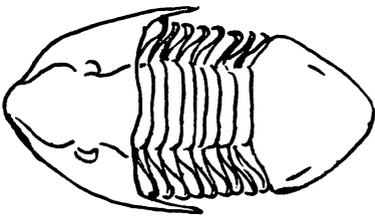
CERAURINUS
ICARUS



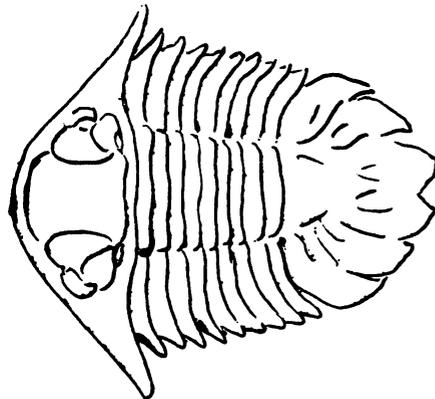
CERAURUS
MILLERANUS



ACIDASPIS
O'NEALLI



ISOTELUS
GIGAS



AMPHILICHAS
SHIDELERI

Ceraurus milleranus

Glabella expanding forward, with 3 pairs of short lateral furrows; eyes set well away from glabella, opposite 3P; fixigenae with long genal spines. Thorax consists of 11 segments; pleurae with deep diagonal furrows ending in blunt spines. Pygidium with long pair of axially recurved pleural spines from anterior segment. Surface tuberculation coarse.

Complete specimens are very rare although cephalons and hypostoma are found abundantly in some beds.

Ceraurinus icarus

Similar to Ceraurus but with longer lateral glabellar furrows and finer surface ornamentation. Posterior border straighter. Pygidium possessing wide axis with 4 to 6 rings; three pair of pleurae with single rounded free points.

This trilobite is very rare with fragments even difficult to find.

Amphilichas shideleri

Cranidium moderately convex; glabella broad and subrectangular; median lobe expanded anteriorly; basal area tending to become depressed; foremost pair of lateral glabellar furrows extended backward to form longitudinal furrows reaching occipital furrow; axial furrows diverted posteriorly; circumscribed occipital lobes present; occipital ring broad; preglabellar field absent; fixigenae subtriangular; palpebral lobes marked off by furrows; anterior sections of facial sutures converging forward, running parallel to axial furrows. Thorax composed of 11 segments; axis broad; axial furrows shallow; pleurae horizontal and transverse proximally, bent downward and backward at fulcra. Pygidium with axis extending whole of length and unfurrowed 3rd pleurae with single free points.

One of the rarest of Cincinnati trilobites, even fragments of this species are extremely rare to find. Only one complete specimen owned by the Smithsonian was known until Jeff Aubry, Bill White, Bob White, Steve Felton, David Cooper and myself made a co-sponsored dig producing 5 complete specimens. 4 of those specimens are now in the possession of the Cincinnati Museum of Natural History.

Acidaspis cincinnatiensis

Glabella tapering forward from basal lateral lobes with 3 pairs of lateral lobes, inflated and prolonged backward into thick, long median spine. Eye lobes close to posterior border and situated at about half-width of genal regions, eye lobes and sutural ridges prominent; lateral cephalic border spines directed vertically, librigenal spines thick, long. Thorax with 10 segments; posterior pleural bands strongly convex, inflated at fulcra. Pygidium with 7 pairs of border spines, 5th thicker and more elongate than others. Surface tuberculate.

One of the more beautiful trilobites, a complete specimen is truly a treasure. Cephalons are fairly easy to find and generally possess the occipital spines.

ISOTELUS--OHIO'S STATE FOSSIL

Michael C. Hansen
Ohio Geological Survey
Fountain Square, Building B
Columbus, OH 43224

Ohio is now one of a dozen states to have an official state fossil. Ohio Governor Richard F. Celeste signed legislation on June 20, 1985, making Isotelus, a well-known Ordovician trilobite, a companion of other state symbols. . .

Many individuals involved in geologically related activities in Ohio, either as professionals or hobbyists, long have thought that the state should have an official fossil, particularly because Ohio is so well known for both abundant and well-preserved fossils and because fossil collecting is a popular activity. As testimony to this popularity, the Ohio Geological Survey each year receives numerous requests for information on fossils and fossil collecting from residents of the state and from individuals throughout the country. The Ohio Geological Survey Bulletin 54, OHIO FOSSILS, traditionally has been a best seller and is now in its eleventh printing, with more than 30,000 copies sold since 1955.

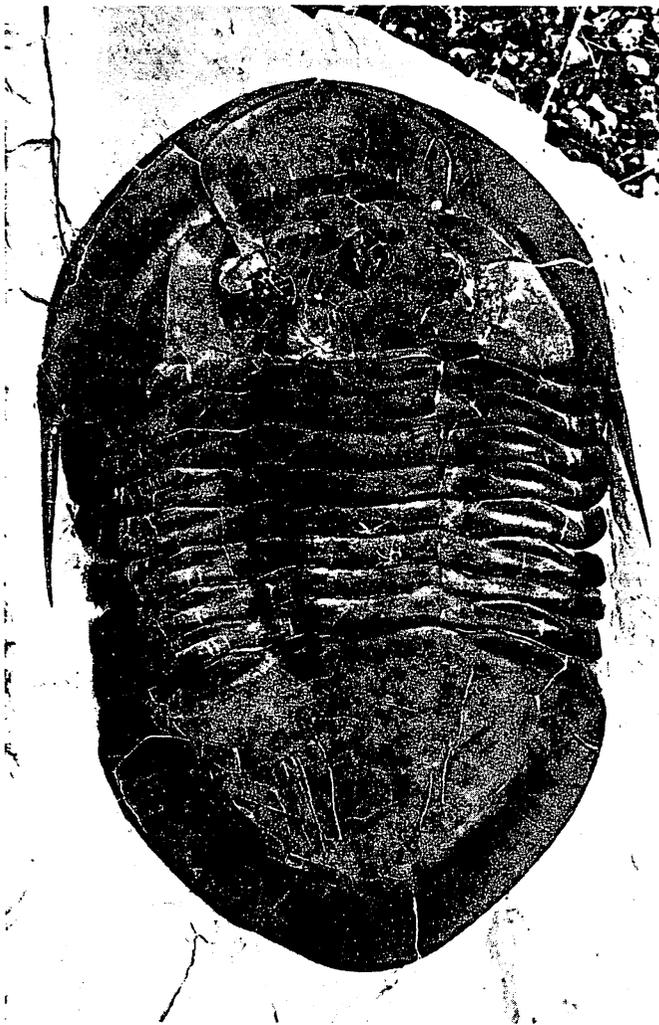


Figure 1: Nearly perfect specimen of Isotelus, 9½ inches in length, from the Ordovician Arnheim Formation in Highland County, Ohio. Dan Cooper specimen.

It was through the efforts of two Dayton-area elementary school classes, Doris Swabb's third graders at Beavertown School in Kettering and Virginia Evers' fourth graders at St. Anthony School in Dayton, that legislation was introduced to designate a state fossil for Ohio. The two teachers attended a summer class at the Dayton Museum of Natural History and were captivated by trilobites, particularly a large specimen of Isotelus that was found during the construction of Huffman Dam, near Dayton, in 1919. . .

Isotelus

The trilobite Isotelus has had a long and illustrious history in Ohio, and the Ohio Geological Survey played a role in the early studies on this fossil. Isotelus is known from rocks of Ordovician age (about 440 million years ago), which, in Ohio, are exposed in the southwestern portion of the state. These rocks consist of a series of comparatively thin, alternating layers of limestone and shale that were deposited as limy mud and clay on the floor of a warm, shallow, tropical sea that covered Ohio during the Ordovician Period.

Serious study of these rocks began during the First Geological Survey of Ohio (1837-1838); John Locke was the geologist in charge of the southwestern portion of the state. Among Locke's many discoveries during this brief period of investigation were the partial remains of a large specimen of Isotelus, which Locke Isotelus maximus. Locke found only the tail (pygidium) of this trilobite, but, by proportional comparison, he was able to reconstruct the specimen as 21 inches in length. He illustrated this reconstruction at natural size in a fold-out plate in the Second Annual Report (1838) of the Ohio Geological Survey. Locke, in his characteristically colorful manner, indicated that local residents referred to trilobites as "petrified locusts, butterflies, bugs, and frogs." Interpreting the morphological characteristics and functions of Isotelus, Locke stated that this specimen, "with a kind of shovel shaped termination at both ends, was well calculated for making his way in the mud, either backwards or forwards."

In an 1842 article in the American Journal of Science, Locke described and figured another specimen of Isotelus found by William Burnett in the hills near Cincinnati. This specimen, 9 3/4 inches in length, was named Isotelus megistos, but later workers have referred it to Locke's original species, Isotelus maximus.

What is perhaps the most famous of the many fine Isotelus specimens collected in Ohio was found in 1919 during construction of Huffman Dam on the Mad River, northeast of Dayton. The workmen who discovered the "fossil turtle" while digging the outlet tunnel for the dam immediately summoned the chief engineer of the Miami Conservancy District, Arthur E. Morgan. This remarkable individual, noted for his broad scientific interests, immediately recognized the significance of this large trilobite.

The giant specimen of Isotelus, measuring 14' inches in length and 10 inches in width, was given to Arthur Morgan's son, Ernest, for the school museum. However, the trilobite was very soon taken to Dr. August F. Foerste, physics teacher at Steele High School in Dayton and one of the most renowned and prolific paleontologists in Ohio. Foerste's research connections with the U. S. National Museum (Smithsonian Institution) in Washington, D.C., resulted in the specimen being transferred to that institution for permanent display. This specimen still occupies a prominent position in the paleontological exhibits at the Smithsonian and is thought to be the largest complete trilobite ever found (pieces of apparently larger specimens have been found, however).

Foerste lost no time in calling the attention of the scientific community to this giant Isotelus and in 1919 used it as the type-specimen of a new species, Isotelus brachycephalus, the specific name referring to the broad head. There has been no modern study of the various proposed species of Isotelus, and at this time the validity of Foerste's species is uncertain. Nevertheless, this magnificent specimen, which has been viewed by many thousands of people during its nearly 70-year reign at the Smithsonian, will always stand out in the annals of paleontology.

No additional specimens approaching the size of the Huffman Dam specimen have been found, although several specimens approaching 10 inches in length have been collected in the intervening years. Bits and pieces of Isotelus turn up frequently in blocks of Ordovician limestone from southwestern Ohio. Occasionally complete specimens, from as small as one-quarter inch to intermediate-sized specimens several inches in length, are found. . .

of the trilobites had smooth carapaces. There were other trilobites in which the carapaces were partly or completely granulated. A few families of Silurian trilobites were also rather spiny in form.

The following list gives the fifteen different families of trilobites and genera under each of the families that lived during the Silurian Period and may be found in the Silurian rocks in the United States and Canada.

Family ILLAENIDAE Hawle and Corda, 1847

Bumastus

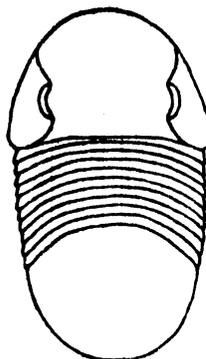
Litotix

Cybantyx

Stenopareia

Illaenoides

Actinolobus



Illaenid

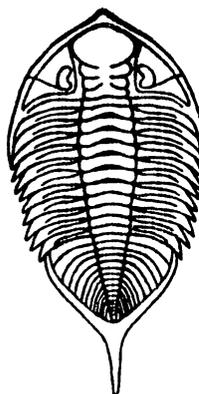
Family DALMANITIDAE Vogdes, 1890

Dalmanites

Ommokris

? Odontochile

Dalmanitina



Dalmanitid

Family CALYMENIDAE Burmeister, 1843

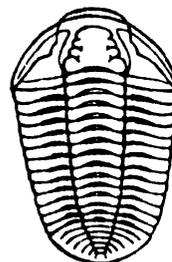
Calymene

Diacalymene

Spathacalymene

Liocalymene

Sthenarocalymene



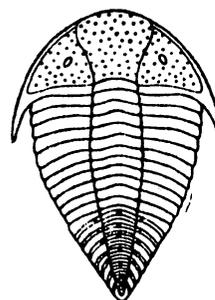
Calymenid

Family ENCRINURIDAE Angelin, 1854

Encrinurus

Fragiscutum

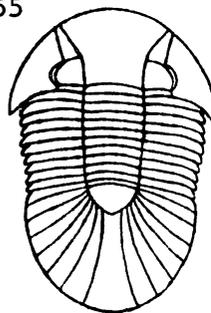
Staurocephalus



Encrinurid

Family SCUTELLUIDAE Richter and Richter, 1955

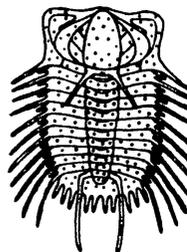
- Scutellum
- Kosouopeltis
- Planiscutellum



Scutelluid

Family ODONTOPLEURIDAE Burmeister, 1843

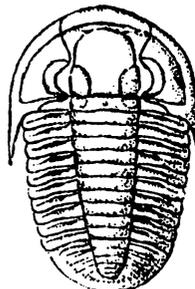
- Cerztocephala
- Acidaspis
- Dudleyaspis
- Leonaspis
- Xanionurus
- Odontopleura



Odontopleurid

Family PROETIDAE Hawle and Corda, 1847

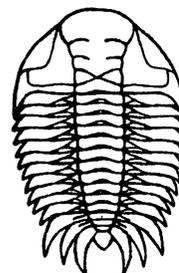
- Proetus
- Decoroproetus



Proetid

Family CHEIRURIDAE Hawle and Corda, 1847

- Cheirus
- Anasobella
- Hadromerus
- Sphaerexochus
- Deiphon



Cheirurid

Family LICHIDAE Hawle and Corda, 1847

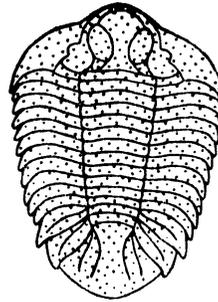
Lichas

Dicranopeltis

Arctinurus

Trochurus

Hemiarges

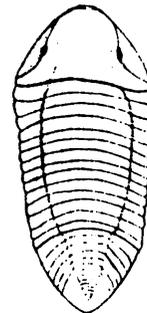


Lichid

Family HOMALONOTIDAE E. J. Chapman, 1890

Homalonotus

Trimerus



Homalonotid

Family PHACOPIIDAE Hawle and Corda, 1847

Eophacops

Acernaspis

Ananaspis

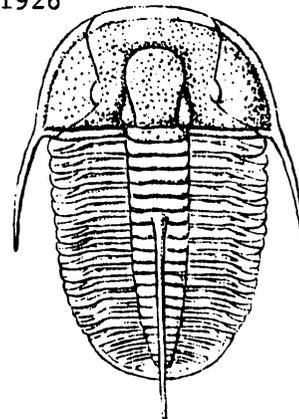


Phacopid

Family OTARIONIDAE Richter and Richter, 1926

Otarion

Rhinotarion



Otarionid

One reason may have been the artistic beauty that was displayed by the fossils themselves. To any avid collector no trilobite is plain, all are exquisite and unique. Those of the Silica Formation were truly God's creation of beauty and detail, and are unsurpassed anywhere in the world.

Perhaps another reason was in the thrill of discovery and the joy of anticipating what you might uncover. The next fossil you found might be a member of an undiscovered species.

Only after many days in the field and long and thorough collecting from any locality, does the hunter begin to realize each layer or bed has its own assortment of fossils. It is also hard to believe that the Silica Formation creatures which secreted them have been dead for over 350 million years.

Several of the units of the Silica Formation are thick shale beds. These represent a slow uninterrupted accumulation of material over a span of time. In 1970 Dr. Robert Kesling (in Ehlers and Kesling, pp. 33-39) called this a diverse fauna zone, characterized by deep mud flats which represent the final seaward transport of clay particles. The claystone, or shale, has generally a very low calcareous content and may reach exceptional thickness without intervening beds. Because of this slow build up, we may conclude that the region of the quarries was fairly far removed from the nearest shore of the Middle Devonian sea, when the Silica Formation was laid down.

Another interesting theory is Dr. Robert Kesling's statement "Inasmuch as corals, which today need light for their existence, are present in the limy parts of the Silica Formation, we may judge that the deepest water covering the area during the period of deposition was probably not much over 150 feet."

In the good old days back in the 60's a steady stream of cars from all over the United States and Canada headed for Silica, Ohio, where the Medusa Portland Cement Company quarries were located. By the early 1960's the south Medusa quarry was no longer in operation. But the Medusa north quarry was going full blast. Most of the hunters tried to arrive at the north quarry after the last shift had finished for the weekend. Of course, one always stopped at the Medusa quarry office and filled out a consent form for permission to collect in the quarry.

Most of these intrepid collectors, amateur paleontologists if you will, were after the "black bugs" from the Silica Formation...These "black bugs" or trilobites could be found rolled up or flat. The majority were folded and it was a very lucky person who managed to capture a whole flat one. It surely was fun to hunt through the piles of Unit 9 shale which had been discarded by the quarry personnel. Equally exciting was to look for cracks on the bottom of Unit 9 and the top of Unit 8. This was where you could find the large "crassies" trying to hide under blankets of shale from the eyes of the fossil hunters.

I'll never forget the day I spent hunting with Cam Oglesbee and Dr. H. R. Bath from Wilmington, Ohio. We were splitting some dumped Unit 9 shale when out popped a huge trilobite the size of a golf ball! It started down the slope! How recklessly I chased after that critter! I grabbed him and gave him a big juicy kiss right between his big compound eyes and his little "butt"! I felt like a prince awakening the beautiful princess with a great big kiss. Of course, I really shouldn't use this analogy as all my trilobites are named "George"; I could have a few "Georgianas" but I haven't figured out how to tell what sex they are yet. That would make a very interesting article for some future Digest..The Sex Life of 'George', The Phacops rana kid".

Those invertebrates, the extinct trilobites, evolved towards outer armor as typified by the living crayfish, lobster or crab, the body and even the joints of the legs are encased in an armor, with complicated internal muscles to operate them; similarly, the extinct trilobites and other arthropods of the Devonian had an external skeleton of chitin and calcium carbonate that was secreted by the animal. (This chitin is similar to the material in one's fingernails). The arthropods at each stage of growth were prisoners in an outside coat of armor; they could grow only by molting, casting off the hard covering to grow rapidly before secreting another and larger suit. The molting process left behind the old skeletons, so that one trilobite could in its lifetime produce several "fossils" in the sediment. Complete extended ones, and the enrolled ones, represent trilobites that have died.

"Trilobites appear to have filled the role of scavengers on the Silica Formation sea floor, probably also ingesting quantities of organic-rich mud. No evidence has been uncovered to suggest that the Phacops trilobite was ever an active predator."

A good example of the beauty of the Silica Formation trilobites can be seen in Plates 33 and 34 or pages 142 and 151 of the Kesling and Chilman book. They have been reprinted here to show the exquisite detail of these fossils.

Strata And Megafossils Of The Middle Devonian Silica Formation by Dr. Robert V. Kesling and Ruth B. Chilman was published in 1975, by The Friends of the University of Michigan Museum of Paleontology, Inc., and are available from Tom Witherspoon at various M.A.P.S. shows. They are also available for \$11.50 postpaid from Friends c/o Tom Witherspoon.

* * * * *

EXPLANATION OF PLATE 33

All figures x 2

Trilobites

- FIGS. 1-5 -- Phacops rana crassituberculata Stumm. 1-4, inclined, side, front, and bottom views of an enrolled specimen from the collection of the Chilmans. 5, top view of an extended specimen, also from the Chilman's collection. In this subspecies, the glabella has coarse tubercles; smaller tubercles are present on the genal area (corner of the head) and on the areas above the eyes. Distinct tubercles are present along the axial lobe, both on the thorax and on the pygidium (tail). "Crassi" has an average of 84 facets on each eye; each facet is bordered by a nearly polygonal rim and its center does not extend beyond the general level of the eye surface. The fairly large facets are arranged in diagonal rows. Figure 5 shows the narrow zones of tuberculation on the lappets of the pleural lobes.
- FIG. 6 -- Phacops rana milleri Stewart, inclined view of an extended specimen from the collection of the Chilmans. As compared with subspecies "crassi" above, this subspecies has smaller tubercles on the glabella and elsewhere is smooth or provided with muted ornamentation. Each eye in milleri has an average of 104 facets arranged in about 18 vertical rows; each facet is small but strongly convex, extending outward beyond the general level of the eye.

Phacops rana crassituberculata is usually found in units 7 and 8, whereas Phacops rana milleri is usually found in units 8 and 9. Occasionally, both species are found on the same slab, proving that for a while they were contemporaries.

PLATE 33

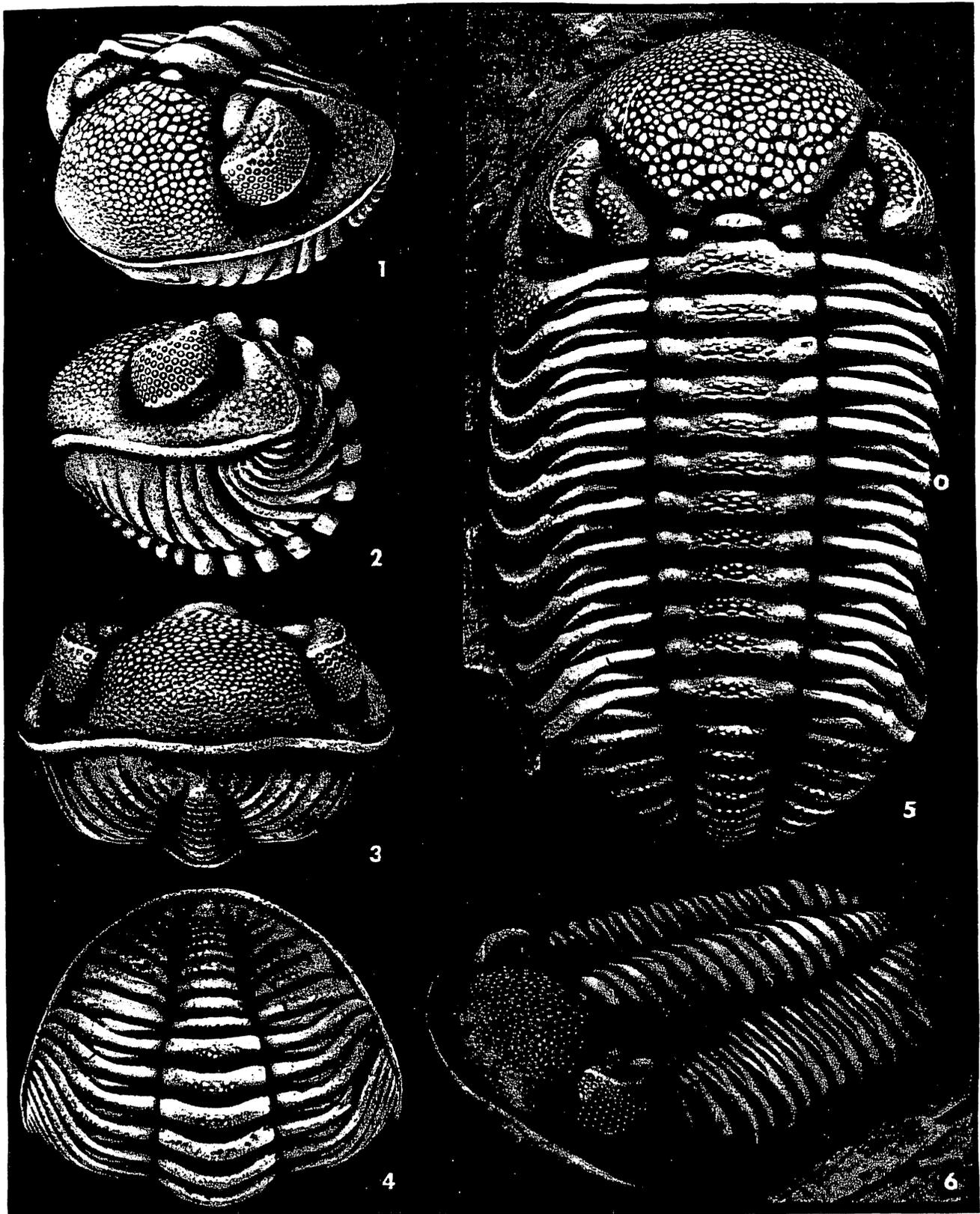
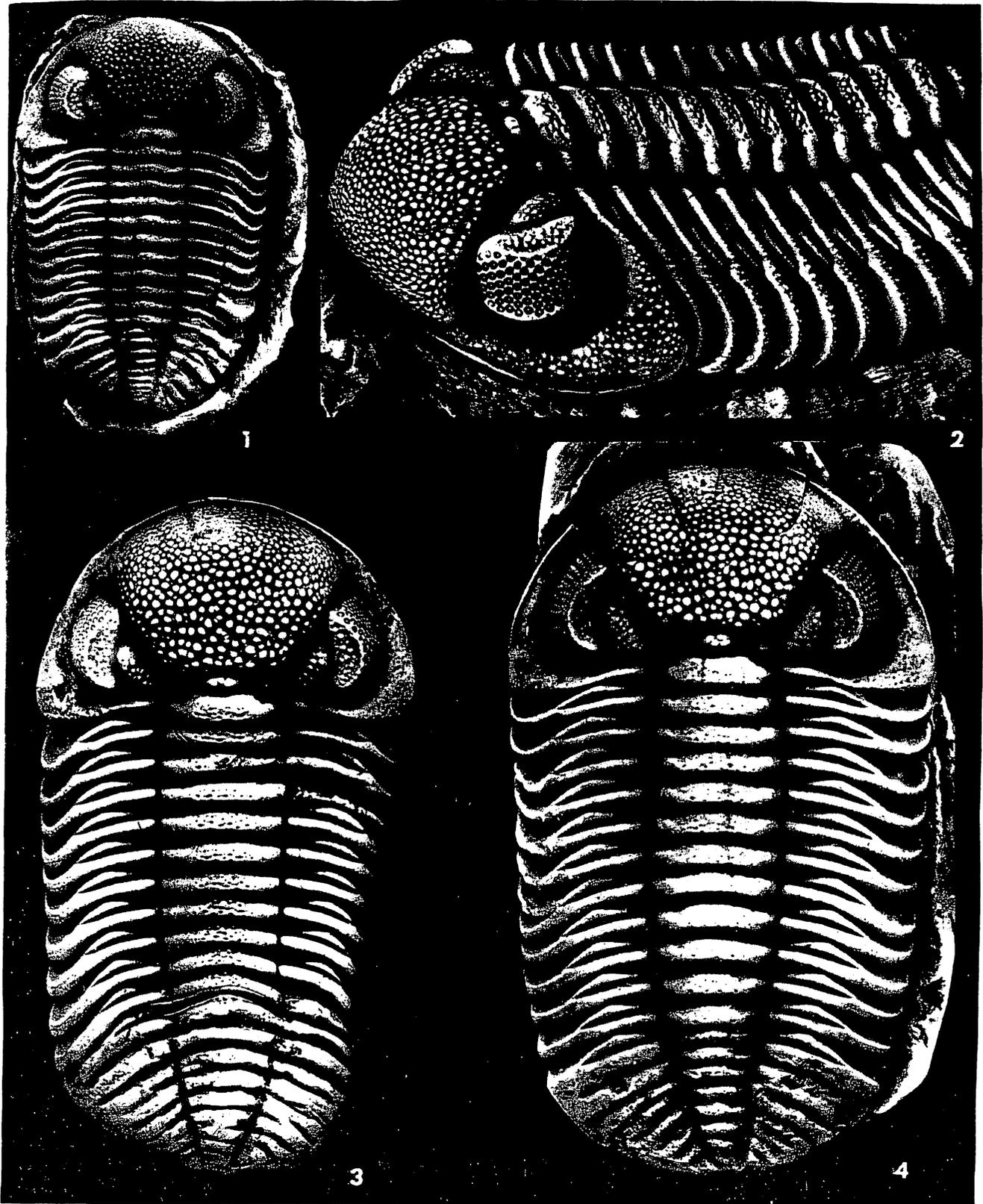


PLATE 34



EXPLANATION OF PLATE 34

All figures x 2

Trilobites

- FIGS. 1, 4 -- Phacops rana milleri Stewart, specimens from the collection of the Chilmans. Top views of a small and a large specimen. In these views, the facets appear to be arranged in vertical rows, with approximately 18 rows in each eye. The average number of facets in this subspecies is 104, the highest number for any Phacops. The free cheeks are nearly smooth, and the axial lobe of the thorax has very faint ornamentation. Each eye facet is nearly circular, and clearly convex, extending outward beyond the general level of the eye.
- FIGS. 2, 3 -- Phacops rana crassituberculata Stumm, specimens from the collection of the Chilmans. Inclined and top views of extended specimens. The eye facets alternate in the vertical rows, so that they appear to be disposed diagonally. Each facet is bordered by a polygonal rim, and is not nearly so convex as those of milleri. The average number of facets per eye in this subspecies is only 84. The glabella has coarser tubercles than does milleri, and the free cheeks are provided with smaller tubercles and pits, in which it is presumed the animal bore sensory hairs. The axial lobe of the thorax is coarsely tuberculate, and even the edges of the pleural lobe segments have distinct tubercles.
- Both subspecies can occasionally be found on the same slab, so that they were actually in competition at one time. Usually, however, Phacops rana crassituberculata occurs in units 7 and 8, whereas Phacops rana milleri occurs in units 8 and 9.

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OKLAHOMA TRILOBITES

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There is probably no other state that has as much to offer in the way of trilobites of so many different ages. Since there is no public land in Oklahoma, all of the trilobite bearing localities are on private land and access is difficult in most cases. There are a few exceptions, as there are two fee areas that do produce nice Ordovician and Devonian trilobites.

Cambrian: While a number of Cambrian trilobites have been described from Oklahoma, localities have not been recorded so that they can be found. Most have been described from parts only, but an occasional complete specimen has been found. Rocks of this age are exposed along I-35 in the Arbuckle Mountains.

Ordovician: Many different trilobites of this age are found in Oklahoma. The most famous trilobite in Oklahoma is Homotelus, which is found as singles and

in pools of from a few hundred to a few thousand individuals in the Bromide Formation. These pods range from 2 feet to perhaps 100 feet across, sometimes with a single layer of trilobites, but in others with several overlapping layers of complete individuals ranging in size from around 1½ inches to 5 inches. Larger slabs make exceptional museum pieces, such as the one in Augustana College Museum. These can only be successfully collected with the aid of a bulldozer. I know of no locality that can be successfully collected by digging by hand. In 1983 we purchased the main locality for Homotelus and will be quarrying these for the next few years. Besides Homotelus, the Bromide Formation produces from time to time, Encrinuroides, Calliops, Bumastus, Illaenus, Eoceraurus, Probolichas, Amphilichas, Dolichoharpes, Isoteloides, Lonchodomas and a few other ultra rare forms.

The Viola Limestone produces Cryptolithoides, Cryptolithus, Isotelus, Vogdesia, Robergia, Remopleurides and a few other very rare forms. Some of these rare forms are now being described.

SILURIAN: Diacalymene is the most common trilobite of Silurian age in Oklahoma. Dalmanites, Fragiscutum, Proetus, Cheirurus, Ananaspis, Anasobella and a few other extremely rare genera do occur. The main site for Silurian trilobites is now under a ten year lease and collecting is not permitted.

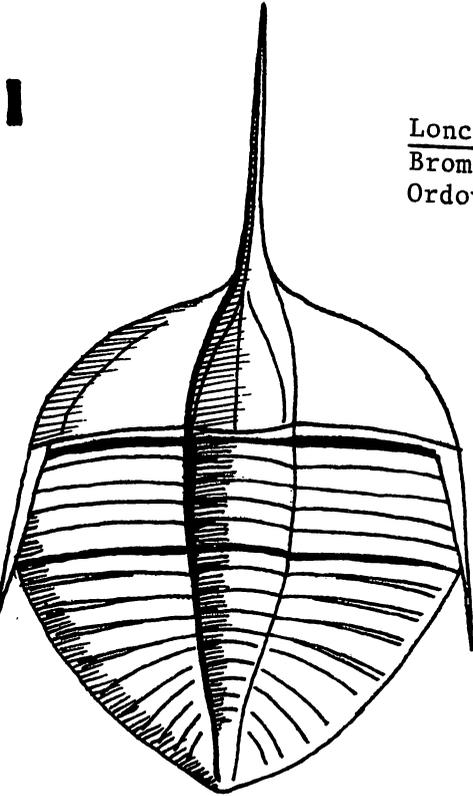
DEVONIAN: The Devonian is especially productive of Paciphacops in Oklahoma. We usually find around 100 of these for every rare trilobite that turns up. Old Hunton Townsite is now under a 30 year lease and collecting is not permitted. However, White Mound, near Dougherty is a fee area and those wanting to collect in the Devonian can collect this locality for a fee of \$1 per person, per day.

Other trilobites found in the Haragan and the Bois d'Arc Formation are Huntonia, Reedops, Otarion, Leonaspis, Ceratourus, Cordania, Breviscutellum and Odontochile. Dicranurus is the most desirable of Oklahoma Devonian trilobites. Only a few complete ones are known, and only one complete spectacular one is known as far as we know. This specimen was shown by us at the 1985 Tucson Gem & Mineral Show, and later sold to a collector in Japan. To our knowledge this specimen brought the highest price ever paid for a single trilobite. Incidentally Reedops is restricted to the Haragan Formation and does not occur in the overlying Bois d'Arc Formation.

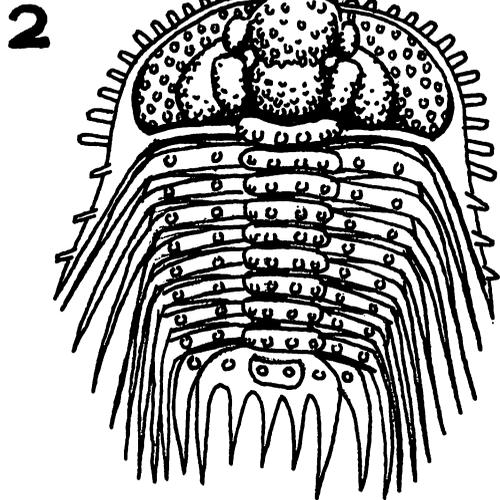
MISSISSIPPIAN: We have never found a complete trilobite of this age in Oklahoma. Parts are relatively common in the Fayetteville Formation of Northeastern Oklahoma. These are probably Paladin.

PENNSYLVANIAN: Ditomopyge, Ameura and Paladin occur in rocks of this age in Oklahoma. Most specimens have been found in the Wewoka Shale. Some localities in rocks of Missourian age produce many poor, enrolled specimens of Ditomopyge in Northeastern Oklahoma. One magnificent Ameura was found in 1952 during an excavation for a crinoid colony near Ada, and is now in the collection at the University of Oklahoma in Norman.

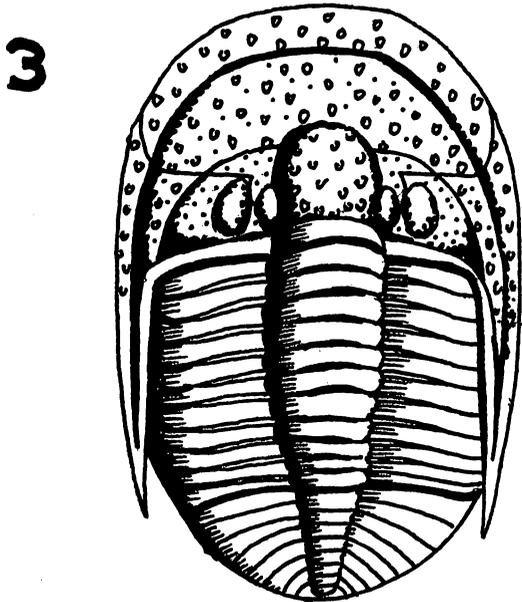
PERMIAN: Ditomopyge of exceptional beauty occur in rocks of this age in North Central Oklahoma. They are rare and not nearly as common as the Ditomopyge that turn up in the Florena Shale of Kansas. I have seen Ameura from the Permian of Kansas, so it would not be a shock to see this genus turn up in the Lower Permian of Oklahoma. Other Permian genera (Delaria and Anisopyge) are found in higher Permian rocks in Texas, but I have never seen these in Oklahoma.



Lonchodomas sp.
Bromide Fm.
Ordovician



Leonaspis williamsi
Haragan Fm.
Devonian

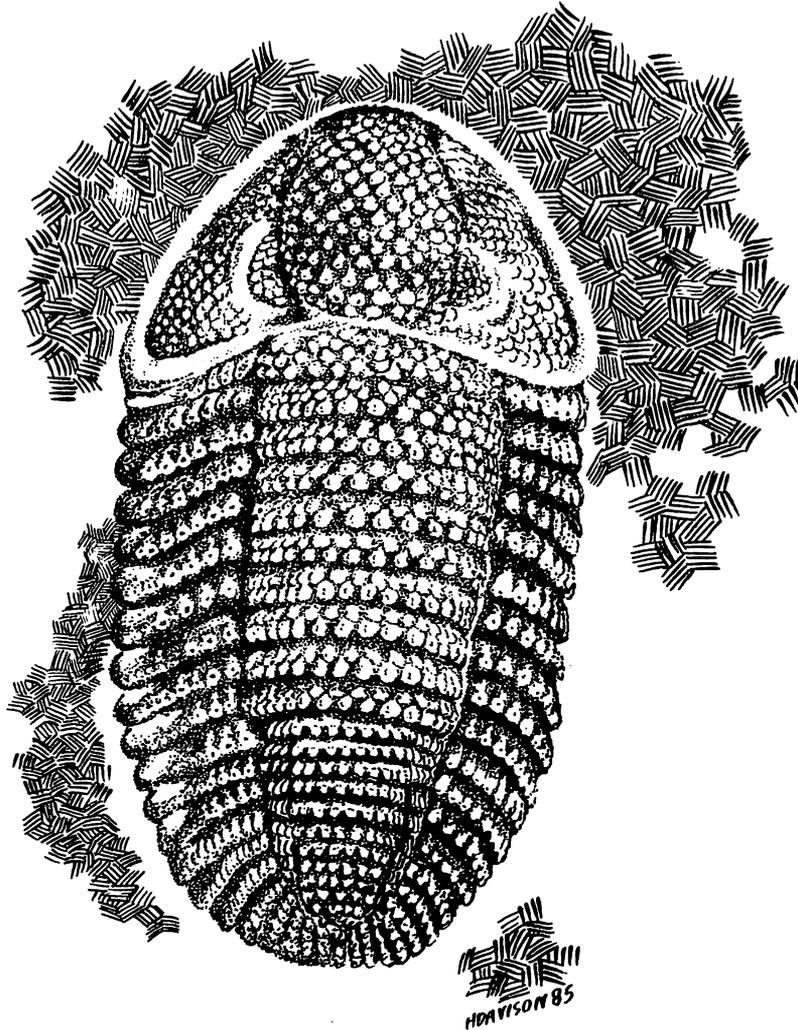


Cordania falcata
Haragan Fm.
Devonian

Thanks to Mark McKinzie, Weatherford
Oklahoma for art work.

SOME TRILOBITES OF THE MISSISSIPPIAN CHOUTEAU CROUP

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By the end of the Devonian Period, many trilobites had died out. Only one order of trilobites (Ptychopariida) survived into the Mississippian Period. The development of nautiloids and shark-like fish with "shell crushing" teeth probably contributed to the general decline of trilobites. As a consequence, trilobite remains are usually not plentiful in Mississippian, Pennsylvania, and Permian rocks. Complete trilobites from these time periods are quite rare.

I have searched long and hard for trilobites in the Mississippian strata of the mid-continent. My greatest success has been the trilobites from the Chouteau Group of central Missouri. Much of the Chouteau is unfossiliferous, but a few sites yield a fairly rich fauna of brachiopods, corals, crinoids, blastoids, cephalopods, and some trilobites. These ancient remains are found in a thin-bedded, fine-grained, gray or brown limestone which exhibits a sub-conchoidal fracture.

Even though pieces of molted trilobite exoskeletons may be fairly plentiful at a particularly choice site, well preserved complete trilobite specimens are still quite rare. Most of the specimens have experienced some deformation either before or during the lithification process. Top quality, inflated, outstretched specimens are extremely rare.

To date, I have found three different types of trilobites in the Chouteau limestones. Like most Mississippian trilobites, they are ~~fairly~~ ^{very} small. Breviphillipsia sampsoni (Vogdes) seems to be the most prevalent species. It is a beautiful trilobite being very highly ornamented with granules that are coarsest on the glabella. Of the specimens that I have found, the average size seems to be approximately 15mm. When cleaning this trilobite, one must be very careful not to destroy the nice granular ornamentation.

Phillipsia swallowi (Shumard) is very similar in general outline to the preceding species. However, the carapace of Phillipsia swallowi (Shumard) has a very smooth surface in marked contrast to the granular appearance of Breviphillipsia sampsoni (Vogdes). Although I have found one complete specimen which measures only 4mm in length, Phillipsia swallowi (Shumard), on the average, seem to be a little larger than Breviphillipsia. Judging from the very few complete specimens I have found, the average size seems to be approximately 18-19mm. Smaller, immature specimens exhibit genal spines while larger, mature specimens to not.

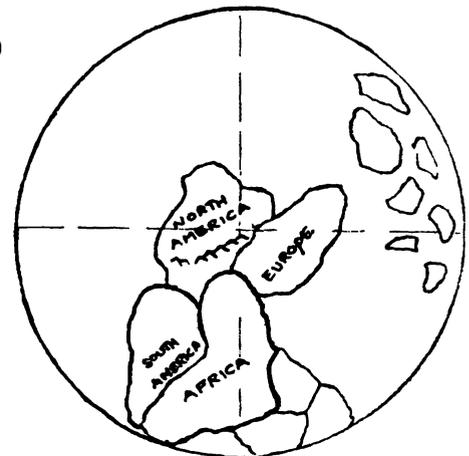
Brachymetopus armatus (Vogdes), although extremely rare, is also present in the Chouteau. To date, I have not found a complete specimen. This trilobite is characterized by having a very short glabella, short genal spines, and two long spines extending downward off the pygidium. Perhaps, some day, I will be fortunate enough to find a complete specimen.

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PENNSYLVANIAN PERIOD TRILOBITES OF NORTH AMERICA

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Pennsylvanian period trilobites are widespread across North America, but are very rare. One may find hundreds of fossils before even a fragment is collected. The late Dr. Charles Rowett, of Texas Christian University, once mentioned a paleoecology analysis he did on the Pennsylvanian Graham Formation, in Texas. Only one trilobite pygidium was found after 1,800 other fossils had been collected. It is exceptional to find two or more complete Pennsylvanian trilobites clustered on a slab.



Trilobites began a steady decline after their peak in the Ordovician period. The Pennsylvanian period with its humid swampy conditions was quite favorable to many animals, but not trilobites. In the marine strata of North America, five Pennsylvanian trilobite genera are known with certainty. This is numerically less than in the following Permian period when they became extinct. Most of the North American Pennsylvanian trilobites were indigenous to this continent alone. Throughout the Mississippian and Pennsylvanian periods, the number of trilobites common to Europe and North America steadily decreased. This well may have been caused by the emergence of land areas in the Appalachian region, which formed a barrier to migration.

Typically, Pennsylvanian trilobites are small, ranging between one half inch to one inch. Ditomopyge lansingensis is pinhead sized, while Ameura major gets as large as four inches long. Colors range from white to dark green to brown and black. Most specimens are found enrolled

There may have been two evolving lines of ancestry, besides that of Brachymetopus which did not change much. Both ancestral lines are based on meraspid and holaspid growth stages. One line extended from the Mississippian genus Griffithides to the Pennsylvanian genus Ditomopyge. The Mississippian genus Paladin longispinus, in a second ancestral line, appears to have been the ancestor of Sevillia and Ameura.

Ditomopyge is the most common genus collected. It is usually $\frac{1}{2}$ " long, but I have found a specimen $1\frac{1}{4}$ " long in San Saba County, Texas. The larger size there has been attributed to colder conditions on an outer shelf environment. The genus has a broad glabella, a broad pygidium, with a pygidial axis that stands well above the plane of the pygidium. Most Ditomopyge specimens have come from Kansas, Iowa, Missouri, Texas, Oklahoma, Indiana, Alabama, Illinois, New Mexico, California, Utah, and Nevada.



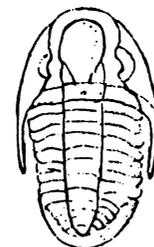
Ditomopyge

Ameura, with a broad bordered, sub-triangular tail is distinctive. This is the largest Pennsylvanian trilobite. The first of its species was described by Shumard in 1855, from a specimen found along the Santa Fe Trail near Topeka, Kansas. This trilobite appeared first in Utah, and appears to have migrated to the mid-continent region later. Good collecting sites for this trilobite are at quarries near Truman Stadium, in Kansas City, Missouri and at Ottawa, Kansas. Other states where Ameura has been collected are Iowa, Texas, Nebraska, Wyoming, and New Mexico.



Ameura

Paladin, named after a knight-errant in Charlemagne's time, is more restricted in distribution in North America, than Ditomopyge and Ameura. Paladin is between $\frac{1}{2}$ " and 1" in length. The area around Lake Bridgeport in Wise County, Texas, and Fayetteville, Arkansas have provided a good number of specimens over many years. Paladin occurs in Michigan and Utah, also. The trilobite is characterized by long genal spines and a narrow glabella. A somewhat confused picture exists about its various species.



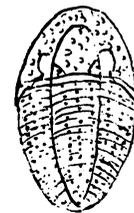
Paladin

Sevillia has a rather pointed tail. It has apparently been collected only at Seville, Illinois, and near Provo, Utah. The trilobite may have been the ancestor of Ameura.



Sevillia

Brachymetopus was known in the Mississippian and Permian of this continent, but not the Pennsylvanian. This was an enigma which has been resolved, with the announcement last January of its discovery in Alaska. The little tubercule-covered trilobite may be found someday in the mid-continent, also.



Brachymetopus

From free cheek material found in Alaska, a report of Pseudophillipsia has been made. Hopefully, more complete material will be found.

At the twilight of their existence, Pennsylvanian trilobites make a very desirable fossil.

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PERMIAN TRILOBITES

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The beginning of the end- This is the Permian Period. It closed the Paleozoic Era and with it the demise of several life forms; the most notable being the trilobite.

Permian trilobites are known from several localities around the world, including North America, Africa, Russia and Sicily. The specimens from Texas are found in far West Texas (The Glass Mountains and the Guadalupe Mountains) and the North Central Plains (primarily from the Moran Formation).

The Illaenida Order includes the superfamily Proetacea, consisting of Proetinae with subfamilies Proetinae, Cornuproetinae, Cyrtocymbolinae, and Griffithidinae; and ten others from Leiostegiidae to Brachymetopidae. Superfamily Illaenacea has many groups also, but none survived until the close of the Permian. Most Permian specimens had development during Devonian times and evolved until late Pennsylvania--then their descendants died out at the close of the Permian. The Proetidae developed during Ordovician and evolved to become one of the dominant trilobite families of the Permo-Carboniferous Age. During this time, four subfamilies existed; one genus of Phillipinae and one genus of Cummingellinae ranged into the Permian--five genera of the Griffithides and five genera of the Paladin (these are known only from the Permian).

Anisopyge belongs to the Paladin group of the Griffithidinae and includes more species than any other Permian genus. The Anisopyge had a long range from early Leonardian to late Guadalupian and is the last genus of the Proetidae in North America. The trilobite is known from Wyoming, Arizona, Texas and Guatemala. Anisopyge represents the last major trilobite genus on earth.

Chamberlain has extended the range of Ditomopyge roemeri (1970) to Guadalupian (Permian) in North America and extends the geographic and stratigraphic range of D. roemeri from the Upper Carboniferous of the Urals.

In order to better understand the demise of the trilobites in Permian times, we must consider other groups that disappeared also; the causes of extinction pose many multifaceted problems. One must examine the ecology of the organism prior to its disappearance. Drawing upon the fossil record to decipher the events that took place regionally and incorporating pertinent information into an overall theory that is based on fact. Obvious data, as well as minor finds, can help to show that it was a combination of many things that caused the extinction of not only trilobites, but other life forms. Associated fauna, climatic changes, expansion of predator domain, demise of main food source (for whatever reason) and temperature fluctuation are areas to consider when dealing with the extinction of any life form. A single catastrophic event may destroy a given area and its ecology; perhaps even have a long range effect on an even larger area, but it is not likely to cause worldwide extinctions by itself. The events that lead to the close of the Permian are well documented and many Geologist and Paleontologist use those events to put forth various theories on extinction.

The Permian saw great changes as the borderlands continued to rise, geosynclines were uplifted into mountain ranges (The American Appalachian Mountains and the Urals in the Eurasia continent). The Epicontinental seas had vanished from all the continents by the end of the Permian.

Life on Earth became abundant on the continents and some forms became very specialized; but by the close of the Permian, several plant forms became extinct (many swamp-dwelling plants). The life forms in the seas also saw the demise of fusulinids, spiny brachiopods, as well as the trilobite. Large percents of the bryozoan, crinoids, blastoids and echinoids, also died out at the close of the Permian.

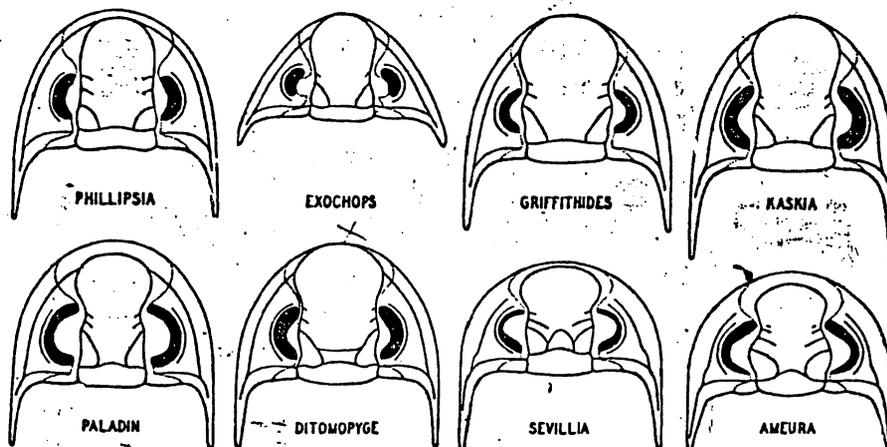


FIG. 1—Cephalic structure of American Carboniferous trilobite genera.

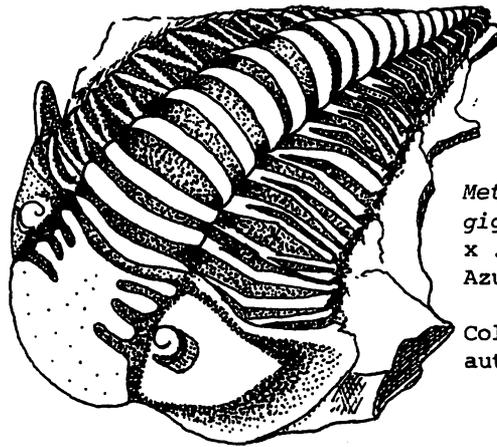
Figure 1. J. M. Weller, December, 1936. Even though some of these genera did not live until the end of the Permian Period, many have representatives that did.

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NOTES ON BOLIVIA'S
EARLY DEVONIAN TRILOBITE
FAUNA

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Metacyphaeus giganteus (Ulrich)
x .9 Pilon de
Azucar, Bolivia

Collection of the
author.

The first curious hand to pluck a trilobite from the soil of a Bolivian hillside surely reached down long before the first European visited South America. The eyes gazing at the small caricature of an animal were probably full of questions--What is it? Where did it come from? How long has it been hiding in this place?--questions not unlike those we are still working to answer hundreds of years later.

Alcide d'Orbigny was the first European to grapple with these basic questions. In his travels to "l'Amerique meridionale" from 1826 to 1833, he visited a number of areas in central and southern Bolivia, collecting natural history specimens. From his explorations came the first scientific description of a Devonian trilobite from Bolivia, "*Calymene verneuili*," in 1842, known to day as *Acastoides verneuili* (d'Orbigny). In recognition of his work a small village on the Rio Pilcomayo in southern Bolivia, near the Argentine frontier, bears the name of this early French naturalist. Many investigators have followed in his footsteps, most notably Ulrich (1892), Koslowski (1923), Swartz (1925), Wolfart (1968), Branisa and Vanek (1973), and Eldredge (1979, 1980). The bibliography at the end of this article will add legions to this esteemed few.

Today when our hand reaches down to pluck a trilobite from a Bolivian hillside we are armed with knowledge gained through the use of the tools of geophysics, the modern concepts of evolutionary biology, paleomagnetic dating, plate tectonics, and much more. Our questions today echo those of the past, but with a certain sophistication. Is it endemic or cosmopolitan? Acastid or calmoniid? It's hard to tell. Is the difference sexual dimorphism? No matter of whom or when the questions have been asked, the motivation remains unchanged--curiosity.

To get a better view of the unusual character of the early Devonian trilobite faunas of Bolivia, it is necessary to review a little biogeography of the area. Rudolph and Emma Richter (1942) were the first to see the interrelationships of many southern hemisphere locations, and originated the term Malvino-Kaffric Province to describe them: Malvino for the Malvinas (Falkland) Islands, along with Brazil and Bolivia; Kaffric for South Africa. Paleomagnetic dating indicates the Malvino-Kaffric Province formed a rough, semicircular arc around the austral (southern) pole during Devonian time, the entire province falling within the boundaries of the supercontinent we call Gondwanaland.

Gondwanaland was composed of South America, Africa, Antarctica, the Indian subcontinent, and Australia; its name is derived from an ancient tribe of India. It was probably formed late in the Cambrian or in the Ordovician, and survived more or less intact for 200 million years. It was not until the middle Jurassic that the signs of a major breakup first appear.

For a number of years it was thought the Devonian trilobite faunas of the Malvino-Kaffric Province had descended from boreal (northern) stock which had migrated south. The Appalachian fauna of eastern North America looked like a logical source for migrating families to reach northern South America. Colombian and Venezuelan Devonian trilobites do appear to be derived from boreal ancestors, and it was thought that somehow further migration took place to Bolivia and Peru, to Brazil and Argentina, and from these to the Malvinas and South Africa. Wolfart (1968, p. 50) diagrams just such a migration route, and includes Europe as a familial provider. He also considers New Zealand and Antarctica to have been on a migration route to South Africa.

J. M. Clarke (1913) was the first to notice that the parent stock of Brazilian Devonian trilobites could be found locally in upper

Silurian beds. Niles Eldredge and Allan Ormiston (1979) showed with limited exceptions Bolivian Devonian trilobites originated from late Silurian stock, and the late Silurian trilobite faunas of Bolivia contained dalmanitids, acastids, proetids, otarionids, and calymenids. Radiations of these families were certainly adequate to produce the endemic populations developing in the early Devonian, and actually precede the Appalachian trilobite fauna. The Bolivian early Devonian trilobites appear to be about 80% endemic and 20% cosmopolitan (wide ranging to some degree).

Viaphacops may be the only Appalachian trilobite to migrate as far south as Bolivia. It is noticed in Colombia's Floresta formation, but is not found to have migrated farther south than Bolivia. Homalonotid trilobites are common in the late Silurian of Bolivia, but their presence diminishes in early Devonian faunas, not again appearing as a major faunal constituent until into middle Devonian times. Homalonotids are also found in Ghana, West Africa, and Antarctica, suggesting a possible Malvino-Kaffric relationship existed with these areas. The homalonotids are typically shallow water inhabitants and may have no zoogeographic significance.

Eldredge and Ormiston (1979) further suggested the Malvino-Kaffric Province should be classed a realm as defined by Kauffman (1973) and this realm should then be broken into three provinces: Andean, represented by Bolivia and Peru; Brazilian; and the South African-Malvinan. Each of these three provinces show unique patterns of faunal development, while still displaying the strong endemic relationship to the Malvino-Kaffric biotic arena.

Calmonioid trilobites are the special bond of the Malvino-Kaffric Realm. Thirty-four genera and subgenera are noted within its boundaries, while no true calmoniids appear to be found outside it, based on recent taxonomic revisions of the calmoniids, acastids, etc. (Eldredge 1980) In the Andean Province Bolivia has been the focal point of collecting and subsequent study; nowhere in the Malvino-Kaffric Realm is this strata exposed for such a great distance, nor do the exposures show the great build-up of sediments. The Bokkevelt beds of South Africa, the Maecuru of Brazil and the Malvinas, have had little recent work done on them. It is hoped that future work in these areas will enlarge our overview of all calmonioid relationships.

In west central Bolivia the lower and Middle Devonian fossil bearing strata is exposed at many sites for a distance of nearly 700 miles from north to south. Trilobite collections from these strata suggest three divisions can be made from north to south, centering on major collecting areas: Belen in the north; Icla in the central portion; and Gamoneda in the south. By using the lowest Devonian biostratigraphic unit in Bolivia, the *Scaphiocoelia* Zone (*Scaphiocoelia* is a terebratulid brachiopod genera with value as a biostratigraphic indicator), Eldredge and Branisa (1980) have shown there is a closer relationship between the Icla and Gamoneda faunas than between the Icla and Belen. *Scaphiocoelia* appears to be missing in the lower gamoneda strata, however the faunal correlation of this strata to the *Scaphiocoelia* Zone of Icla and Belen seems sound.

The trilobites of the carbonate rich Devonian strata of Colombia and Venezuela suggest a warm water environment of boreal origin, while the carbonate poor faunas of Bolivia suggest cooler water. The division of the two faunas is sharp and distinct, with the exception of the southward migrating *Viaphacops* moderately low in the Devonian section. The trilobite communities of the *Scaphiocoelia* Zone appear to be intertidal; slightly deeper water in the basal Gamoneda formation would account for the lack of *Scaphiocoelia* there (Isaacson, 1977).

The following chart offers a simple framework for a basic understanding of Bolivian trilobite community relationships.

| PERIOD | STRATIGRAPHIC UNIT | COMMUNITY |
|----------------|---|-------------------------------------|
| M. Dev. | Sicasica fm. | Homalonotid |
| Lower Devonian | Belen fm. (northern) Icla fm. (central) Gamoneda fm. (southern) | <i>Metacryphaeus venustus</i> Zone |
| | | <i>Metacryphaeus giganteus</i> Zone |
| | | <i>Scaphiocoelia</i> Zone |
| U. Sil. | Catavi fm. | Homalonotid |

Our interest in Devonian trilobites from South America began about two years ago when a friend of a friend (i.e., trade secrets) mentioned he knew where to dig some fossils on a hillside above the tiny village of Tomina in the Chuquisaca district of Bolivia -- for money! The proposition seemed intriguing, the cost nominal, and so we entered into what has become an ongoing, pulse-pounding adventure. Along with the trilobites have come intrigue, postal strikes, bandits, a corpse, a customs contraband sticker and subsequent questioning, customs agents who have never heard of fossils, plus enough old fashioned snafu to fill a robust short story. Maybe we will tell all someday for the MAPS Digest.

The Tomina location produced some interesting specimens of *Phacops*, stretched, enrolled, Salterian molts, and little else. We suggested a search higher or lower in the strata might produce the calmonioid fauna we really wanted. Higher in the section was an area of fragmented homalonotids. This corresponded with the lowest strata of the middle Devonian, locally called Siltita formation (Sicasica). We pressed for a new location; after all, how many *Phacops* do you wish to amass? You stand there and watch your liquid assets trickling down the central spine of the Western Hemisphere, only to disappear into the sandstones along some interior margin of the Andean geogyncline, and believe me, you want more than *Phacops*!

Our insistence met with one excuse after another. "Oh, Senor, I must go home and make sure my wife harvests the crops she planted." "We cannot go there; too many bandits" or "That was worked out many years ago!" One might get the impression that a deep trench has been dug the full length of Bolivia, that all the trilobites have been excavated except the ones guarded by bandits or under the sacred altar of some iglesia. Finally, after several months of negotiating (begging), a parcel arrived from a new location. These were mostly bits and pieces, a few complete trilobites, but they were the Calmonioids we wanted. There was no doubt, the boys had found a place to dig, Pilon de Azucar, not far from Icla, the village lending its name to the lower Devonian type section for central Bolivia. It is also near the Spanish Colonial city of Sucre, the legal capital of Bolivia, although most government operations are carried out in La Paz.

Enough parcels have now bobbed their way north, against the current of cash flowing

south (a paleo-economic phenomenon) that we can pinpoint the biostratigraphic location of our dig with some assurance. We are at the top of the *Scaphiocoelia* Zone and in the base of the *Metacryphaeus giganteus* Zone, or near the upper (superior) section of the lower (lutita) Icla formation. The limited brachiopod and trilobite fauna from this location (?) mentioned by Ahlfeld and Branisa (1960) seems to be much higher in the section than our dig.

To date we have identified the following trilobites, some from fragments, but most from reasonably complete specimens. Some of the most unusual have been donated to the research collection of the American Museum of Natural History in New York.

Phacopina sp.

This *Phacopina* appears to be an intermediate form of *P. convexa* Eldredge, Branisa 1980, and *P. padilla* (*ibid.*) (p.c. 1985 Eldredge) Specimens, AMNH collection

Vogesina lacunifera Wolfart 1968

A rare constituent of the fauna at our location, should occur plentifully higher in the section.

?*Acastoides* sp.

This ?*Acastoides* shows an affinity to ?*A. gamonedensis* Eldredge, Branisa 1980 (p.c. 1985 Eldredge) Single specimen, AMNH collection

?*Acastoides verneuili* (d'Orbigny 1842)

A highly variable species at our location. The typical form is common, there is also a less common robust form that may prove to be a new species.

Schizostylus brevicaudatus (Kosłowski 1923)

An uncommon species at our location.

Metacryphaeus giganteus (Ulrich 1892)

Specimens of this species are usually not as well preserved as the other specimens from our location. Partial specimens up to 125mm have been recovered, though most are under 60mm.

Kosłowskiaspis superna Branisa & Vanek 1973

A few specimens of this interesting calmonioid have been found, some nearly complete. Identification confirmed Eldredge, p.c. 1985. Specimens, AMNH collection

Malvinella haugi (Kosłowski 1923)

3 partial specimens have been noted. We are not sure these were dug at our present site; they may have been picked from the surface higher in the section.

Phacops (Viaphacops) orurensis Bonarelli 1921

Kosłowski redescribed the Bolivian *Phacops* as *P. salteri*. However, he lumped at least 2 species under this name. I feel this voids

further consideration of his name until a proper study can be undertaken. It has been suggested that several species might be described from this group (Eldredge p.c. 1985). Many of our specimens come from the Padilla area (Siltita fm).

Otarion dereimsi (Koslowski 1923)

A few reasonably complete specimens have been recovered, and a few fragmentary remains.

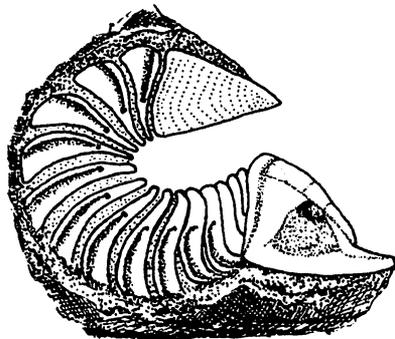
Burmeisteria sp.

A few partial specimens fall loosely toward the description of *Homalonotus clarkei* Koslowski 1923.

There are four species with a close affinity to the *Schaphiocoelia* Zone, though none at present suggest anything more. The balance of the species indicate correlation to the *Metacryphaeus giganteus* Zone (Wolfart 1968). *Phacopina* sp. and *Acastoides* sp. may be transitional forms and it is with this in mind that we have placed the horizon of our dig just above the *Schaphio-coelia* Zone.

Burmeisteria sp. xl.5 Pilon de Azucar,
Bolivia

Collection of the author.



The figure above pictures an unusual form found in a small percentage of Bolivian Devonian trilobites. It is not limited to one location, examples having been found from north to south and from at least two horizons. It has been found in more than one species, including *Phacops orurensis*, *Burmeisteria* sp., *Metacryphaeus giganteus*, and *Acastoides verneuili*. Niles Eldredge of the American Museum of Natural History (p.c., 1985) has noticed the phenomenon in the Bolivian collections he has studied, and has also seen similar specimens from upstate New York.

If we could peer into the cool intertidal shallows of the Devonian sea now frozen in rock, we might see the bodies of dead trilobites being pulled gently to and fro by the currents. Their muscular systems relaxed, they are rolled and turned at the whim of the sea. The soft silt adheres ever increasingly to the bodies until they start to resemble mud balls. If the remains of the animal are rolled sideways, the fossil we find will be outstretched. If the animal retained his natural tendency to enroll at his demise, we will find him so enrolled. If the limp remains were started rolling sideways, then shifted end over end, we might find our fossil has been rolled backwards. And indeed, all our trilobites are found in concretions formed from the mud of the shallow sea.

This scenario was suggested by Dr. Eldredge; only the embellishment is mine.

How do you describe this phenomenon? Do you say rolled backwards? tail-over-tea-kettle? contrary to popular enrollment? I would like to propose the term *contraflexure* until something better comes along. *Contra*, opposite, on the other side; *flexura*, from the Latin, a bending. Enrollment as defined in the *Treatise*, Part O, Arthropoda, 1959, does not cover this unusual form. Reflexure might be suggested, but taken in its literal meaning, only describes a return from flexure. Counter enrollment is cumbersome and sounds like a rowdy who, getting miffed with his local tavern owner, rolls up the bar and takes its home.

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FAUNAL LIST

The following list of trilobites covers the named species of the lower Devonian of Bolivia. Included are some related species from the upper Silurian and some species restricted to the middle Devonian. There are a

number of genera and species yet to be described, and as they are we will bring them to the attention of the MAPS membership.

Calmoniidae

- Andinacaste chojnocotensis* (Swartz 1925)
Northern, U-Silurian
- Andinacaste legrandi* Eldredge & Branisa
1980 Northern, U-Silurian
- Phacopina convexa* Eldredge & Branisa 1980
Southern & Central, L-Devonian
- Phacopina* cf. *convexa* Eldredge & Branisa
1980 Northern, L-Devonian
- Phacopina padilla* Eldredge & Branisa 1980
Central, L-Devonian
- Vogesina aspera* Wolfart 1968
Northern, L-Devonian
- Vogesina devonica* (Ulrich 1892)
Central, L-Devonian
- Vogesina lacunifera* Wolfart 1968
Northern & Central, L-Devonian
- ?*Acastoides acutilobata* (Knod 1908)
Northern, L-Devonian
- ?*Acastoides gamonedensis* Eldredge & Branisa
Southern, L-Devonian
- ?*Acastoides cerneuili* (d'Orbigny 1842)
Northern & Central, L-Devonian
- Deltacephalaspis (Deltacephalaspis) comis*
Eldredge & Branisa 1980, So., L-Devonian
- Deltacephalaspis magister* Eldredge &
Branisa 1980 Northern, L-Devonian
- Deltacephalaspis (D.) retrospina* Eldredge
& Branisa 1980 Southern, L-Devonian
- Deltacephalaspis (Prestalia) tumida*
Eldredge & Branisa 1980, Central, L-Dev
- Bainella (Belenops) insolita* (Wolfart 1968)
Northern, Central, & Southern, L-Devonian
- Schizostylus (Curuyella) granulata* Eldredge
& Branisa 1980 Southern, L-Devonian
- Schizostylus brevicaudatus* (Koslowski 1923)
Northern & Central, L-Devonian
- Metacryphaeus boulei* (Koslowski 1923)
Northern, L-Devonian
- Metacryphaeus boulei pujravii* Wolfart 1968
Northern, L-Devonian
- Metacryphaeus convexus* (Ulrich 1892)
Central, L-Devonian
- Metacryphaeus cornutus* Wolfart 1968
Northern, L-Devonian
- Metacryphaeus curvicolata* (Wolfart 1968)
Northern, L-Devonian
- Metacryphaeus dereimsi* (Groth 1912)
Central, L-Devonian
- Metacryphaeus giganteus* (Ulrich 1892)
Northern & Central, L-Devonian
- Metacryphaeus praecursor* Wolfart 1968
Northern, L-Devonian

- Metacryphaeus tuberculatus* (Koslowski 1923)
Northern, M-Devonian
- Metacryphaeus venustus* Wolfart 1968
Northern & Central, M-Devonian
- Koslowskiaspis (Koslowskiaspis) superna*
Branisa & Vanek 1973 Central, L-Devonian
- Koslowskiaspis (Romanops) australis* Eldredge
& Branisa 1980 Southern, L-Devonian
- Koslowskiaspis (R.) borealis* Eldredge &
Branisa 1980 Northern, L-Devonian
- Malvinella haugi* (Koslowski 1923) Northern
& Central, L-Devonian
- Bouleia dagincourti* (Ulrich 1892)
Central, L-Devonian
- Bouleia sphaericeps* (Koslowski 1923)
Central, L-Devonian
- Parabouleia calmonensis* Eldredge 1972
Northern, L-Devonian
- Probolops glabellirostris* (Koslowski 1923)
Central, L-Devonian
- Cryphaeoides rostratus* (Koslowski 1923)
Northern, M-Devonian
- Tarijactinoides jarcasensis* Suarez Soruco
1971 Southern, L-Devonian
- Tarijactinoides tikanensis* Eldredge &
Branisa 1980 Northern, L-Devonian
- Chiarumanipyge profligata* Branisa & Vanek
1973 Northern, L-Devonian

Phacopidae

- Phacops (Viaphacops) orurensis* Bonarelli
1921 Northern, Central & Southern,
M-Devonian & L-Devonian

Dalmanitidae

- Francovichia boehmi boliviensis* (Koslowski
1923) Central, L-Devonian
- Francovichia branisi* (Wolfart 1968)
Northern & Central, L-Devonian
- Francovichia maecurua* (Knod 1908)
Northern, L-Devonian
- Fenestraspis amauta* Branisa & Vanek 1973
Northern, L-Devonian
- Chacomurus confragosus* Branisa & Vanek 1973
Northern, L-Devonian
- "*Dalmanites*" *andii* (Koslowski 1923)
Northern, U-Silurian
- Gamonedaspis scutata* Branisa & Vanek 1973
Southern, L-Devonian
- ?*Dalmanites patacamayensis* Koslowski 1923
Northern, M-Devonian

Proetidae

- Bolivoproetus branisai* Eldredge & Ormiston
1979 Northern, L-Devonian
- ?*Proetus problematicus* Swartz 1925
Central, L-Devonian

Brachymetopidae

"Australosutura" n. sp Eldredge & Ormiston
1979 Northern, L-Devonian

Otarionidae

Otarion (Maurotarion) dereimsi (Kosłowski
1923) Northern, Central & Southern, L-Dev.

Odontopleuridae

Leonaspis aracana (Steinmann 1912)
Northern, U-Silurian
Leonaspis berryi (Swartz 1925)
Northern, U-Silurian
Leonaspis chacaltayana (Kosłowski 1923)
Northern, U-Silurian

Lichadae

Acanthopyge balliviana (Kosłowski 1923)
Northern, L-Devonian

Calymenidae

"*Calymene*" n. sp. Kosłowski 1923
Central, L-Devonian

Homalonotidae

Burmeisteria clarkei (Kosłowski 1923)
Central, L-Devonian
Digonus cf. noticus (Clarke 1913)
Northern, U-Silurian
Homalonotus? linars Salter 1861
Northern, U-Silurian
Trimerus (Dipleura) dekayi boliviensis
(Wolfart 1968) Northern, M-Devonian

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FOR LANCE MORGAN, TAKEN FOSSIL HUNTING AT AGE 9 MONTHS

The House Range of Utah has little rain,
the bunch grass and pinons grow thin.
Elsewhere one acre can feed a fat cow;
Here a thin one needs nine or ten.

The weather's haphazard, it might frost in
June;
there are sunny warm days in November.
It's as likely to snow on the morn of May 5th,
as it is on the 5th of December.

Then why should two parents who claim to be
fond
of their son bring him here, take a chance
of freezing, or broiling, or just getting
lost!
Why do they upset little Lance?

The rocks show the reasons this place is well
known;
in valley, on hillsides are signs,
this desert was one of earth's prolific places
in Middle and Late Cambrian times.

The Utah we know wasn't Utah back then
but an ocean of shallows and reefs.
Mud washing down from the craton above
formed Wheeler and Marjum and Weeks.

Eocrinoids stayed put, but waded in each
swell,
worms burrowed deep out of sight,
inarticulate brachs kept very still
before the master of all, trilobites.

In every deep bay and broad shallow cove
they swarmed in races unnumbered.
Some had great eyes and some were without
and some with long spines were encumbered.

Their legs were more numerous than we might
suspect;
their bodies were curly and flexible.
Their bones were replaceable and on the outside
which is why we find them so collectible.

But the rocks hold more questions than
answers.
How did a trilobite live?
How many children did each mommie have?
What kind of care did she give?

Did they live in a clan, or fend for
themselves?
Was their life all hard struggle or ease?
When we find a great mass, were they smothered
in mud,
or die from some Cambrian disease?

What did they eat? Did they breakfast at dawn?
Was their dinner at noon or at night?
Most threateningly, was some Cambrian beast's
favorite lunch raw trilobite?

Did he prey on their nests and their newly
hatched young?
Did he lurk in the depths for his meat?
Was roast Asaphiscus his favorite meal
with Elrathia tails for a sweet?

With so many questions we're glad to see come
a curious new generation.
Brainwashed so young, maybe Lance will provide
some answers to perplexing questions.

-- Martv Sutherland

TRILOBITES OF MOROCCO

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I would like to address several related subjects and clear up a few misunderstandings regarding the trilobites and other fossils of Morocco. My qualifications include 15 years of studying trilobites, amassing a sizeable collection, and three trips collecting trilobites in the Sahara.

The wonderful thing about collecting fossils in Morocco is the large amount of exposed and undeformed Paleozoic outcrops, very fossiliferous Ordovician and Devonian sections and the almost complete lack of any weathering layer. The arid climate with little or no vegetation means that a little geologic sense will yield enormous areas for collection of trilobites and other fossils; in fact, more than anyone could collect in a lifetime.

Morocco is easy to reach with New York-Casablanca round trips running about \$550 and expenses in Morocco being extremely cheap with the exception of cars or land-rovers. If you don't buy a lot of "stuff" and if you share a car with one or two people, the trip should cost less than \$1,000 for a week or two including air fair, transportation, food and lodging. A thrifty "student" willing to go a little "native" could do well and roam the country for under \$10 a day. Remember, the average Moroccan typically earns \$200-300 per month, and can live on that.

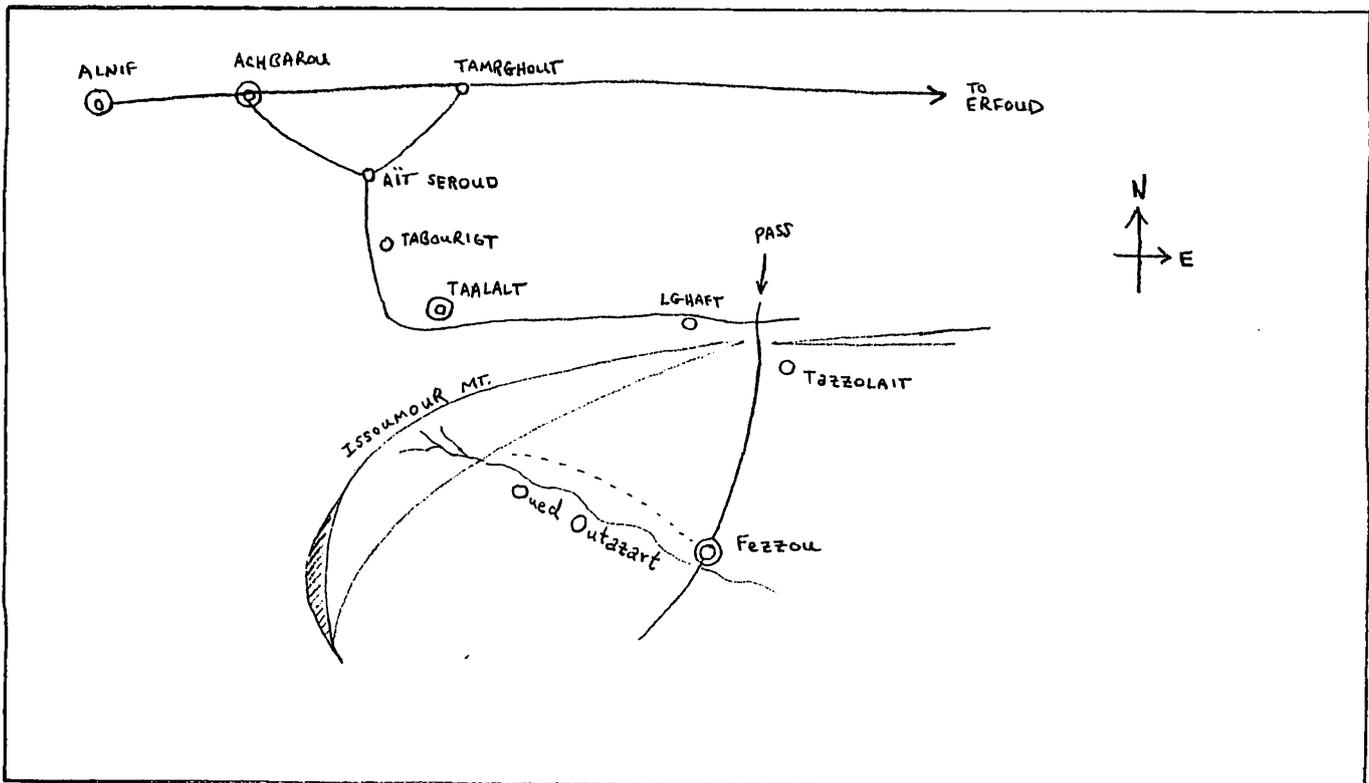


Figure 1 - Region Around Issoumour (Trilobite) Mountain

Fossil Dealers of Erfoud:

It is important to know that travel to Morocco is like traveling back in time and the distance from the coast is directly proportional to the distance in time. The interior of the country is populated with mostly farmers and merchants. These merchants do not specialize as in our country but sell anything and everything for more money than they paid for it. In the marketplace, or souk, with some variation, almost everybody sells the same things for about the same prices. These businessmen, in the region about Erfoud, learned many years ago that the steady stream of European people passing through their town would pay money for rocks. As a result, almost every merchant in the town can and will sell some fossils and some minerals.

Of course, some people will always do things better and have better sources of material. Some of Erfoud's more outstanding (in terms of unusual fossil material) dealers include Brahim Badra (stall #4 in souk), Mohamed Madane (stall #1 in souk), Madani Drissi (hotel boutique) and Sagaoui M'Bark who has his "rock shop" isolated in the desert about ten miles east of town and near no roads. Sagaoui is only a mile or so from the Middle Devonian quarry that produces all the famous table tops and has probably the best selection of the above mentioned dealers. It is very important to realize that even these better fossil dealers are not experts on the fossils themselves. They are only experts at finding out what items people will pay money for and obtaining these items for less money than they can sell them for easily. Even these dealers still sell the usual rugs and other native crafts.

The fossil dealers have usually bought the material from someone who came out of the desert, who probably bought or traded for the material himself. As a result, few of these dealers even know which direction the fossils came from, much less any age or identification. This doesn't stop them, however, from giving you this information anyway, and this has contributed to the vast amount of misinformation about almost all Moroccan fossil material. It is pretty obvious to anyone that a rock with a "story" sells for more than any anonymous rock. The locality of almost all material, even from hundreds of miles away, is given as Erfoud and fifty different species of trilobites are easily recognized as either Kallymeen or Faykops by all of the fossil dealers.

There is a species of trilobite from Morocco, replaced by Limonite, that is usually in bad condition and has been common in the U.S.A. for at least five to eight years. At the M.A.P.S. EXPO convention two years ago, I circulated among the tables and noted the I.D. for this trilobite. I listed six different identifications as follows:

- | | | |
|--|-----------------------|-----------------|
| 1. <u>Calymene ouzregui</u> | Ordovician | Erfoud, Morocco |
| 2. <u>Calymene blumenbachii</u> | Ordovician-Ktaoua Fm. | Erfoud, Morocco |
| 3. <u>Diacalymene ouzregi</u> | Devonian | ? |
| 4. <u>Diacalymene ouzregui</u> | Ordovician | Erfoud |
| 5. <u>Flexicalymene ouzregui destombes</u> | Ordovician | Erfoud |
| 6. <u>Gravicalymene maura</u> | Silurian | Atlas Mts. |

The facts are that the trilobite is definitely Upper Ordovician and probably from a mountain about three miles south of Alnif (about 100 miles from Erfoud). There are many other Ordovician outcrops, however, in all directions from Erfoud, but I don't think any are closer than fifty miles. A close examination of a good specimen (I collect mine near Alnif) easily eliminates all of the above genera except Diacalymene which is a very good fit. Allen Grafham of Geological Enterprises doesn't have a reference on this trilobite, but goes along with the British Museum identification. For the time being, that's good enough for me.

Diacalymene ouzregui Upper Ordovician Alnif, Morocco

I also have a few other trilobites from this section and a fair number from the Lower Ordovician section south of Taouz. More work needs to be done but I might have a new species of Harpides from this section.

A Devonian Fossil Mountain:

There are a great deal of Middle Devonian rock outcrops very close to Erfoud, most of which are extremely thick (50 to 100 meters) black limestone that contains the very abundant Orthoceras and other cephalopods that the local people make such a good living by cutting and polishing. There are trilobites in this material but they are mostly fragments and very hard to collect. The section above this layer which is mostly absent around Erfoud is much easier to collect from and almost abundant with different species of trilobites.

A large crescent-shaped mountain contains probably all of this trilobite-rich section just south of the road from Erfoud to Alnif. The name of this mountain is Issoumour, but I call it Trilobite Mountain. I have hundreds of trilobites from this mountain that still need identification but a partial list of genera present include:

Odontochile
Asteropyge
Bumastus
Crotalocephalus
Reedops
Phacops
Lepidoproetus

This mountain is probably twenty miles from point to point in length and is located across the oued (river) from the village of Taalalt where I stay. Figure 1 is a map of this area showing the village locations.

The Large "Phacops" Trilobite:

On my last trip to Africa in September, 1985, Fred Wessman and I were the first Americans to visit the locality where these new large "Phacops" type trilobites originate. These trilobites have been coming to the U.S.A. for about three years now and probably still need to be identified. We were taken to this locality near the top of Issoumour mountain by M'Hamed Ignoui and Ahmed Amouri who are two diggers and promoters for the family that has been digging these trilobites (up to 7" long) since March, 1984. Large scale surface collecting of these fossils began early in 1982 before the dig became necessary. People will probably remember these new large trilobites arriving in the U.S.A. about 1983 after passing through the hands of several fossil dealers in Erfoud and Casablanca. These

fossils have been pretty badly cleaned, using a rock hammer instead of an air abrasive, and some nice spines on this trilobite are completely destroyed. The locality had been visited by only seven non-natives before Fred and I planted our American feet on the mountain last year.

The locality is best reached by walking up the Oued Outazart on the back or south side of the mountain. It is possible to drive within a few miles of the locality this way, even though it is near the top of the mountain (see Fig. 1). The rich layer with the new large trilobite is about 15" thick and a hard grey to black shale. The layer gets thicker toward the west but has less trilobites in the matrix. Digging is underway on the south side of the valley and overburden is about 6' thick in most digs. Some digging has been done on the north side of the valley but the large trilobite is rare there. An extremely nice specimen of what is probably Lepidoproetus lepidus is fairly common there, however.

Figure 2 shows an illustration of the new large "Phacops" type trilobite. It has to be a new genus separate from Phacops but it has probably not been described. The Europeans have two variations that look to me like the difference between having part of the shell knocked away or not. They are calling these:

- Geesops sparinosus Devonian Alnif, Morocco
- Pedinopariops (Hypsirariops) lohrensis Devonian Alnif, Morocco

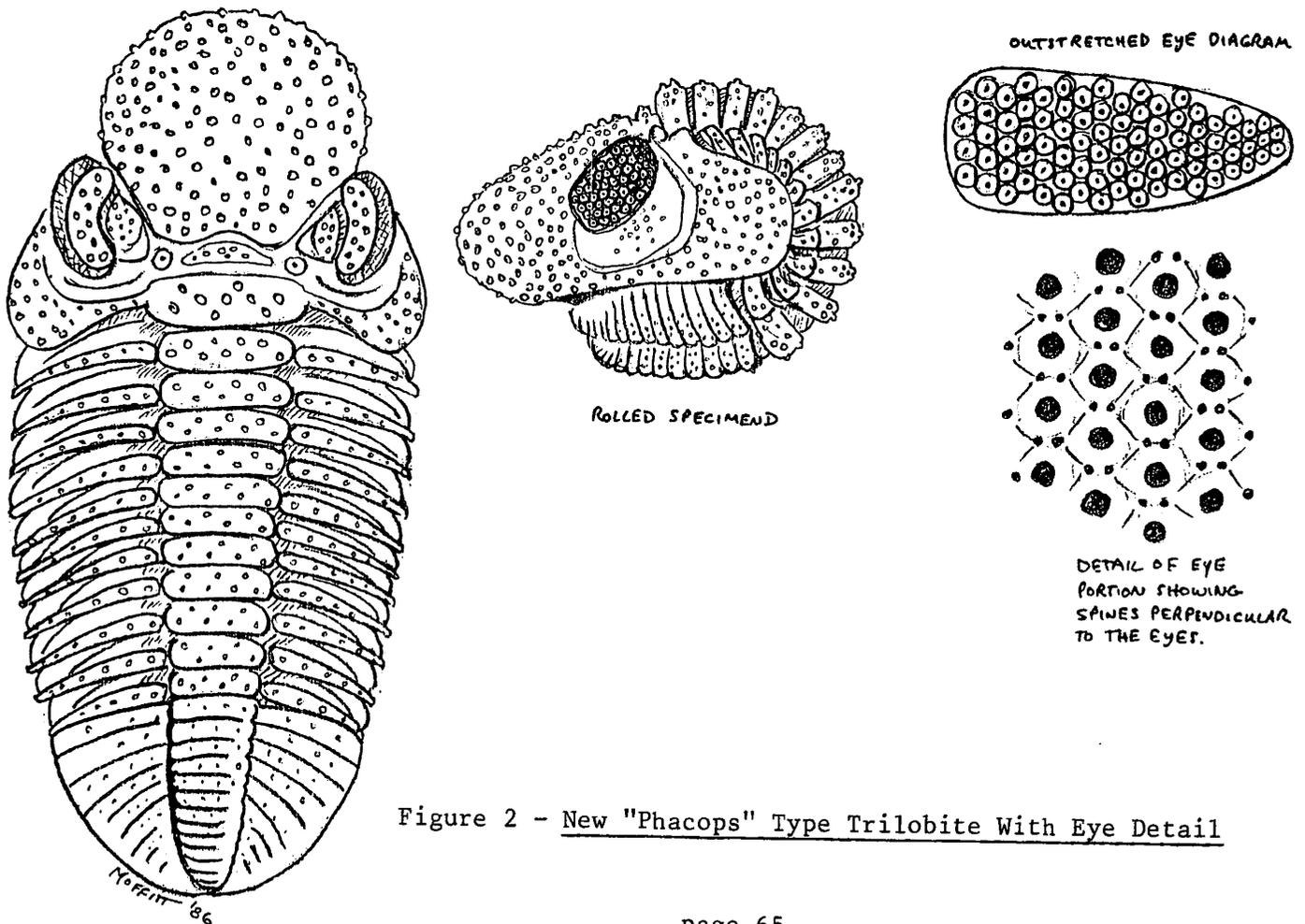


Figure 2 - New "Phacops" Type Trilobite With Eye Detail

unit called an Air Scribe. The idea is to remove most of the matrix by these methods and then use the air abrasive to remove the remaining bits of matrix in the furrows and in other delicate areas. If the fossil is of matrix that would not be destroyed by water then a solution of Quaternary-O can be used to help dissolve or soften some of the matrix.

Fossils in soft matrix are best worked by hand using a needle point scribe. It is easiest to remove matrix soon after the trilobite is collected since the shale will harden after it dries. Any attempt to soften the shale with water after it has dried will usually cause the shale to crumble along with the specimen. Trilobites in soft shale should be wrapped in several layers of newspapers in order to prevent the matrix from drying too fast and result in cracking. Elmer's Glue makes an excellent cement for repairing breaks and a solution of Elmer's and water can be used to harden the matrix. Again the air abrasive is best used as a finishing cleaning technique to remove matrix in difficult or delicate areas.

The air abrasive is also useful in exploring the matrix for other specimens which may be hidden in the matrix. The abrasive stream can cut small grooves to locate other fossils which chisels or picks would otherwise destroy.

There are a choice of powders that can be used in the air abrasive. Sodium bicarbonate is the softest and least damaging to the fossil. Intermediate powders are dolomite, glass beads and garnet. The hardest abrasive is silicon carbide which should never be used to clean fossils. This is followed by aluminum oxide which should be mixed with a softer abrasive to lessen its damaging nature. A mixture of 75% sodium bicarbonate and 25% aluminum oxide is satisfactory. I have seen many fossils seriously damaged by the use of aluminum oxide at high pressures. It will cut small grooves and remove surface detail very easily. The hard abrasives may be used at small pressures of 5 to 15 psi to lessen their effects. It is best to practice on a scrap piece.

The pressurized air may be obtained from bottled carbon dioxide or from an air compressor. If an air compressor is used, you must pay attention to removal of moisture and oil. The success of your air abrasive will be determined by the quality of the compressed air. The abrasive powder will pick up moisture and oil from the air and will result in numerous cloggings. Sodium bicarbonate is the most susceptible to moisture. "Airless compressors" do not use oil in their pistons, but are limited by low pressure and air flow. Moisture can be removed by a dessicant filter. Such a filter can be purchased from the W. A. Hammond Co. (P.O. Box 460, Xenia, Ohio 45385). Oil in the air can also cause damage to plastic housings, (such as the filter previously described) so a granular carbon filter should be employed to remove oil vapor if you are using a compressor that uses oil. Otherwise the plastic housing may explode after it is pressurized.

The mixture of abrasive and air is focused by a tungsten carbide jet orifice at the handpiece. The tips that are available range in size from four thousandths of an inch to 50 thousandths. Generally the tips in the 16 to 22 thousandths range are most useful for fossil work.

The manufacturers are a good source of abrasive powder, although quite expensive. If you decide to re-use powders, then it is necessary to screen them to remove any large particles that will clog or damage the machine. Screens are available from chemical laboratory supply houses. 100 mesh seems to work well. Sodium bicarbonate should be kept very dry as it will absorb moisture from the air quite readily and become one large mass. A mixture of sodium bicarbonate and a harder

PREPARATION OF TRILOBITES

(From the Book TRILOBITES Chapter II)

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Cleaning trilobites takes a skillful hand and sharp eyes. There are various techniques used for each trilobite, but generally speaking, trilobites of most species receive the same process with only a few variations. First, the rough matrix is removed by hammer and awl or sharp chisel. Second, the scribe is used to remove excess matrix from the furrows of the segments. Third, the air-abrasive is the final stage to further clean matrix from the specimen.

The variations are as follows: Hammer and chisel or awl are used on solid types of matrix, placing the specimen in a vise helps tremendously. Softer matrix will not withstand the vibrations, and tend to fracture with hammer and chisel. For the shale and clay, I use small amounts of water, a few drops at a time, placed on the area to be worked on. This saturates the area to be worked on, and softens matrix. With the matrix moist, a hand scribe is used. It's surprising what water can do to a hard piece of shale. At this point, I will recommend not using water to the extent of saturating the trilobite. This will not affect mineralized exoskeleton, but rather its supporting matrix. Let me explain how this happens.

While digging in the field, you expose the matrix to air for the first time. The matrix housing the specimen is stable when exposed, and should be wrapped within a few moments, using newspaper. This prevents the matrix from drying too quickly. Fast drying can cause fractures to develop due to shrinkage, so wrap the specimens as soon as possible. When you unpack specimens from the dig, store them in cardboard flats. This will absorb the moisture as they dry. I try to keep the flats from the direct sunlight--preferably in the basement.

When the specimen dries, (sic) you will notice a difference in matrix color. Usually, the matrix will turn lighter when dried. Now that it's dry, the matrix is lighter in weight and honeycombed. The introduction of water at this point is critical.

Once I was working on a dig in Ohio for about thirty (30) days. Each day I took the specimens home, and placed them in flats on the basement floor so they would dry slowly. At the end of one (1) month, I had fifty (50) flats or so along two (2) walls of the basement. It was early summer, and the work was going well, or so I thought. Cleaning began on the trilobites one evening, and I retired rather late. When I awoke the next morning, it was to the sound of running water. I sprang from my bed only to find I was standing in 6" of water. I walked to the side of the basement where my trilobites were laid out. You might say I was in shock after seeing pile upon pile of wet mud in the boxes. The only trilobites that survived were enrolled, the rest (approximately 200 specimens) were scooped up with a shovel, and disposed of. Don't learn your lesson the way I did. Make sure water never reaches matrix once it's dried.

High humidity will affect dried matrix only over extended periods of time. Try to use a dry atmosphere if possible for storage and use lots of newspaper. This will help to absorb humidity.

Hand Preparation

One can learn this unique process with a lot of practice and patience. A steady hand is a must. Knowing the morphology of the trilobite helps. The TREATISE (Moore, 1959), on Arthropods, is a big help as most genera are covered in great detail. Much like a blueprint, a line drawing of the genus and specie will help you understand the surface structure better so mistakes are minimal.

Practice on broken specimens first, and learn your way around before taking on good specimen.

Always remember to take your time. I look at it like this, A trilobite has been around for hundreds of millions of years, why destroy it with haste.

Always have a bottle of Elmer's Glue handy, just in case you manage to break a piece off. No matter how nice the specimen looks, I always seem to flake off a small piece of the exoskeleton while hand cleaning.

Air-Abrasive Preparation

Learning to use the air-abrasive machine requires hours of patience. One learns by trial and error, not by reading about methods. Most people don't discuss their methods, as they regard them as secrets. The advantages of air abrasives are numerous. By using this method, no vibrations are introduced to the specimen--only an even pressure, which you can control at the turn of a dial. The results are superior cleaning over conventional methods, (picking and brushing).

I can only explain how I use the system, and what to watch out for: To begin with, you must have good vision and a steady hand. The secret is in taking your time. Cleaning a trilobite takes a great deal of time, even to the most experienced.

The air-abrasive is no more than a miniature sand-blaster with a nozzle diameter of .026" to .040" (orifice opening). The small diameter of the orifice allows one to clean excess matrix from the fine microstructure and furrows of the trilobite.

Warning: The air-abrasive will abrade the exoskeleton as well. This is why you must experiment with the unit before working on a good specimen. Take molted pieces you find (pygidiums, cephalons, etc.) and work with these first. Air pressure is important, and so are the types of abrasives you use.

The lower the pressure, (5-25 lbs.) used on a specimen, the better the results. This always takes longer, but like they say, "good things take time". The higher the pressure, the more damage caused to the fine microstructure of the trilobite; this is called "burning".

Warning: The use of air-abrasives can be hazardous to your health. As you clean the matrix from a trilobite, you create a dust which contains silica. Silica dust becomes lodged in your lungs, and causes Silicosis of which there is no cure. Only preventive measures can be taken. Dust collectors remove free dust and abrasives from the work area; thus preventing inhalation of silicia dust to take place. If some of my friends had known this, they would be alive today. While working, if your work area becomes full of dust, leave the area, and let the dust settle before attempting to fix the problem. Sometimes dust collectors will spring a leak, or your cabinet will leak. These problems must be solved immediately, so no physical harm will come to you.

Mixtures of Abrasives

There are many abrasives available for these units, and several are used for trilobites. These include aluminum oxide, dolomite, crushed walnut shells, glass beads, sodium bicarbonate, and silicone carbide.

I mix sodium bicarbonate with all abrasives, as it's the softest of abrasives. When I come across a very delicate trilobite, I'll use a straight sodium bicarbonate. It may take longer, but the results are superior.

Most trilobites require aluminum oxide and sodium bicarbonate mixed 50/50.

Dolomite is mixed in the same proportions as aluminum oxide. The best way for you to learn, is to experiment on scraps, and acquire your own method as everybody's different.

(☺ ☺ ☺ ☺ ☺ ☺ ☺)

THE TRILOBITE EYE - A BRIEF REVIEW

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"Methinks I see thee grazing from the stone with those great eyes and smiling as in scorn of notions and systems which have grown from relics of the time when thou wert born"

"The race of man shall perish, but the eyes of trilobites eternal be in stone, and seem to stare about in mild surprise at changes greater than they have yet known."

--T. A. Conrad

Single structures of fossils have seldom elicited a great deal of study and speculation. In recent years, a notable exception to this has been the trilobite eye. The trilobite itself has always excited much interest among both professional and non-professional paleontologists. In fact, there is little doubt in my mind that the trilobite is the most popular invertebrate fossil. The trilobite eye may be a major reason for this extinct animal's great popularity. The quotes at the start of this paper by the pioneer American paleontologist Timothy Conrad epitomize this human fascination with the trilobite eye. Why are we intrigued by the trilobite eye? I think I know at least some of the reasons. They have an attractive form. They function for vision which is one of man's outstanding senses. They are the oldest known visual organs going back over 600 million years before the present. Finally, they probably have the longest (400 million years) and best known history for a body part.

BACKGROUND

Introduction.--Intense study of the trilobite eye has largely occurred in two phases. One around the turn of the century culminating in the works of Clarke (1889) and Lindstrom (1901). The second phase started about 1966 and

seemingly ended in 1980. The most active worker who may well have stimulated this last phase of study was Clarkson (1966 a-b, 1967 a-b, 1968, 1969 a-b, 1971, 1973 a-b, 1975, 1979) and with Levi-Setti (1975). Other important workers include Towe (1973), Campbell (1975), Cowen with Kelley (1979), Jell (1975), Levi-Setti (1975 and 1976), Stockton with Cowen (1976), and Miller with Clarkson (1980).

Visual structures in trilobites.--Eyes occur in most trilobites, but we currently have no way of knowing whether the eyes were functional or not. We presume that most of them were functional. The only large trilobite group that largely or totally lacked eyes was the suborder Agnostina. These are the trilobites with only two or three thoracic segments and a head (cephalon) and tail (pygidium) that are almost identical in size (see fig. 1).

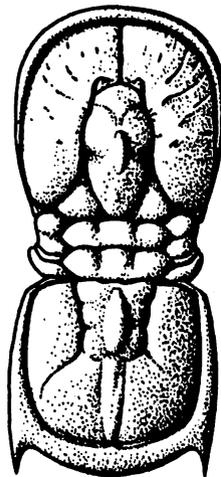


Fig. 1--An agnostid trilobite Machairagnostus tmetus Harrington & Leanza, Lower Ordovician, Argentina x 18.5 (after Moore, 1959)

Structures that are probably not eyes, but may have been light sensitive, have been reported in both eye-bearing and eye-less trilobites. For example, the median node in agnostids is thought to have been light-sensitive. The glabellar tubercle in Nileus and an area of the median tubercle of Cryptolithus are also thought to have been light-sensitive structures.

EYES IN LIVING ANIMALS

Introduction.--What is an eye? Very roughly, it is a structure in animals which, with the help of the nervous system, can make some kind of image of all or part of the immediate environment surrounding the animal possessing it. Eyes intergrade with and probably evolved from structures that can only sense the strength of the light striking an organism. An eye consists basically of three parts. The outermost parts are the lenses and related parts whose function is to direct and focus light inward to the light sensitive structures. The second parts are the photoreceptors, the structures that react to the light coming to them from the lens systems. In our eyes, the photoreceptors are the layer of cells are called the retina. The third and final part of the eye is the nervous system culminating in the brain which picks up and interprets the message of the photoreceptors. There are at least two fundamental types of eyes in modern animals: the camera eye and the compound eye.

The camera eye.--In the camera eye (see fig. 2), the lens projects a continuous image on the retina which is a layer made up of many light-sensitive cells. The retinal cells break up the image into point elements. These elements are conveyed via the nervous system to the brain which reconstructs a continuous image. This is the kind of eye we humans possess. It is also found in other vertebrates, cephalopods, and some arthropods.

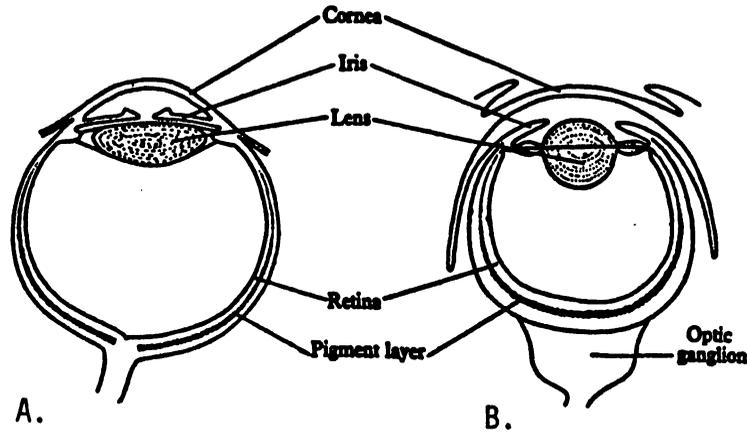


Fig. 2--Cross-sections through camer-type eyes in a A) vertebrate and B) cephalopod (after Ramsay, 1962)

The compound eye.--The compound eye (see fig. 3) consists of closely packed repeated units called ommatidia. Each ommatidium is a hollow cylinder capped by a lens. The photoreceptors are located in the bottom half of the cylinder.

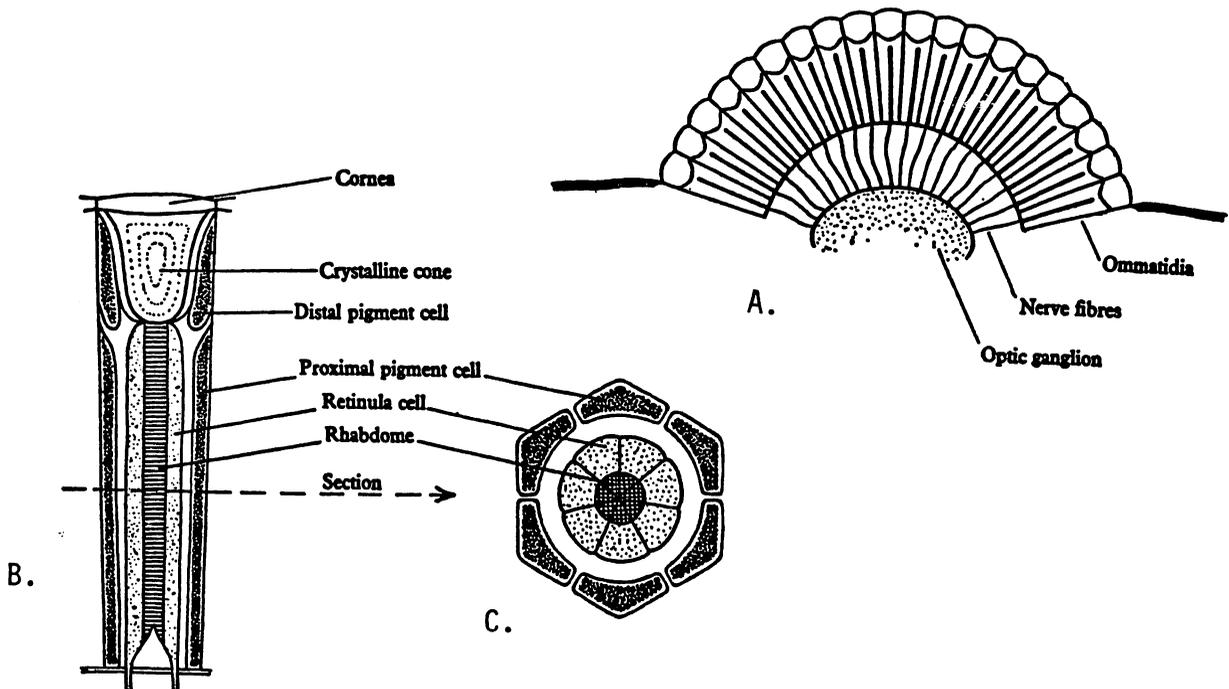


Fig. 3--Illustrations of the compound eye of an arthropod
 A) Section through the compound eye
 B) Ommatidium from the compound eye - longitudinal section
 C) Ommatidium from the compound eye - transverse section
 (after Ramsay, 1962)

The following is the most popular theory as to how this eye functions. The multiple lenses of the many ommatidia break up the image or light of the image into light spots of different intensity. Thus, the lenses rather than the retinal cells break up the image. It has not been determined whether each ommatidium could create a mini-image or not. The photoreceptors with their associated nervous system are thought to build an over-all image from the light spots in the same way that a half-tone photograph is built up by an array of dots (see fig. 4).

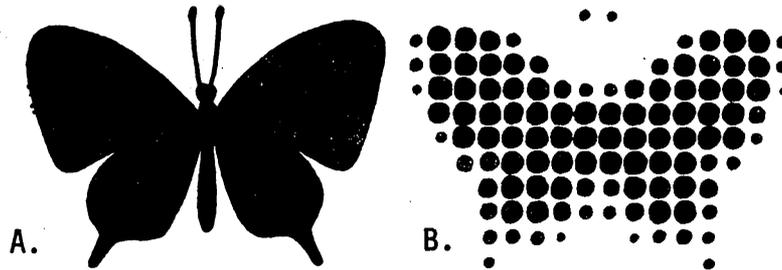


Fig. 4--Most popular idea as to how an image is formed by the compound eye.
 A) Outline of a butterfly and B) How it might be registered by the eye of a dragonfly at a distance of 10 inches. (after Ramsay, 1962)

The coarseness of this mosaic of dots depends on the number and size of the lenses and the angular separation of the ommatidia. This type of eye is largely limited to arthropods. A comparable eye occurs in some polychaete worms and possibly the peculiar Silurian Chordate Anikitizoon. Much more remains to be learned about the compound eye. Even some basic assumptions aren't proved without doubt.

GENERALITIES CONCERNING THE TRILOBITE EYE

The lens.--The only part of the trilobite eye that we have found with certainty is the lens. The presumed absence of the photoreceptors and nervous system is probably a result of the difficulty of fossilizing such delicate "soft" structures. Our knowledge of them, to date, has had to be inferred from the lenses.

The trilobite lens seems to be unique among animals in being composed of calcite instead of clear organic material. Calcite has at least one potential disadvantage as a lens material. It has a very high birefringence. Birefringence is the phenomenon whereby light passing through a transparent material is split into two beams. Those minerals or materials with greater birefringence split the rays further apart. You may be familiar with the well-known demonstration of a rhomb of very clear calcite ("Iceland spar") splitting a single image into two separate images. This strikingly illustrates the high birefringence of calcite. Birefringence occurs in most inorganic minerals and materials except glass and the isometric minerals such as diamond, halite, and fluorite. These substances do not split light passing through them. This high birefringence in calcite could be a serious problem in making a good single image in vision. Fortunately, calcite doesn't exhibit birefringence for light passing parallel to the c-axis. The evolution of the trilobite eye lens has been in keeping with these optical relationships. Each lens behaves optically

like a single crystal of calcite and is oriented in such a way that its c-axis is perpendicular to the eye surface. Thus the incoming light will exhibit little birefringence to spoil the image. There is strong suspicion that each lens may not actually be a single crystal, but is a composite of many smaller crystals. Within each lens, there appear to be trabeculae that curve outward in such a way that they come to be almost perpendicular to the curved outer surface of the lens (see fig. 17). These trabeculae may have served to guide light through the lens with little or no birefringence even when that light isn't going parallel to the overall c-axis of the lens.

Types of eyes.--All of the paired eyes in trilobites seem to consist of two or more units with lenses. Two major types of trilobite eyes have been recognized since the basic work of Clarke (1889) and Lindstrom (1901). They are the holochroal eye (figs. 5-10) and the schizochroal eye (figs. 6, 8, 11-20). Recently, Jell (1975) recognized a third type of trilobite eye with multiple lenses he called the abathochroal eye (figs. 21-22).

THE HOLOCHROAL EYE

Introduction.--The holochroal or compound eye proper (figs. 5-10) is the most common trilobite eye, by far, and occurs in almost all the major trilobite orders. The earliest ones are found in Early Cambrian trilobites--the latest ones in Permian trilobites. They, thus occur throughout the entire range of trilobites. The lens-bearing surface is rarely seen in adult eyes of Early Cambrian trilobites because adults had a suture below the visual surface of the eye. Because of this, the visual surface was lost in molting. By the Ordovician, most trilobites except the Calymenina (Flexicalymene and its kin) lost this suture and thus retained the visual surface in fossils.

The holochroal eye is believed to be essentially similar to the eyes of living invertebrates with compound eyes.

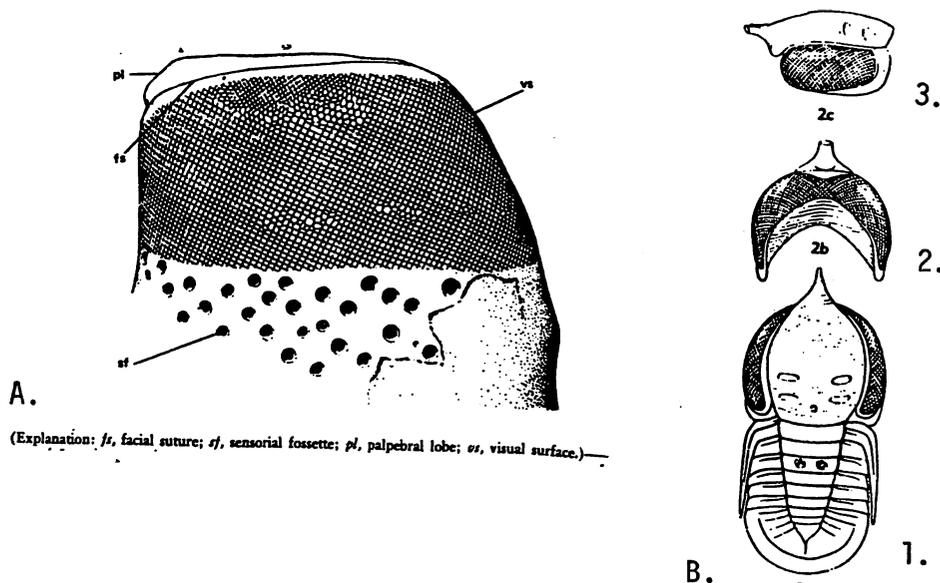


Fig. 5--A) Holochroal eye of Asaphus cornutus Pander, Ordovician, Russia.
 B) Confluent eyes of Symphysops subarmatus (Reed), upper Ordovician, Great Britain in 1) dorsal view of carapace, 2) ventral view of cephalon, and 3) lateral view of cephalon (after Moore, 1959).

Morphology.--The holochroal eye consists of numerous closely packed lens units (figs. 5-6). The number of lenses in known eyes ranges from 100 to 20,000 per eye. The individual lenses are small ranging in size from 30 μm to 200 μm in diameter. They are still, however, larger than most lenses in modern invertebrate eyes which range from 8 to 45 μm in diameter. The lenses in holochroal eyes range in form from thin biconvex structures to elongated hexagonal prisms (fig. 7). Their size and shape may depend directly on the thickness of the cuticle. A common corneal membrane covers all the lenses (see fig. 8a).

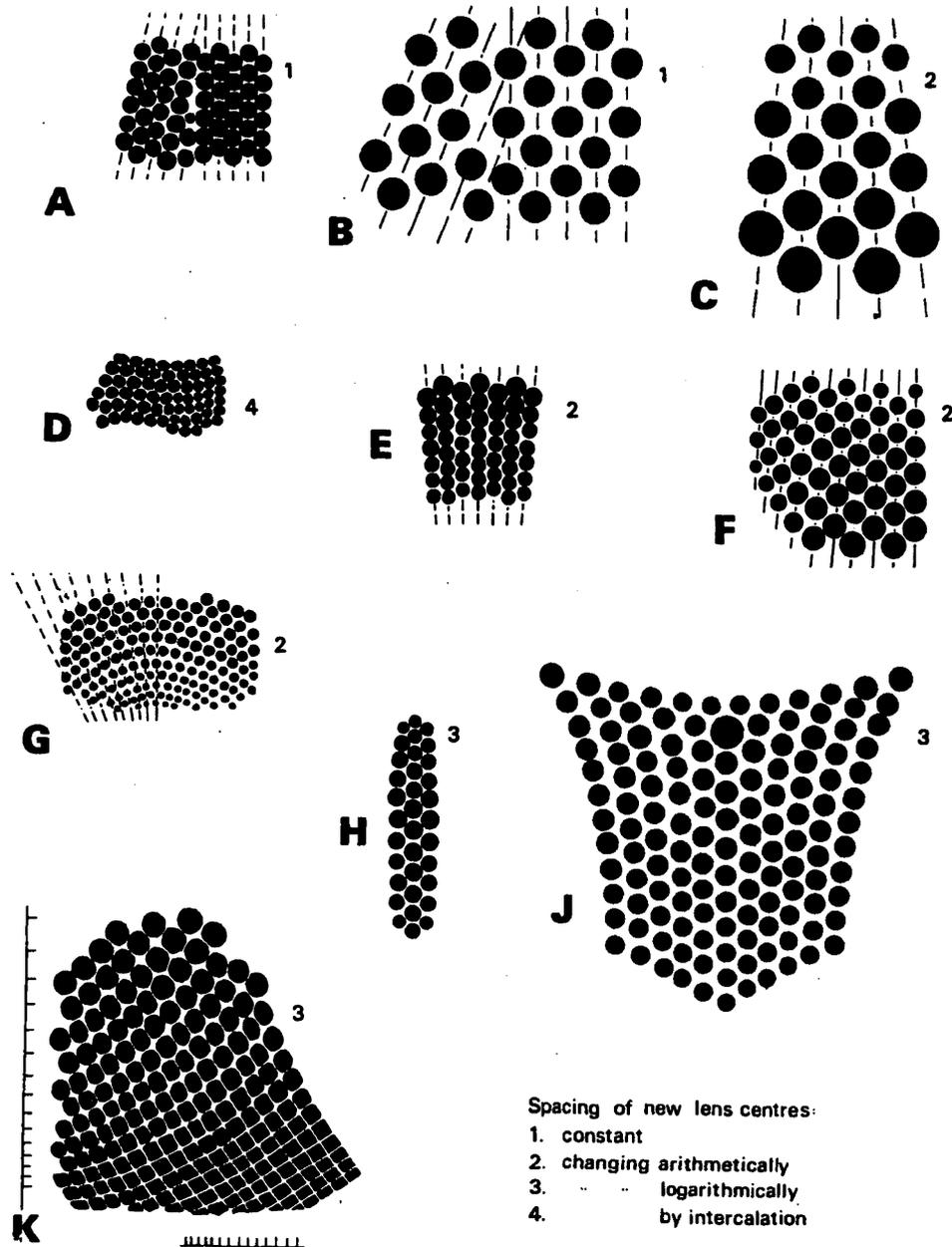


Fig. 6--Lens-packing systems in various trilobite eyes--A, D, E, G-K are from holochroal eyes--B, C, and F are from schizochroal eyes.

- A) Isotelus (Ordovician). B) Ormathops (Ordovician). C) "Phacops" (Siluro-Devonian). D) Ctenopyge (Cambrian). E) Cydonocephalus (Ordovician). F) Dalmanites (Siluro-Devonian). G. Peltura (Cambrian). H) Telephina (Ordovician). J) Pricyclopyge (Ordovician). K) Paralejurus (Devonian). (after Clarkson, 1975)

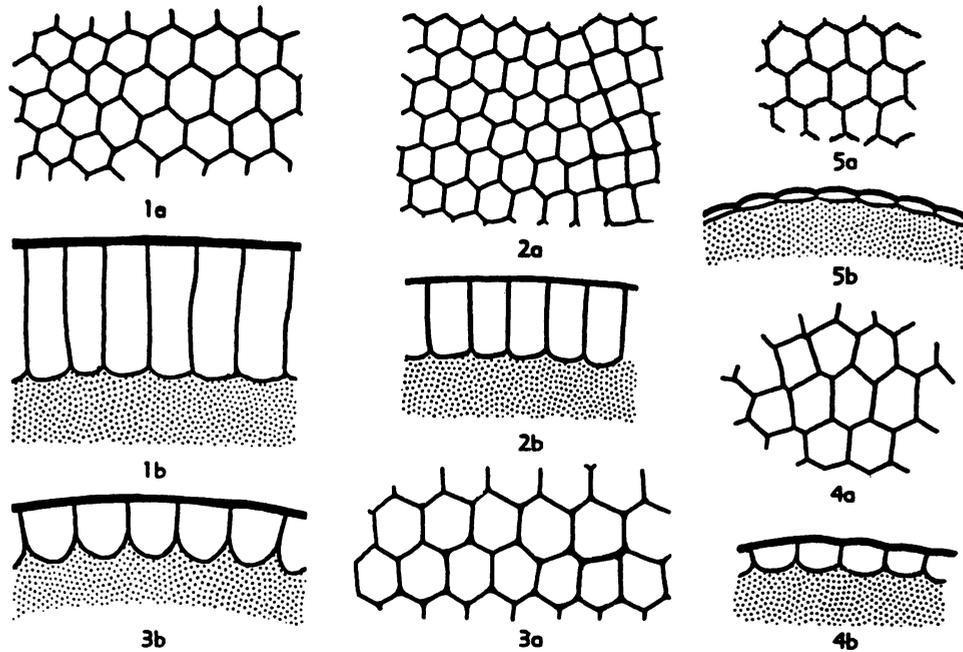


Fig. 7--Transverse and longitudinal sections of portions of holochroal eyes in Swedish trilobites showing the lens forms.
 1) Illaenus Chiron Holm, (Ordovician) x 60. 2) Dysplanus centrotus (Dalman) Ordovician x 60. 3) Cyrtometopus clavifrons (Dalman) (Ordovician x 60. 4) Sphaerophthalmus alatus (Boeck) (Upper Sweden) x 100. (after Moore, 1959)

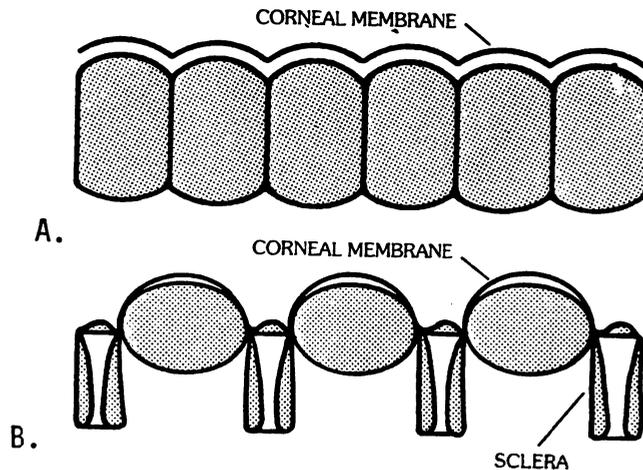


Fig. 8--Schematic cross-sections of portions of trilobite eyes.
 A) Holochroal eye. B) Schizochroal eye. (after Levi-Setti, 1976).

Visual Fields.--One of the more interesting lines of research explored by Clarkson was the determination of the visual fields of the eyes in a variety of trilobites. To do this, he determined the angular bearing of each lens axis and plotted it on a stereographic projection. He called the area enclosed by the plot of the peripheral lens-axes, the visual field (see figs. 9, 10, and 16).

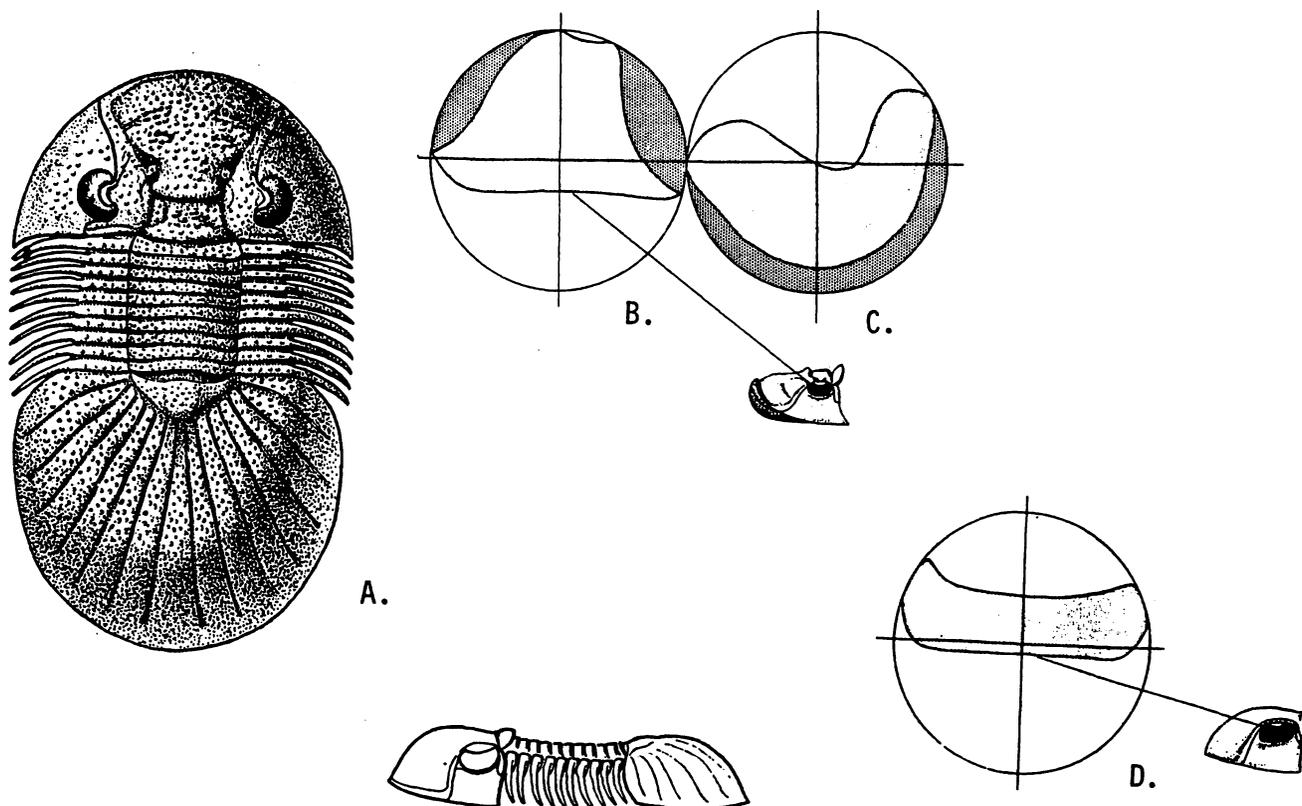


Fig 9--Trilobites with holochroal eyes and their fields of view.

A) Dorsal view of *Scutellum campaniferum*. B) Equatorial projection of field of view of left eye of *Scutellum c.* C) Polar projection of field of view of left eye of *Scutellum c.* D) Visual field of view of left eye in equatorial projection of *Paralejurus brongniarti*. (After Moore, 1959 and Clarkson, 1975)

The actual field of view of the eyes may have been larger since each lens could have "seen" a wider field than just along its axis.

The visual fields amongst the trilobites Clarkson studied show considerable variety. Some such as *Crotalocephalus* and *Paralejurus* (fig. 9d) show latitudinal visual ranges of only about 30° . Others such as *Cheirurus* and *Scutellum* (fig. 9 a-c) have almost a spherical field of vision with a range of greater than 90° of latitude. *Pricyclopyge* had a peculiar downward-directed field of view (see fig. 10).

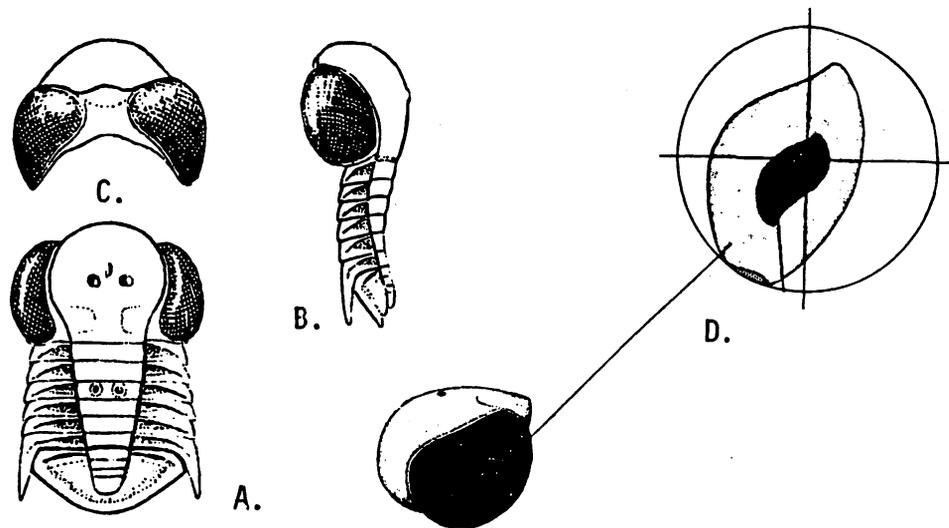


Fig. 10-- Priscyclopyge binodosa (Ordovician, Czechoslovakia) and its visual field.

A) Dorsal view. B) Lateral view. C) Ventral view of cephalon. D) Visual field of eye in equatorial projection. (after Moore et al., and Clarkson, 1975)

This variety in visual fields probably reflects visual adaptations to varying life styles. Those with a downward-directed field of view must have had particularly bizarre behavior.

THE SCHIZOCHROAL EYE

Introduction.--The schizochroal or aggregate eye (figs. 6, 8, 11-20) is the most popular trilobite eye and is almost certainly the one that intrigued and inspired Timothy Conrad and many fossil buffs since his time. The famous Phacops rana has this type of eye.

The schizochroal eye is probably unlike the eye in any living animal and is dissimilar to most. This type of eye is only found in the phacopide suborder Phacopina. It is found in trilobites from the Ordovician to the Devonian. This eye is thought to have evolved from the holochroal eye by neoteny. That is the juvenile holochroal eye with its large and separated lenses was retained into the adult stage of the trilobites with a schizochroal eye.

Morphology.--The schizochroal eye tends to be larger and more conspicuous than the average holochroal eye (figs. 6, 8, 11-20). The number of lenses in each eye tends to be much lower than in most holochroal eyes (see figs. 6, 12, and 13). The known numbers range from 3 to 770 lenses per eye. In the famous Phacops rana they range from 86 to 136 per eye. The exact number in Phacops rana depends on the subspecies, possibly sex, and the individual. The lenses are relatively large and, unlike the holochroal eye, easy to see with the naked eye.

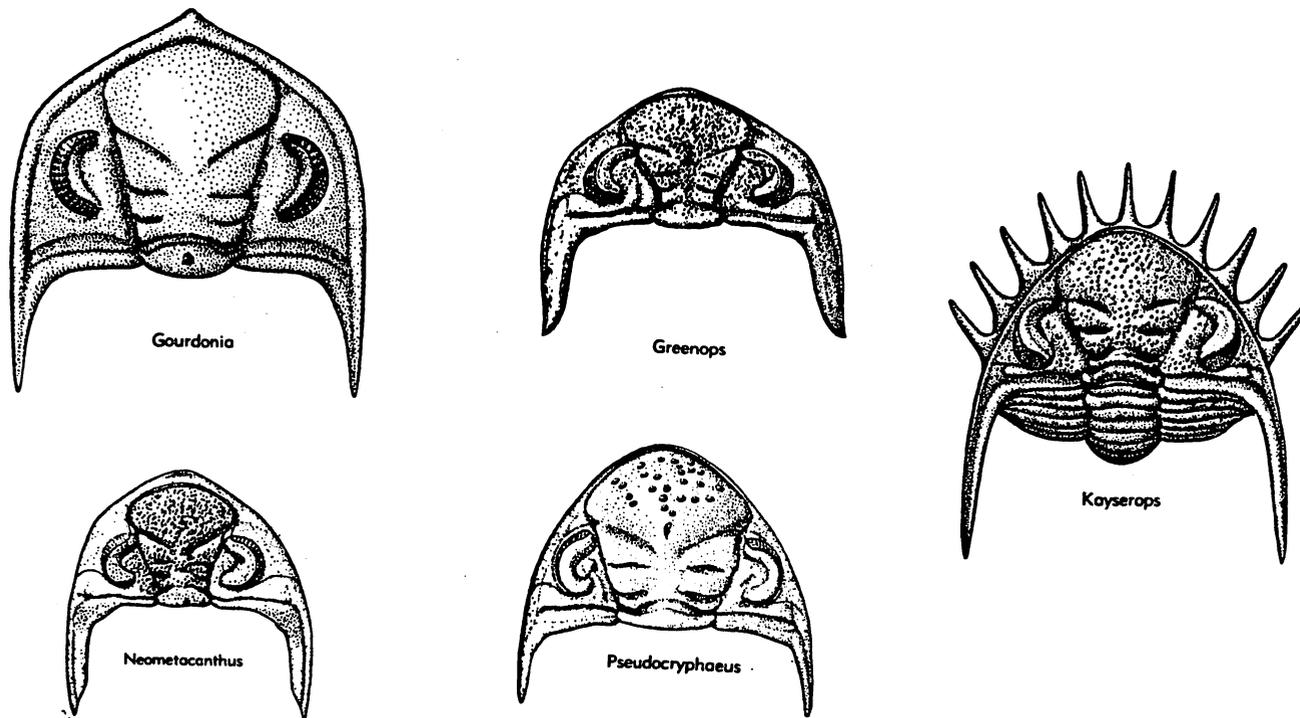


Fig. 11--A variety of trilobites with schizochroal eyes. All dorsal views. (after Moore, 1959)

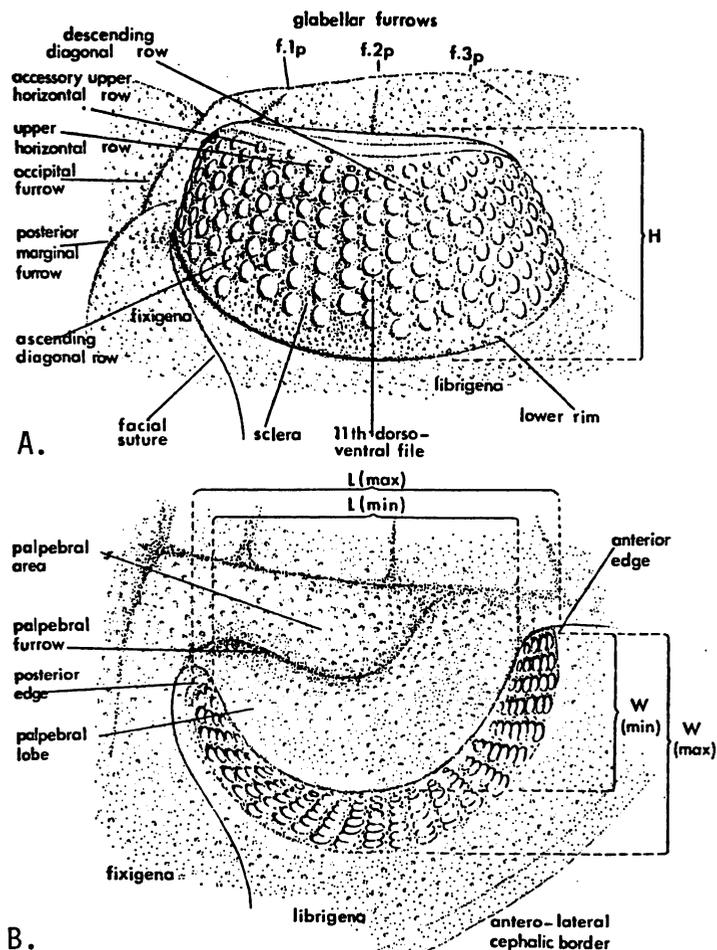


Fig. 12--External morphology of eye of *Acaste downingiae* (Salter). A) Lateral view. B) Dorsal View. (after Clarkson, 1966a)

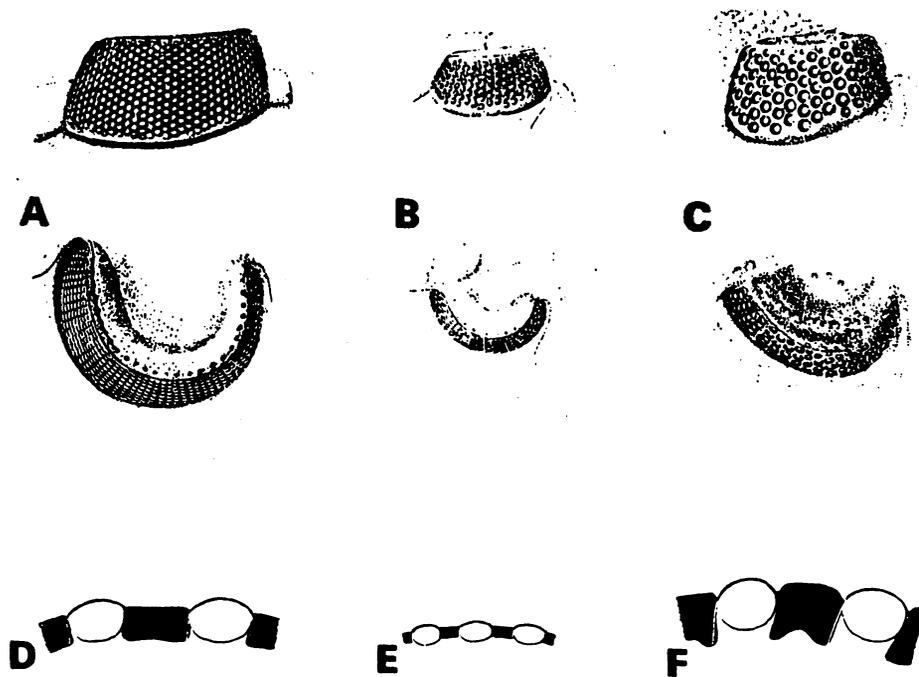


Fig. 13--Three basic kinds of eyes in post-Ordovician Phacopina in lateral view, dorsal view, and horizontal section.

A, D) Dalmanitiform - Odontochile rugosa (Hawle and Corda) (Devonian, Czechoslovakia). B, E) Acastiform eye - Acaste downingiae (Salter) (Middle Silurian, England). C, F) Phacopiform eye - Phacops rana crassituberculata Stumm (Devonian, Ohio). (after Clarkson, 1975)

They range in size from about 0.2 to 1 millimeter in diameter. The lenses are distinctly separated from one another by cuticular material called intralensar sclera (see figs. 13 and 17). The lenses are arranged in a logarithmic spiral (see fig. 6) as they are in holochroal eyes, but differ in having the lenses strongly arranged in obvious dorsal-ventral rows.

The trilobites with schizochroal eyes usually have unusually large lobes below the visual surface of the eye (see fig. 14). Some paleontologists speculate that these held integrative nervous tissue for the eye similar to the large "optic lobes" in Octopus and Limulus where there is a great deal of preliminary filtering of signals in integrative circuits behind the retina (see fig. 15).

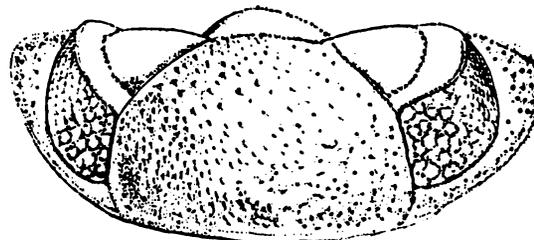


Fig. 14--The cephalon of Phacops viewed from the anterior. Note the volume behind the eye surface which has been interpreted to hold integrative nerve tissue. (after Stockton and Cowen, 1976)

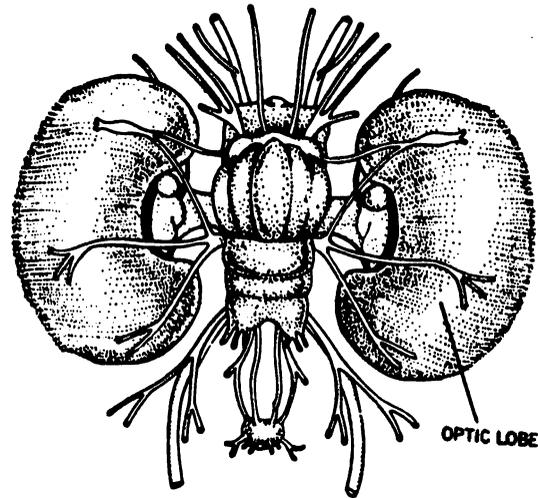


Fig. 15--Diagram of the brain of *Octopus*, with large optic lobes which lie immediately behind the eyes. (after Young, 1961)

The visual fields of schizochroal eyes are much more limited than those of some holochroal eyes. They never have a latitudinal range more than 40° above the equator and most are less than 30° (see fig. 16).

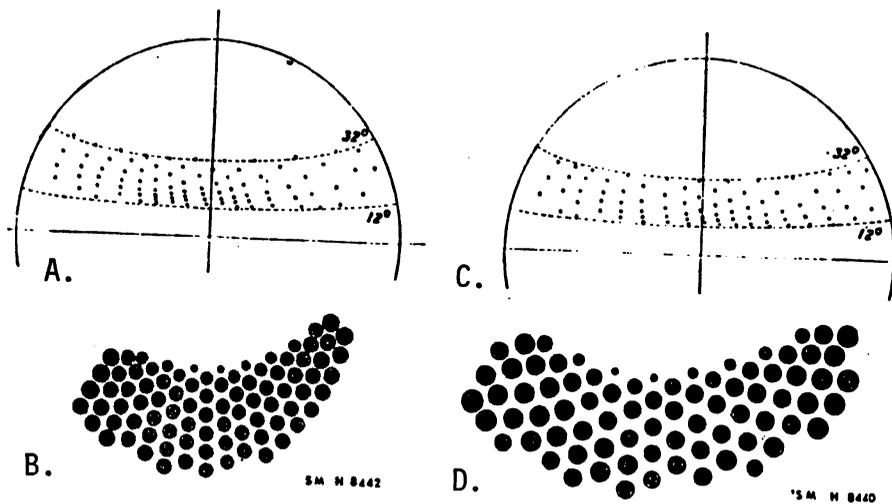


Fig. 16--*Phacops breviceps* Barrande. A) Visual field of right eye in equatorial projection. B) Visual surface of right eye. C) Visual field of left eye in equatorial projection. D) Visual surface of left eye. (after Clarkson, 1966b)

Structure of individual eye units.--Each individual eye unit, or lens capsule (see fig. 17a) has its own separate corneal membrane which leaves the periphery of the lens to plunge through the interlensar sclera as a cylindrical ring (intrasccleral membrane). Each lens is compound with an outer part called the upper unit and an inner part called the intralensar bowl. Beneath the lens is a girdle and an alveolar ring. The upper unit contains a spheriform area made of dense ferroan calcite like that in the intralensar bowl. This area is called the core. Miller and Clarkson (1980) suggest that the core and intralensar bowl were originally made of high magnesian calcite.

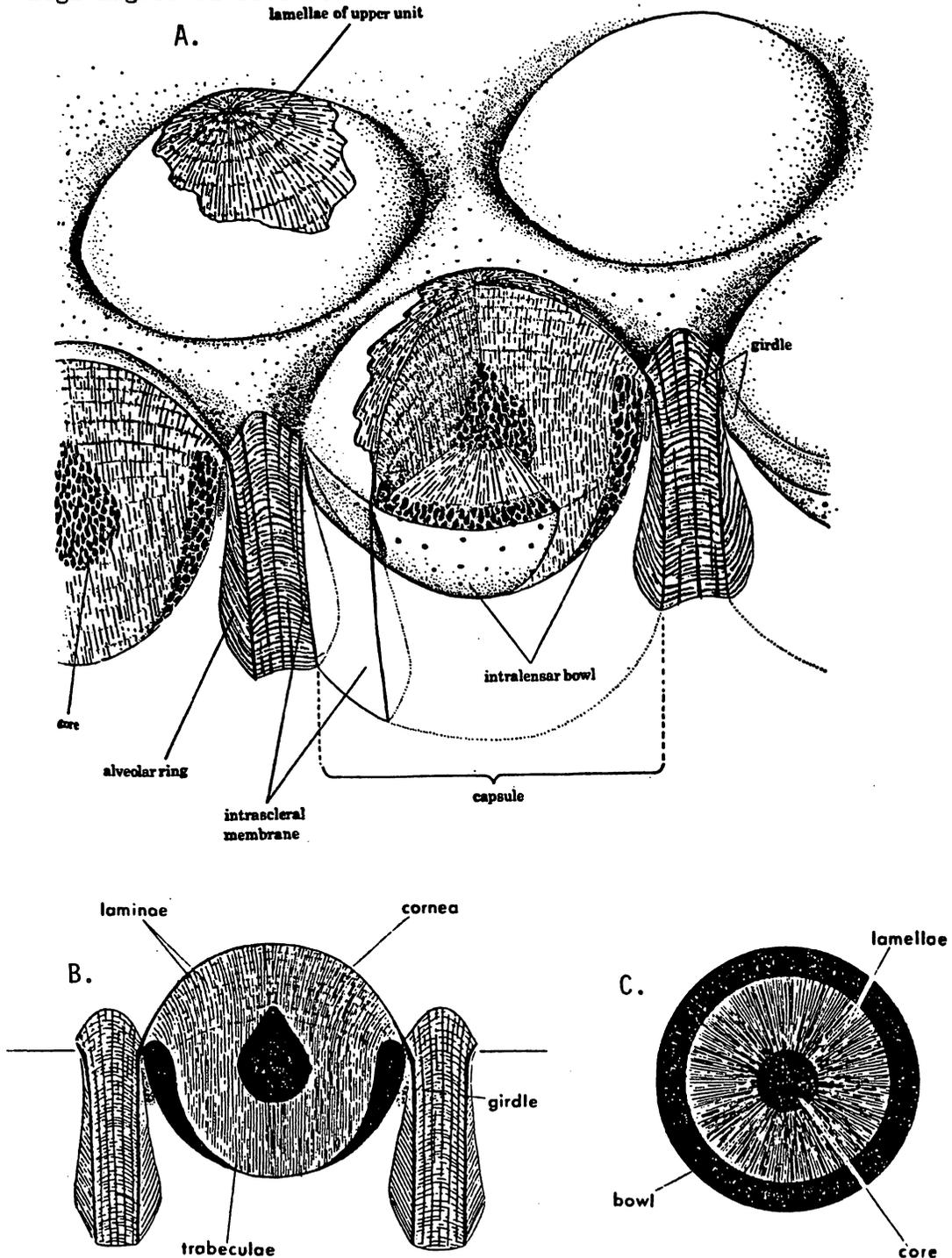


Fig. 17--Lenses and their internal structures in Phacops rana milleri. A) Overall view of lenses and their structure. The details of the cornea have been omitted. B) A somewhat schematic vertical cross-section of a lens and the surrounding intralensar sclera. C) Horizontal cross-section of lens in B. (after Miller and Clarkson, 1980 and Clarkson, 1979)

In dalmanitacean trilobites, the intralensar sclera is normally thinner than the lenses (see fig. 13e). In phacopacean trilobites, the intralensar sclera is thicker than the lens so that the lens is set in the top of a cylindrical cavity called the sublensar alveolus (see fig. 13f).

Interpretation of the compound structure of the lens.--Clarkson and Levi-Setti (1975) first drew attention to the unusual shape of the upper unit of the lens (see fig. 18 c, d). In particular, they pointed out the unusual shape of the lower surface of the upper unit. They noted that the upper units resemble lenses designed to correct for spherical aberration. For example, the upper unit in Dalmanitina socialis resembles the lens designed by René Descartes in his La Geometrie in 1637 and the upper unit in Crozonaspis struvei resembles the lens designed by Christiaan Huygens in his Traité de la Lumière published in 1690 (see fig. 18).

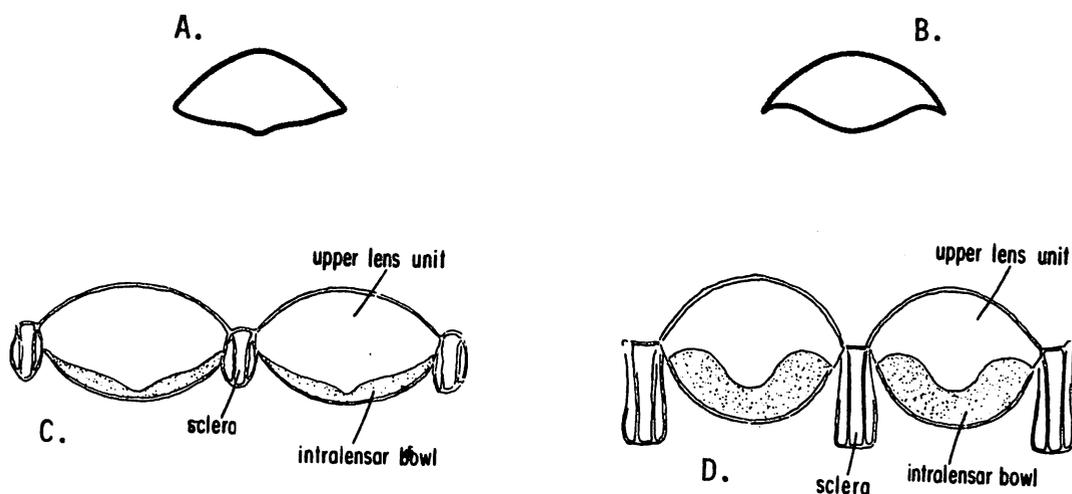


Fig. 18--Lenses to correct for spherical aberration and lenses of phacopine trilobites.

A) Lens of Descartes. B) Lens of Huygens. C) Lens of Dalmanitina socialis. D) Lens of Crozonaspis struvei. (after Clarkson, 1968 and Clarkson and Levi-Setti, 1975)

You get spherical aberration in a lens if the lower surface does not bend (refract) the light so that the beams of light come together below the lens in a single point. When this happens, you get a blurry distorted image. The lower surfaces designed by Descartes and Huygens bend the light so that it comes together at one point making a better image in less light. These trilobite upper units would be even more like those of the early physicists except the man-made lenses were designed for air, not water. Thus, trilobites discovered the same thing physicists have discovered--only they did it over 500 million years earlier.

Clarkson and Levi-Setti speculate that the intralensar bowl may have helped to bring the peripheral light rays into better focus. Experiments by these investigators appear to support their contentions.

Stereoscopic vision in Schizochroal eyes.--Cowen, Stockton, and Kelley observed that the lenses in the vertical rows of the schizochroal eye are closer than those in the horizontal rows. From this and other considerations, they postulated that adjacent lenses in one eye, especially those in a dorsal-ventral row could be used in stereoscopic vision provided there were appropriate nerve links and relays connecting the photoreceptive units. In other words, each individual eye may have been capable of depth perception or stereoscopy. Where the fields of view of the two eyes overlap, there would also have been stereoscopic vision. Cowen and his co-workers determined that, if only the lens less than the extreme ones were interconnected they would have depth perception up to 25 cm. from the eye. If the extreme lenses in each eye were interconnected, the depth perception would have extended up to 2 meters from the eye. If there was stereoscopy between both eyes, they could have depth of field perception up to 450 meters from the eyes. These speculations suggest that trilobites with schizochroal eyes may have had a wider range of stereoscopy than any other organism ever to live!

Mysterious fibers of Phacops.--Stürmer and Bergström (1973) used "soft" x-rays on pyritized specimens of Phacops from the Lower Devonian Hunsrück shale of Germany. With this technique, they discovered apparent fibers leading away from the eye (see fig. 19).

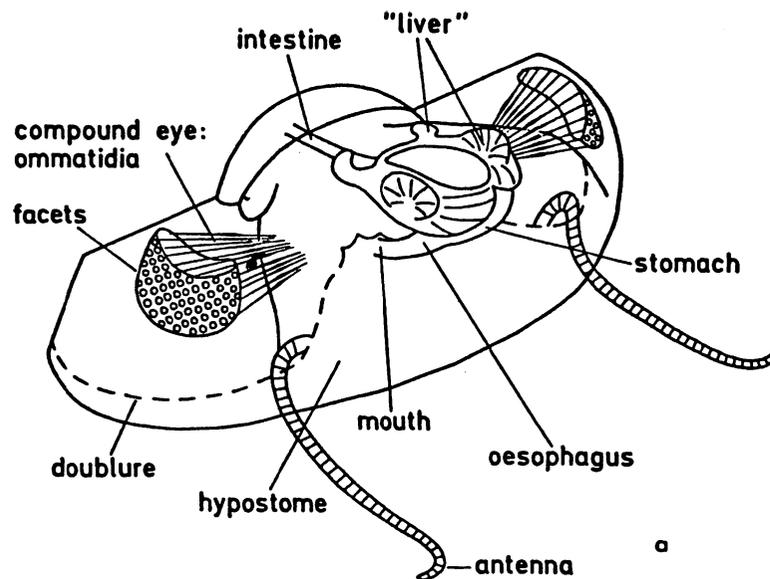


Fig. 19--Cephalon of Phacops sp. in translucent reconstruction to illustrate the fibers leading from the eye. (after Stürmer and Bergström, 1973).

They suggested that they were crystalline fibers comparable to those in the ommatidia of many modern arthropods. Other scientists questioned this because coupling ommatidia with schizochroal lenses would seem to defeat the purpose of the sophisticated design of the latter. They suggested the fibers might be nerves. However, this seems questionable because they lead, not to the brain, but posterior to the esophagus. The most recent suggestion is that they are the "gill" branches of the trilobite's appendage. The true nature of these mysterious fibers still seems to be in doubt.

The image-making ability of the schizochroal eye.--Considerable speculation has been made as to how the individual unit in the schizochroal eye compares to the ommatidium of the modern compound eye. An early view was that the schizochroal eye was just a peculiar ommatidium with similar photoreceptors. Virtually all of the recent workers believe there is no modern eye comparable to the schizochroal eye. They suggest that each unit of the schizochroal eye was a camera-type eye with a flat layer of narrow retinal cells (see fig. 20). Thus each unit made its own image, not just a spot of light. The entire eye made an overall image made by a mosaic of many micro-images.

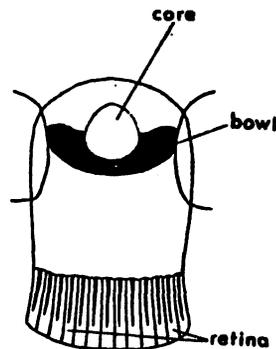


Fig. 20--Reconstruction of an individual optical unit of a phacopid trilobite. (after Clarkson, 1979)

There are various reasons for believing that each unit in the schizochroal eye was a camera-type eye with a retina. The units are not designed like ommatidia. The lenses are designed for good images. The units are too few in number and too widely spaced to make a useful visual image if each makes only a spot of light.

The significance of schizochroal eyes.--The schizochroal eye may have been one of the most significant visual innovations of its time or any time. It may have been able to do a superb job of coding information concerning the position, size, speed, and nature of objects in its environment. One investigator noted that those trilobites with schizochroal eyes were also good enrollers. Since enrollment is a defensive maneuver, it has been suggested that the schizochroal eye was also defensive. They both developed about the same time in the Early Ordovician when many new predators were appearing. The schizochroal eye, in this view, was an early warning system for detecting approaching predators.

It has also been suggested that some trilobites actually used their excellent vision in predation themselves.

The percentage of trilobite genera with schizochroal eyes in the Ordovician was less than 10%; in the Silurian 10-20%; and in the Devonian 20-40%. So that over this period, it appears that the schizochroal eye-bearing trilobites were gaining ground on the holochroal eye-bearing trilobites. Why then did the Phacopina not survive the Devonian whereas the holochroal eye-bearing trilobites survive to the Permian? I think there are at least two possible explanations. The Phacopina may have had superior eyes, but were inferior to the other trilobites in other attributes over the long haul. Perhaps the Phacopina were superior overall to other trilobites, but were eliminated just by chance. I lean towards this last hypothesis because this sort of thing seems to be rather common in the fossil record. Extinction does not always or possibly even usually mean inferiority.

ABATHOCHROAL EYES

The newest type of trilobite eye to be recognized is Jell's abathochroal eye (see fig. 21). It is somewhat like the schizochroal eye in having a small number of widely separated biconvex lenses arranged in dorso-ventral and diagonal rows. It differs from the schizochroal eye, in having thin intralensar sclera, smaller lenses, and corneal membranes which are anchored to the interlensar area around each lens margin, but don't go deeply into the interlensar sclera. This type of eye is found only in some eodiscids (fig. 22).

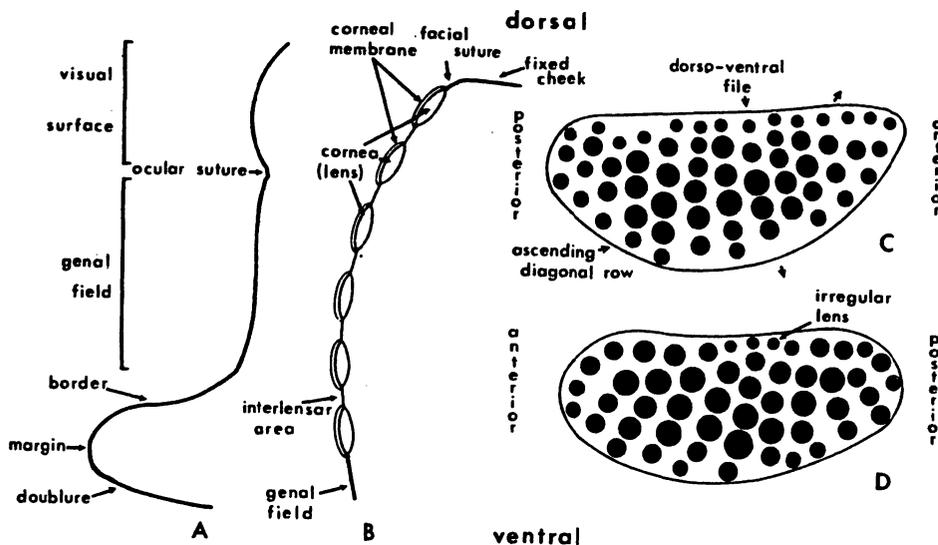


Fig. 21--Pagetia illustrating visual features.

A) Transverse section of free cheek of P. ocellata with the visual surface attached. B) Diagrammatic transverse section of the visual surface. C) Arrangement of lenses in the right eye. D) Arrangement of lenses in the left eye. (after Jell, 1975)

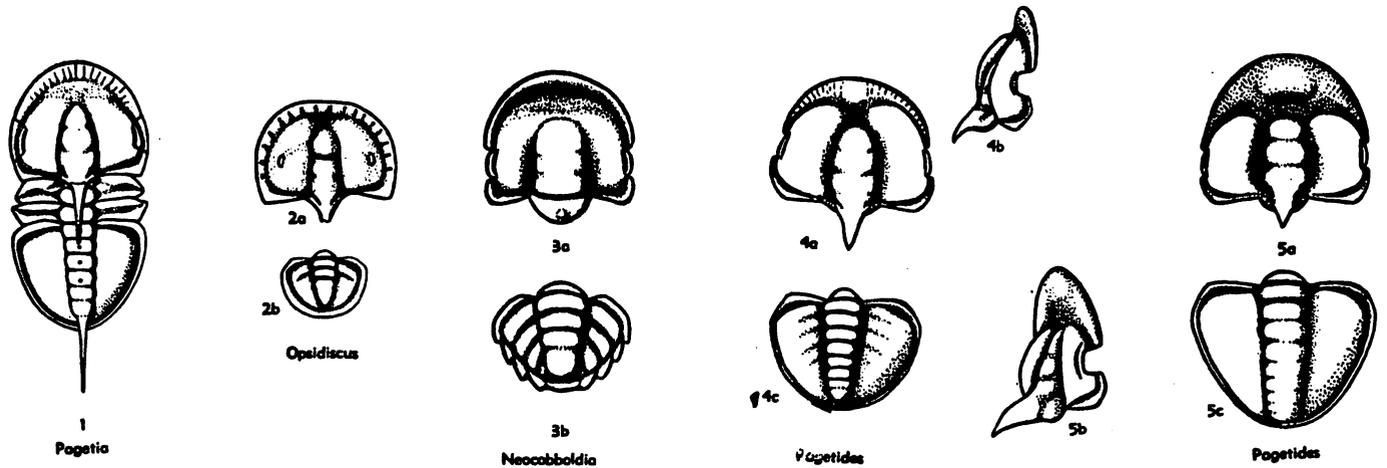


Fig. 22--Representative eodiscid trilobites with eyes. (after Moore, 1959)

CONCLUSIONS

The modern burst of discovery and speculation concerning the trilobite eye is very revealing. It shows that trilobites invented structures and solved problems of physics hundreds of millions of years before man. We haven't come near to learning all we can about the trilobite eye. Think how many other structures in so many organic groups remain to be thoroughly investigated! Much more remains to be learned. New specimens need to be dug up, old material needs to be examined more carefully with new techniques and from different perspectives and new thoughts should be raised. The future of fossil study is unlimited.

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MARK YOUR CALENDARS

- 3 May -- MAPS Field Trip -- Monmouth Stone Quarry, Monmouth, Illinois. Meet at the restaurant SE corner of HWY 34 & HWY 67 junction 9:00 a.m. Geology students from Monmouth College invited to attend. Burlington FM. of the Mississippian Periods.
- 24 May -- MAPS Field Trip -- Lone Star Quarry, Oglesby, Illinois. Meet in the parking lot of Holiday Inn in Peru, Illinois, located at the junction of HWY 51 and I-80 at 9:00 a.m. Pennsylvanian Fossils.
- 25
- Then Sunday, we will go to the Butler Quarry at Lee Center, Illinois, for Ordovician material, especially straight cephs and saucy gastropods, many species. Lew Kehr will be our host for the weekend.
- 13 June - Bedford Show and Swap -- Bedford, Indiana. MAPS Meeting Saturday
15 June 14, 2:30 p.m. Meet your friends at Bedford. Make new friends! Good show!
- 12 Aug -- North American Paleo Convention IV Field Trips Before and After.
15 Approximately 26 Symposiums. Send requests and/or questions to: NAPC IV, Campus Box 315, University of Colorado, Boulder, CO 80309-0315.
- 17 Aug -- Second International Symposium on Devonian System, c/o C.S.P.G.
20 #505, 206 7th Avenue S.W., Calgary, Alberta CANADA T2P 0W7. Up to 250 talks. Exhibits at Glenbow Museum, next door to convention center.
- 30 Aug -- MAPS Field Trip. Not crystallized quite yet. See Summer DIGEST for
1 Sep details. Doug DeRosear in control. You can ask him at EXPO, but he has Trilobite Fever and you know how it is with Trilobite Fever.

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PS

25 June - California Show, Sacramento, California
27

17 July - American and Midwest Federation Show, South Bend, Indiana, Notre Dame Campus. Show Chrm. James Russell, 27911 North St., North Liberty Indiana 46554

8 Aug-- Medford, Oregon -- Fossil Show -- Petrified Wood the order of the day.
10

Sorry! I don't know the dates or places of other Federation Shows.

(X X X)

NEWS RELEASE -- Ottawa, Ill -- Lewis Kehr. MAPS May 24, 25 Field Trip has taken an International Flavor. MAPS member Jeffrey Barrett, Calgary, Alberta, CANADA if flying in for a walk on 2 ancient sea floors.

PLEASE ADD THE FOLLOWING TO YOUR NEW MEMBERSHIP DIRECTORY

NEIL PLUMMER

New Road
St. Stythians, Near Truro
Cornwall, UNITED KINGDOM
0209-860-574

Geologist. Collecting 20 years. Will trade
Likes all fossils, invertebrates and vertebrates
trilobites, ammonites, crinoids, sea urchins.
Many for trading and sale. I love fossils their
finding, development, identification and display.
Interested in building a museum display.

JIM COCKE

Geology Dept.
Central MO State Univ.
Warrensburg, MO 64093
816-429-4936

Paleontologist. Major interest Pennsylvanian
invertebrates--chiefly coral. Several genera
of corals from Missouri, Texas for trade.

GUY & DORIS DARROUGH

3619 West Maline
St. Louis, MO 63121
314-423-5897

Self-Employed. Will trade. Major interest L.
Ordovician and dinosaur material. Has L. Ordo-
vician and Cambrian fossils for trade. Wants
to help further the study of fossils & discovery
of new life forms.

GERHARD G. H. MUEHLE

745 W. Calle Casquilla
Tucson, AZ 85704
602-297-8637

Police Sergeant. Major interest shark & mam-
mal teeth, echinoids and trilobites. Not enough
to trade yet. Want to make acquaintance with
others sharing my interest in paleontology.

JOE F. SMITH

P. O. Box 8604
Chattanooga, TN 37411
615-622-1274

Retired. Will trade. Major interest crinoids
blastoids, etc. Has the same for trade.

Dr. Annabelle C. Powell

Geoscience Resources
P. O. Box 2096
Burlington, NC 27216-2096
919-227-8300

Geologist. Major interest fossils for teaching
kits. Has lots of fossils for trade. Would
like to receive bulletin.

STEPHEN A. WILSON

ROXANE WILSON
P. O. Box 1308
Arcadia, FL 33821
813-993-1649

Forest Ranger. Interested in vertebrate mater-
Bookkeeper ial, teeth and jaws. Willing
to trade invertebrate material and some verte-
brate material or shark teeth.

CAROLYN ZIMMERMAN

Rt. 5, Box 477
Wilmington, NC 28403
919-799-0806

Old member, returning. Self-Employed. Will
trade. Would like to share interest in paleon-
tology, and information, particularly on a
layman's level.

Many thanks and love to you from M.A.P.S:

Gil Norris -- trilobite slides, table dinner, display reservations
Allyn Adams -- trilobite slides, tax exempt status, quiet reinforcement
Doug DeRosear -- ancient critters--slide material
John Iellamo -- trilobite slides
LaVeta Hodges -- Paleo section of Mem. Dir. -- GOOD JOB!
Alberta Cray -- update for all Mem. Dir. sections
Tom Witherspoon -- publicity to all the right places
Marv Houg -- prompt payments and EXPO Chairman
Bob Durnal -- table layout and setup
Peg Walsh -- desk organizer
Peg Wallace desk first assistant
Dennis Kingery -- auctioneer
Don Auler -- artwork
Tom Walsh -- signs
Lloyd Gunther -- MC and clear-thinking chairman
Gerry Norris-- wherever she's needed, she's there
Lloyd Gunther; Val Gunther; R. A. Robison, Prof; Tom Whitely; George Melloy; John Iellamo; Joseph Emielity; Allen Graffam; Jowana Cavner; Tom Witherspoon; Dan Cooper; Doug DeRosear; David Bradbury; Don O'Neill, Denny and Marty Sutherland; John Moffitt; Jack Shirley; Tom Johnson; Dr. Merrill Foster. WOW! Are we lucky!

Dr. R. A. Robison, "Mr. Fossil"; Dr. Donald Mikulic; Frederick J. Collier,--if one reaches, one may as well reach high.

Special thanks to Fred Collier for his expertise and guidance.

No wonder MAPS is a love affair!

MAPS Board of Directors