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TRILOBITES

M.A.P.S. DIGEST

EXPO XX III EDITION

MID-AMERICA PALEONTOLOGY SOCIETY

A LOVE OF FOSSILS BRINGS US TOGETHER

Western Illinois University
Union Ballroom
Macomb, Illinois 61465
March-April - 2001



ACKNOWLEDGEMENT

TRILOBITES

This edition of the EXPO Digest -- "**TRILOBITES**" is a repeat of the fauna which was the THEME in 1986. The first EXPO EDITION published was in 1984, since then there have been many interesting articles contributed by members of M.A.P.S. and others such as the Paleontology Society; Smithsonian Institution and the Paleontological Research Institution. I truly appreciate those who have taken the time to contribute to these Editions in the past and look forward to seeing many more articles in future EXPO EDITIONS from many of you.

This edition on TRILOBITES could be said to be the favorite fossil of many collectors, and is much sought after.

Again we have some first time contributors: Wendell Rickets, Wolfgang Vogel, Anthony Verdi, The Dry Dredgers of Cincinnati, Nigel Hughs & Dan Cooper, Dr. Allan Russell, Kenneth Gass, Stewart Hollingsworth, and Ronald C. Meyer. And I must not leave our stand-bys, Mark McKinzie, Don Bissett, Geoff Thomas, Gerald Gunderson, Ernest Hammons, Jean-Guy Pellerin, And Les Heinzl . Thank you so very much. We could not have an EXPO DIGEST without all of you. A big thank you To Rudy Turner for taking the picture of my trilobite for the cover.

This EXPO EDITION is the twelfth one for me, (doesn't seem that long, does it?) The first Edition was titled "Leaves and Grasses - the year 1990. I was scared almost to death, but once I got into it and started talking to people, asking for articles I relaxed and began to look forward to the next edition. I have thoroughly enjoyed the work on the EXPO Digest. We have had some interesting THEMES over these twelve years, and I have learned more about fossils than I ever imagined- - I wish to

thank Tom McNamara for putting up with me all these years; and the M.A.P.S officers for always being so kind, concerned and helpful.

This Edition of the EXPO Digest will be the last one of which I will be your editor, (you knew I was working up to something, didn't you?) So I thought you would not mind if I furnished the Cover myself this time. Over the years I have asked someone else to do the covers and the cover story, they have been wonderful "Yes, I really have enjoyed it, I like to keep busy." But now its time to turn it over to someone else. Charles Oldham, of Crestwood, Kentucky has agreed to assume the duty of Editor of your EXPO Digest. He will have a lot of new ideas and his own way of doing things, and I am quite sure he will do an excellent job. He is far more versed in the knowledge of paleontology than I am. So I feel good about leaving this job in capable hands. I will still be around for "I hope" many years, and I intend to watch over him, and keep him on the "straight & narrow," Ha!Ha! I'm asking you **authors** to please send him articles for the Digest.

The Mid - America Paleontology Society was formed to promote popular interest in the subject of paleontology, to encourage the proper collecting, study, preparation and display of fossil material; and to assist other individuals, groups and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

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Cover Story

Margaret E. Kahrs

The trilobite **Brachymetopus spinosus** which graces the front cover was collected at a location in Morgan County Indiana a site that has had very few visitors. Kinderhookian Series, lower Mississippian, Spickert Knob Formation of the Borden Group (formerly known as the Carwood/Locust Point Formation. Some call it the Borden Silts, the shale turns into a slimy mud with a very small amount of water; so you never want to hold the specimen under gushing running water, only a small trickle will do the job. If you brush the specimen make sure it is an extra soft bristled tooth brush or paint brush.

One of the rare forms of trilobite is the **Brachymetopus**. The first one I found was in May 1978. It didn't seem too significant to me at the time, it was small, but seemed to be complete, so I wrapped it and put it in my bag along with corals, brachiopods, crinoid parts and various sundry. The trilobite needed very little cleaning, I just brushed off the loose dirt. Much later I searched the fossil books to identify it; and decided it was a **Brachymetopus spinosus**.

I had been collecting at the site for 2 or 3 years, and found several really nicely preserved fossils, new brachiopods, (which had not been described) pelecypods, crinoids, corals, cephalopods, conocardium and bryozoa, but that was my first trilobite. I found the second one in June 1980.

I had been telling the late Alan Horowitz and Franklin Hadley about this wonderful place, and showed them all the fossils I had found there. They were both greatly impressed and was eager to see this site. I invited them to go collecting with me. They were amazed at the beautifully preserved fauna found there. They had been collecting at another site nearby and didn't know about this one. The site where they had been collecting (about a mile away), fossils were not preserved very well. I don't think they ever returned to their previous site, but visited this one often. I have never heard of another trilobite being found at this site, but its quite possible there has been.

Its one of my favorite trilobites even though it is not of the best quality. I call it, (Brachy).

It is somewhat like the Phillipsi. The glabella is short and the pygidium granulose. The Thorax consist of a center axis with three rows of nodes. The pleural lobes each have two rows of nodes. This specimen has a small gob of pyrite attached to the pygidium. I opted not to try and remove it for fear of the damage which might be done. Some of the pyrite at this site has a tendency to oxidize and literally eat up the fossil, so I watch it real close and if it starts to oxidize I will simply put neutralizer (permanent wave solution) on it and that will make it (all well) again. I think if it was going to oxidize it would have by this time, its been 20 years since I found it, and it stays the same. It is only 1 inch long, that's twice as long as the first one I found, its only 1/2 inch long, but I love them just the same.

One of the M.A.P.S. members saw one like these at last years EXPO and stopped at my table and was telling me about this rare trilobite some guy had at his table,"he said, I would give almost anything for that trilobite its the first one I ever saw, I've seen pictures of them , but never have I seen a real one. I asked him what kind was it and he said " a Brachymetopus" and I said, Oooh! " I've got two of those" his reply was, "now come on, you're pulling my leg" I said "no I'm not really I have". So he wanted to come to my home and see them. About two weeks later he came. He said "now, I want to see those trilobites you said you have". He saw and he believed.

Front Cover- Photograph: Dr. F. Rudolph Turner

BACK COVER ---- **Phacops**

Don Auler-- He is a **talented Artist**, and is much appreciated.

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PALEOBIOLOGIC AND TAPHONOMIC ASPECTS OF THE "GRANULOSA" TRILOBITE CLUSTER, KOPE FORMATION (UPPER ORDOVICIAN, CINCINNATI REGION)

Nigel C. Huges and Dan L. Cooper

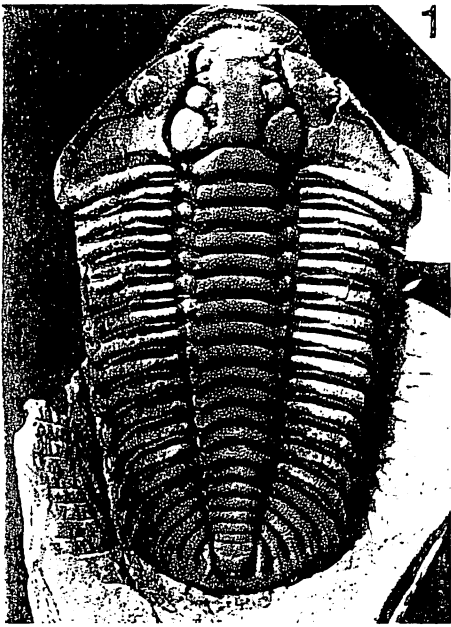
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Abstract -- A new low-density trilobite body cluster from an upper ordovician Kope Formation mudstone in the Cincinnati region is characterized by well preserved, articulated specimens. This cluster is polytaxic, size-segregated, and shows an usual variety of flexure tubular burrows, and were preserved by rapid deposition of mud from a sediment-laden flow. Size-segregation among species, but size-consistency within species, coupled with sedimentological data and apparently haphazard body orientation data, suggest that the trilobites represents a biological association, rather than the product of mechanical sorting. While the majority of specimens are inverted, many are dorsal-up, and some are inclined to bedding. Postures include prone (ie., nonflexed), simple dorsal or ventral flexure, and complex stances that combine both dorsal and ventral flexure. Flexure pattern appears largely unrelated to sediment compaction. We interpret the cluster as an association of live trilobites that were entombed in situ. Specimens may have inverted prior to burial as a behavioral posture, or as a response to onset of burial. The animals were likely preserved in the process of escaping, as they tried to free themselves from being buried. This is in contrast to the tightly enrolled stance in some trilobites, especially other *Flexicalymene*, commonly associated with rapid burial events, and indicates a new behavioral aspect of trilobite paleobiology. The distribution of associated burrows suggests that the rotting carcasses attracted scavengers

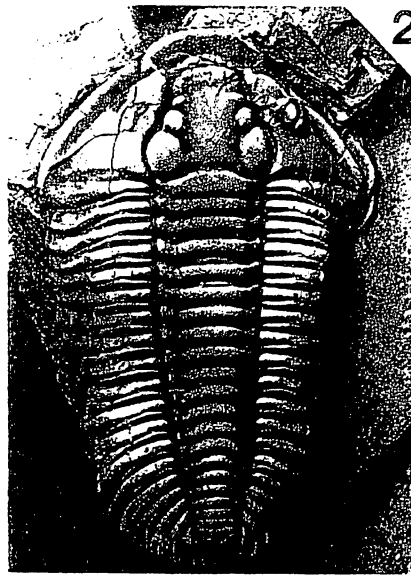
Introduction

The Cincinnati Series in its type area is famous for its exceptionally rich and well-preserved Upper Ordovician fauna. Trilobites are a conspicuous element of this fauna, evident from both body and trace fossils, and accumulations of numerous articulated exoskeltons within single beds are well known (e.g., Brandt, 1985 Schumacher and Shrake, 1997). A newly discovered cluster within the Kope Formation, stratigraphically low in the Cincinnati Series, contains an assemblage of trilobites showing novel preservational features, including abortive escape postures and scavenging upon trilobites carcasses.

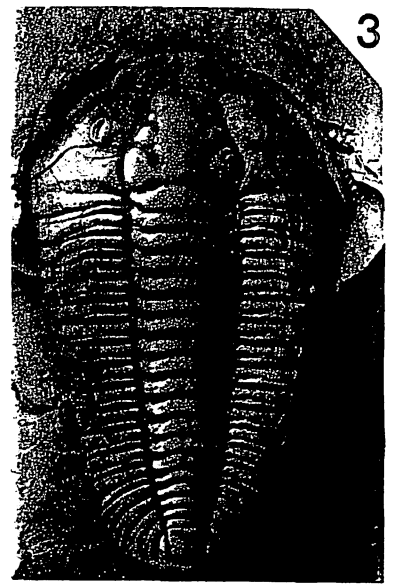
FIGURE 1—Trilobites from the "granulosa" assemblage, Kope Formation, Kentucky. All specimens were coated with ammonium chloride sublimate prior to photography. 1–9, *Flexicalymene* aff. *granulosa* (Foerste); 1, prone specimen with cranidium slightly flexed ventrally, CMCP2504, $\times 1.5$; 2, prone specimen, CMCP2525, $\times 1.5$; 3, prone specimen, CMCP2535, $\times 1.5$; 4, prone specimen with cephalon flexed ventrally, CMCP2508, $\times 1.5$; 5, prone specimen with dorsal flexure of anterior thorax, CMCP2523, $\times 1.5$; 6, prone specimen with dorsal flexure of posterior thorax, torsion of the postcephalic region, and fracture of the right pleural tips, CMCP2532, $\times 1.5$; 7, 8, CMCP2539, $\times 2$; 7, dorsal view showing strongly dorsally flexed thorax and bedding parallel cephalon and pygidium; 8, ventral view showing absence of hypostome, oral region contains plate-like pyritic laths; 9, specimen showing partial enrollment, CMCP2530, $\times 2$; 10, ventral view of cephalon and anterior thorax, and dorsal view of postcephalic region of *Ceraurus* sp., CMCP2507, $\times 1.25$.



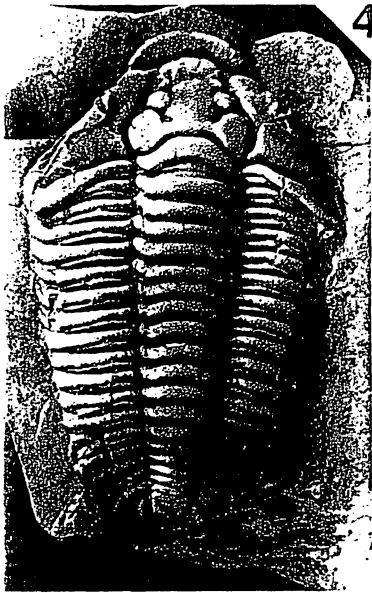
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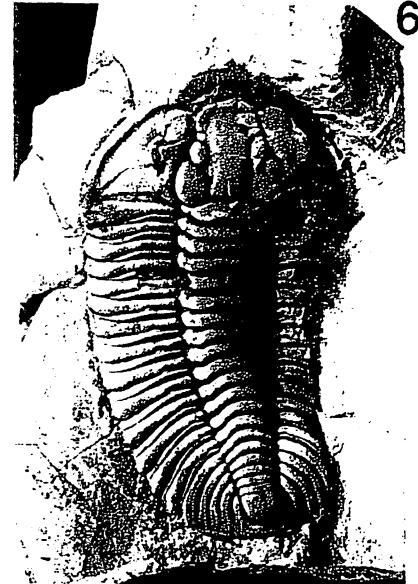
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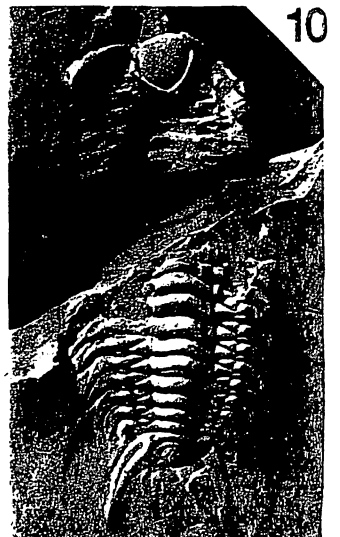
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MATERIALS AND METHODS

The "*granulosa*" cluster was excavated by hand. Specimens were first exposed and data on their disposition were recorded in situ. Upon extraction the specimens were immediately wrapped in thin plastic film to limit the rate to which they dried. They were then prepared by hand and cleaned using an air abrasive operated at very low pressure. slight irregularity of bedding fracture made it difficult to determine the exact position of each specimen within the cluster layer. Subsequent analysis (see below) revealed that the cluster layer was made up of two discrete beds. In rare cases where specimens were found above or beneath other specimens it has been possible to determine which was their original bed, but in most cases this information is unknown. Any taphonomic differences that did originally occur between these two beds were certainly subtle, and trilobites showing a variety of postures occurred in both levels.

In the paper we use "attitude" to indicate whether the specimen was dorsal surface upward (dorsal up), dorsal surface downward (dorsal down) or transversely inclined to bedding (inclined). "Flexure" refers to the posture of the trilobite in the sagittal plane; ventral flexure indicates that ventral surfaces have been drawn together, as in enrollment, and dorsal flexure indicates arching of the specimen, the opposite of enrollment. "Torsion" refers to differential stacking and spalying of pleurae on opposite sides of the thorax, such that in dorsal view the specimen appears laterally twisted. The specimens, numbered CMCP2501-2539, are repositied in the invertebrate paleontology collections of the Cincinnati Museum Center. Additional material collected on an earlier occasion is CMCP2281, 2284-2285A/B.

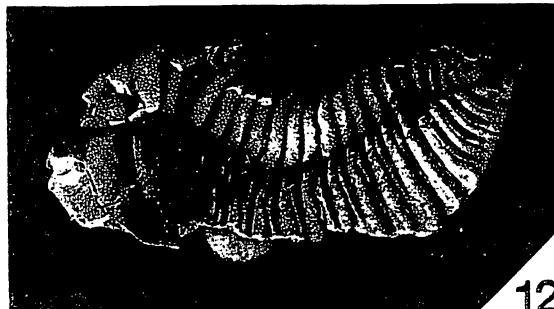
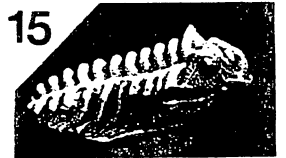
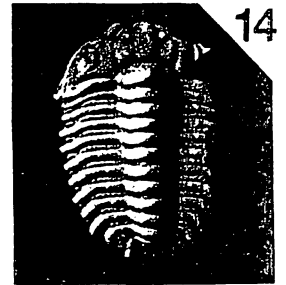
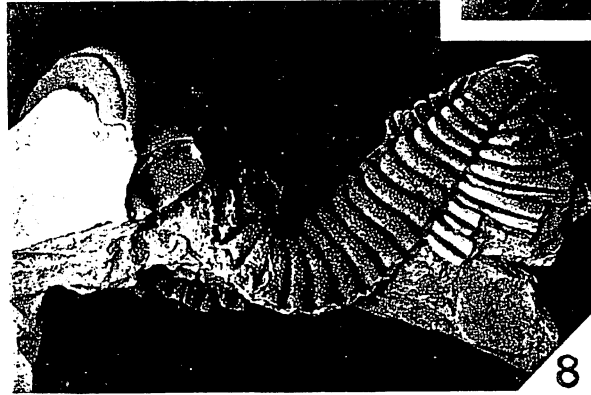
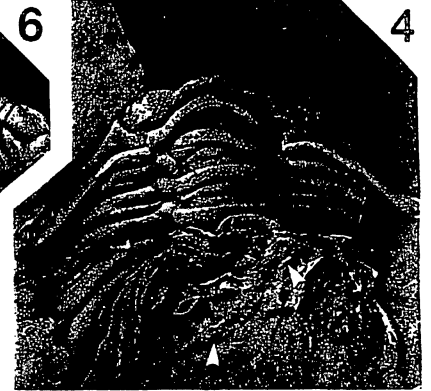
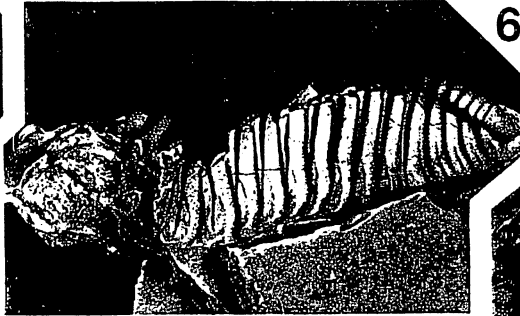
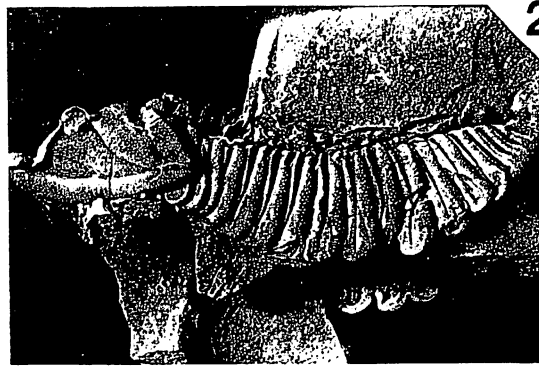
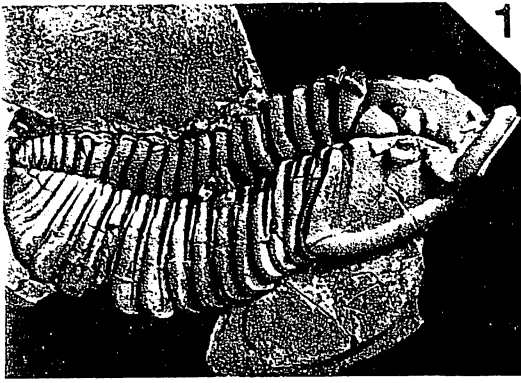
SYSTEMATIC REMARKS

The assemblage is here referred to as the '*granulosa*' cluster because its fauna is dominated by trilobites comparable to those described as *Flexicalymene granulosa* (Foerste, 1909) from the same stratigraphic unit. Foerste (1909, p 294) considered *granulosa* to be characterized by its small size and the "less strong" elevation of the anterior border with respect to the glabella relative to *F. meeki* (common in the units immediately above the Kope Formation). Subsequent illustrated descriptions (Bassler, 1919; Foerste, 1924) emphasized the markedly granulated surface as a diagnostic feature. Our material is significantly larger than Foerste's specimens, and is of comparable size to the largest *F. meeki*. Our specimens also have a long (sag.) preglabellar and an

equally long (sag.) border that slopes upward and forward anteriorly (Fig. 1-1-1.7. The first specimen of *F. granulosa* to be figured (Bassler, 1919, pl 656 figs 1,2) does not preserve details of the anterior border, but an unfigured topotype in the same lot number (USNM41857) is a partially enrolled specimen with a markedly upturned anterior border. The preglabellar field is absent in this specimen, but this may be a taphonomic artifact because the base of the border appears to have been fractured. As Foerste (1924) apparently accepted the assignment of the topotype to this species, the significance of the "less strong elevation of the anterior border" in the original description of this species (Foerste, 1909) is unclear. Material assigned to the type suite of *F. granulosa* is more pustulose than the holotype of *F. meeki* Foerste, 1910 pl 3 fig.18), but the holotype of *F. meeki* abraded (Brandt, 1980). and degree of pustulation may also have varied intraspecifically in *Flexicalymene* as in many other trilobites (Hughes, 1994).

In our material palpebral lobes are relatively small and opposite L2 (Fig. 1.1-7), whereas in previously figured *F. granulosa* the eye is opposite L3, as in the holotype of *F. meeki* and *F. retrorsa*. both in the type *F. granulosa* and our specimens the anterior width of the glabella is approximately equal to the width at L3. This approaches the condition characteristic of *Gravicalymene*, and the anterior flexure of the border and position of the palpebral in our material is comparable to the condition in *G. truncatus* (Ross, 1979, pl.3 figs. 12,16), also from the Kope Formation of northern Kentucky. In that species the preglabellar field is shorter than in our material, and hence the occipital-glabellar length accounts for a greater proportion of the entire cranial length. Some of our specimens differ from type *F. granulosa* in that the pre-palpebral dorsal furrows are anteriorly divergent (exsag.) (Fig. 1.5), but other specimens within our collection also show a convergent condition (Fig. 1. 2, 1.3, 1.6,). The quality of preservation of this material offers the possibility for detailed systematic revision of Kope Formation calymenid using a morphometric approach to document intracollectional variation and the assess the influence of taphonomy on patterns of variation. Until such work is completed, our material is best considered *F. aff. granulosa*. Because this paper is not systematic in focus, for convenience we use the term "*granulosa*" as a general descriptor for the assemblage.

FIGURE 2—Trilobites from the "*granulosa*" assemblage, Kope Formation, Kentucky. All specimens were coated with ammonium chloride sublimate prior to photography. 1-13, *Flexicalymene* aff. *granulosa*; 1, 2, CMCP2512, $\times 1.5$; 1, right lateral view, showing dorsal flexure of thorax and ventral flexure of cephalon; 2, left lateral view; 3, 4, CMCP2503, $\times 2$; 3, anterolateral view of ventrally inclined cephalon; 4, dorsal view of posterior cephalon, anterior thorax, and strongly dorsally flexed posterior thorax. Note the depth of the articulating furrow, and pyritic infilling on the posterior thoracic cavity, marked by white arrows; 5, 6, CMCP2517, $\times 2$; 5, right anterolateral view, showing dorsal flexure of thorax and ventral flexure of cephalon. Note the pyrite-filled tubular burrow; 6, left lateral view; 7, 8, CMCP2506, $\times 2$; 7, right lateral view, showing dorsal flexure of thorax; 8, left anterolateral view; 9, 10, CMCP2502, $\times 2$; 9, right posterolateral view, showing strong dorsal flexure of thorax and ventral flexure of cephalon; 10, left anterolateral view, showing obliquity of specimen to bedding direction, which is parallel to the long axis of the photograph; 11, 12, 13, CMCP2509, $\times 2$; 11, right lateral view, showing dorsal flexure of thorax and ventral flexure of cephalon; 12, left lateral view; 13, dorsal view showing compression and shearing of this specimen that was oriented almost orthogonally to bedding. 14, 15, *Primaspis* cf. *erosotus*, CMCP2538, $\times 4$; 14, Dorsal view; 15, Left lateral view.



A 250 cm² surface of the bed was prepared and systematically excavated to yield 39 articulated trilobites from the 750 cm³ of mudstone examined (Fig. 7, 8). Continued digging at the site revealed that the cluster extended slightly beyond this area, but that it was laterally restricted. Excavations of the same horizon conducted 150 cm northwest of the cluster exposed a sequence indistinguishable in bed thickness and sediment fabric from the "*granulosa*" layer. These beds yielded articulated crinoid stems but no trilobites. All trilobite specimens within the cluster were articulated and well preserved, showing fine details of surface ornament (Fig. 1.1- 1.9, 2.1- 2.13). Specimens collected included 35 *Flexicalymene* aff. *granulosa*, three *Primaspis*, and one *Ceraurus* sp. The cluster was approximately twice the thickness of the largest *F.* aff. *granulosa* specimens. A full set of data on attitude and orientation was recorded for all specimens except for CMCP2538, a *Primaspis* specimen, and CMCP2539, a *F.* aff. *granulosa* specimen recovered in the matrix after excavation, and specimens in the CMCP2281-2285 series, which were recovered on a previous occasion. While a broad range of trilobite sizes is present considering all taxa, there is marked size selectivity within *F.* aff. *granulosa* (Fig. 9).

Ceraurus specimen had a robust hypostome in place (Fig. 1.10), but the hypostome of *F.* aff. *granulosa* was relatively thin, and was forced into the glabellar cavity during compaction in some specimens (Fig. 6). The longitudinal axes of the trilobites lack preferred orientation within the sample (Fig. 10).

Many specimens show extensive pyritization (Fig. 1.4, 2.4, 6, 11). Pyrite is commonly present as filled burrows that converge on the specimens (Fig. 2.5, 11). These burrows have a constant diameter of about 2-3 mm, are convoluted, and are generally oriented sub-parallel to bedding. During excavation it was noticed that a complex of burrows about one *F.* aff. *granulosa* was linked by a single burrow some 6 cm long to a separate burrow complex associated with another trilobite specimen.

We use the term "cluster" to describe the assemblage because of the spatial restriction of the association to a defined area of relatively high concentration. Speyer and Brett (1985) suggested that clusters might be defined as having individuals of no more than 2 cm apart, but we did not find that definition to be useful in this study. A series of nearest-neighbor tests, computed using the Bio stat III statistical routine, failed to show that of either the distribution of *F.* aff. *granulosa* specimens or that of the entire trilobite sample within the excavated area was significantly subclustered. The Clark and Evans mean distance test, Campbell's goodness of fit, and William's G probability all implied a random distribution [see Pimentel (1994) for procedural details].

Co-occurrent trilobite taxa include a cheirurid (Fig. 1. 10) for which the dorsal cephalon is not known and which we tentatively refer to *Ceraurus* sp. and an odontopleurid (Fig. 2. 14, 2. 15), comparable to *primaspis crosotus* (Locke, 1843) described from the Kope Formation, and *Primaspis* species x (Rosset al., 1979) from Clays Ferry Formation. Further systematic work is needed to refine the definition of these taxa. The trilobite genera discussed in this paper are all previously known from the Kope Formation (Dalve, 1948).



GEOLOGICAL SETTING

The "*granulosa*" cluster occurs within the Kope Formation at a locality on a northwest facing hillside in which bedrock has been extensively exposed, just east of Rte. 17, 1.5 km south of the intersection with highway 275 in Covington, Kentucky. The Kope Formation consist of gray mudstone interbedded with calcisiltite and skeletal grainstone beds (Fig. 3,4) the gray mudstone contains a skeletal fauna dominated by small brachiopods, trepostome bryozoans, trilobites, crinoids, graptolites, and bivalves. Both sediment fabric and faunal composition (based on the dalmanellid brachiopod paleocommunities) suggest that the mudstones were deposited in the distal parts of a ramp in open-marine conditions at water depths of several tens of meters (Jennette and Pryor, 1993) Skeletal grainstones are interbedded with the mudstones (Fig. 3, 4) and range from mm-thick shell lags to > 30 cm thick amalgamated bioclastic limestones. Some limestone layers are capped by symmetrical ripples (ripple index 5.5) and contain horizontal burrows up to 20 mm wide. Internallamination is present within limestone beds where the clast size is about 2.80. The composition of bioclasts may vary markedly within and between limestone beds, but the limestone fauna is similar in overall aspect to that of the mudstones.

Some Kope Formation mudstones are deposited as discrete graded beds, resulting from occasional catastrophic burial events (Brandt, 1985; Holland et al., 1997; Jennette and Pryor, 1993; and Shrake, 1997). These events have been attributed to diffuse mud-laden flows associated with these events is thought to have been "quite low" (Jennette and Pryor, 1993, P. 188) such events often resulted in obrution deposits, in which living communities were smothered alive or killed shortly beforehand. The top of the Kope Formation is not exposed at the locality considered in this paper, but the presence of









FIGURE 3—The section containing the "*granulosa*" cluster prior to extensive excavation. The arrow marks the base of the 3 cm horizon containing the trilobites. The trough of the underlying megaripple is the 0.5 m level on Figure 4, and the top of the thick limestone band at the top of the photograph is the 2.0 m level.

-  Limestone (M = Mudstone, P = Packstone, W = Wackestone, G = Grainstone)
-  Mudstone

★ F. "GRANULOSA" CLUSTER




DOMINANT MACROFOSSIL

-  - BRYOZOAN
-  - ARTICULATE BRACHIOPOD
-  - BIVALVE
-  - CEPHALOPOD
-  - CRINOID
-  - GRAPTOLITE

TRILOBITE GENERA

- F - FLEXICALYMENE
- P - PRIMASPIS
- C - CERAURUS
- I - ISOTELUS

TRACE FOSSILS

-  - CHONDRITES
-  - RUSOPHYCUS
-  - HORIZONTAL BURROWS

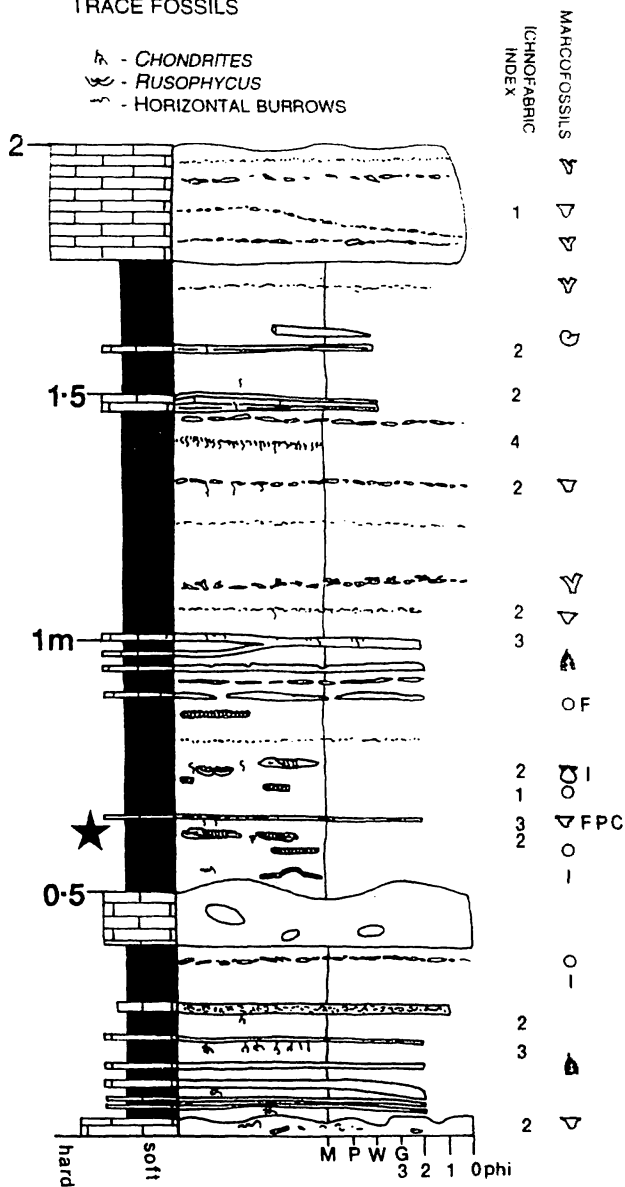


FIGURE 4—Graphic log of section containing "granulosa" cluster. Dominant macrofossils are shown to the right of the log, relative induration is indicated on left, phi scale refers to modal skeletal grain sizes. Star marks the position of the 3 cm interval containing both trilobite-bearing beds.

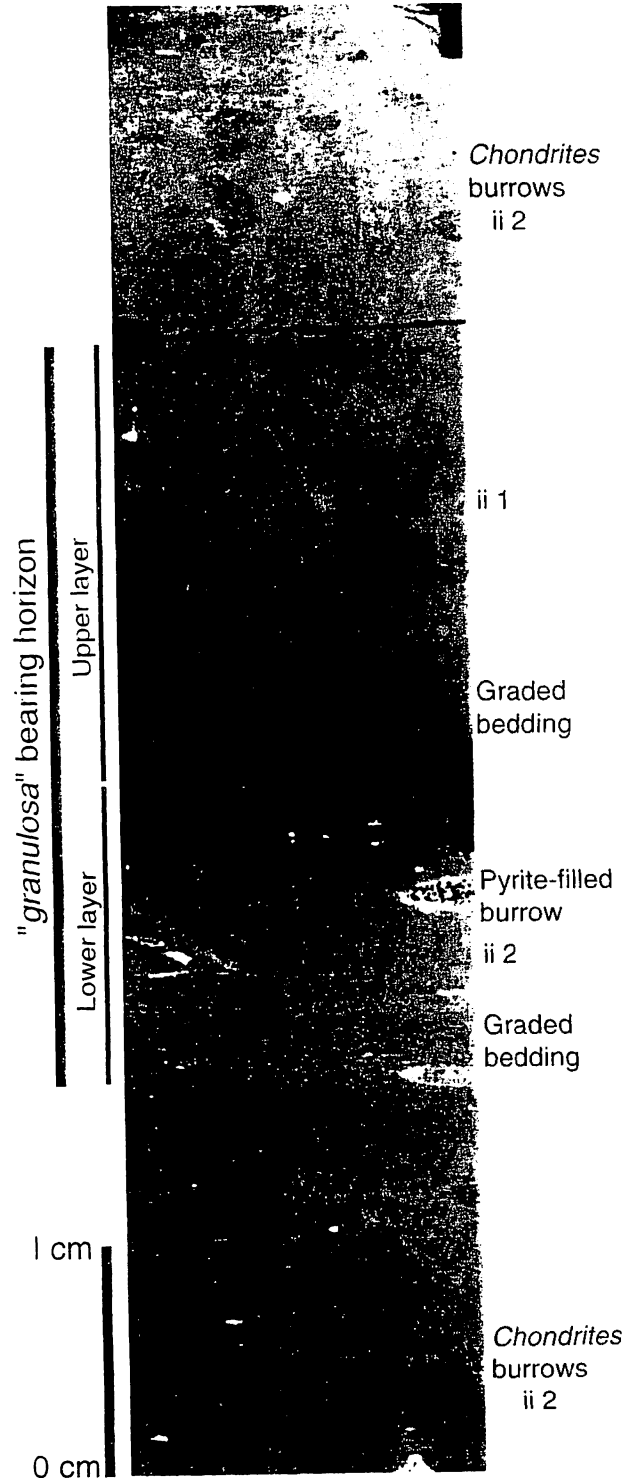


FIGURE 5—Micrograph of the section containing the "granulosa" cluster. Trilobites occur in both of the two layers outlined. Note minor normal grading in both layers, and lamination at the base of the upper layer. Bioturbation is uncommon, with ichnofabric 2 in the lower layer and 1 in the upper layer.

the *Sowerbyella* in the mudstones adjacent to the "*granulosa*" cluster, and recover of *Rafinesquina*, *Iocrinus*, and *Cryptolithus* significantly higher in the section at this site, coupled with the details of cycle anatomy (S. M. Holland, pers. comm.) indicate that the "*granulosa*" cluster lies toward the base of cycle 16 of the meter-scale cycles in the Kope and Fairview Formations (Holland et al., 1997). The limestone at meter 0.4 to 0.5 in our log (Fig. 4) corresponds to the top of the Holland et al., (1997) cycle 15, and the thick grainstone at meter 1.8-2.0 corresponds to the top of cycle 16. It is located approximately 39 m below the base of the Fairview Formation

THE "*GRANULOSA*" CLUSTER__DESCRIPTION

The "*granulosa*" cluster is located towards the top of a 13 cm mudstone interval that is capped by a thin skeletal lag. Lithologically the bed is almost entirely composed of clay, with small amounts of quartz silt. The uppermost 1.5 cm of this bed does not preserve articulated trilobites, but contains *Chondrites* burrows (ichnofabric index [ii] 2 in the scheme of Droser and Bottjer [1986] that are filled with fine silt. The "*granulosa*" cluster is contained within a 3 cm zone immediately below this uppermost layer. A thin section cut just outside of the area containing abundant trilobites shows that the zone consists of two units: 1) an upper unit, 1.8 cm thick, that shows undisturbed parallel lamination toward the base and fines upward from claystones (in the sense of Tucker, 1977) containing 10-15 percent by volume of quartz silt at the base to claystone containing <5 percent by volume of quartz silt at the top (Fig. 5); and 2) a lower unit, 1.2 cm thick, that shows similar fining-upward and contains pyrite-filled tubes. The nontrilobite skeletal fauna includes small specimens of the brachiopod *Zygospira*, and articulated crinoids belonging to *Ectenocrinus*. The "*granulosa*" cluster horizon is underlain by mudstones similar to the layer immediately above the "*granulosa*" cluster and also containing sediment-filled *Chondrites* of ii 2. Articulated trilobites are also recorded in mudstone overlying the 13 cm layer containing this assemblage, but are far less abundant (Fig. 4).

Thin sections cut through specimens within the assemblage suggest disturbance of the sedimentary fabric. The two distinct layers recognized laterally cannot be distinguished, and there is no trace of lamination or grading, other than a general bedding parallel fabric to the clay (Fig. 6). The trilobite body cavity contains patches of wispy pyrite and blocklike pyrite beneath thoracic segments. The bases of voids within the exoskeleton are filled by dense masses of framboidal pyrite, whereas the upper portions of these voids contain sparry calcite geopetals (Fig. 6). Pyrite infillings of pore canals in the exoskeleton (Fig. 6) are composed of small framboids. The blocklike pyrite appears to be aggregates of framboids.

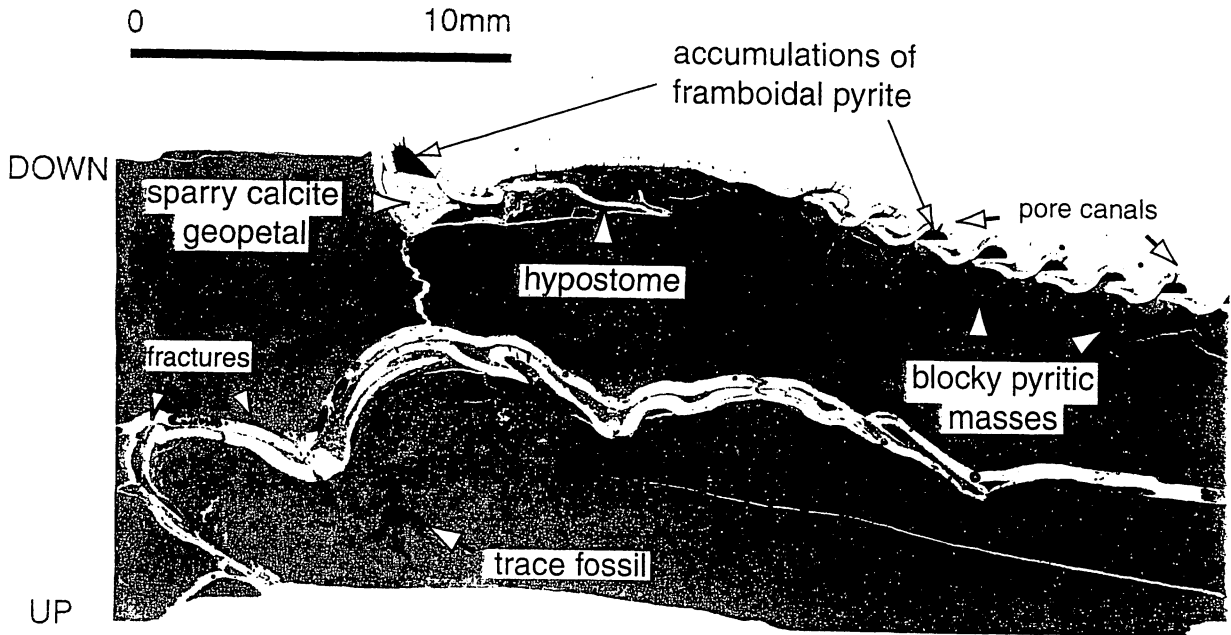


FIGURE 6—Thin section through two specimens of *F. aff. granulosa* (Foerste). Note that the micrograph is inverted, and that stratigraphic up is at the base. The specimen shown at the upper part of the figure is a transverse section along the sagittal axis of the thorax, but the cranidium is rotated with respect to the thorax, and is slightly sagittally oblique. The specimen at the lower part of the figure is an oblique section across several thoracic segments. The exoskeleton is commonly fractured due to compression, but several fractures in the matrix are of recent origin. Sparry calcite infills give evidence of the original orientation of the specimen, and must have formed after pyritization. Blocky and wispy pyrite concentrated around the specimens indicate decaying soft-tissues. Pore canals and tubercles are infilled with framboidal pyrite. CMCP2284.

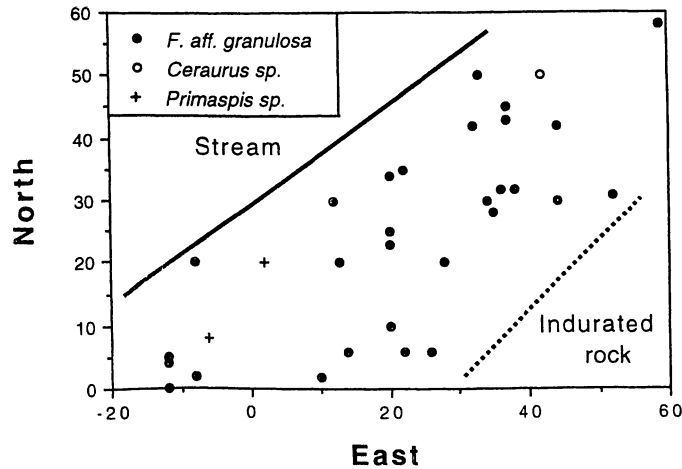


FIGURE 7—Distribution of articulated trilobites within the “*granulosa*” cluster. Northeastern area eroded by stream activity, southwest corner too strongly indurated to collect. Trilobites within the cluster are not significantly sub-clustered.

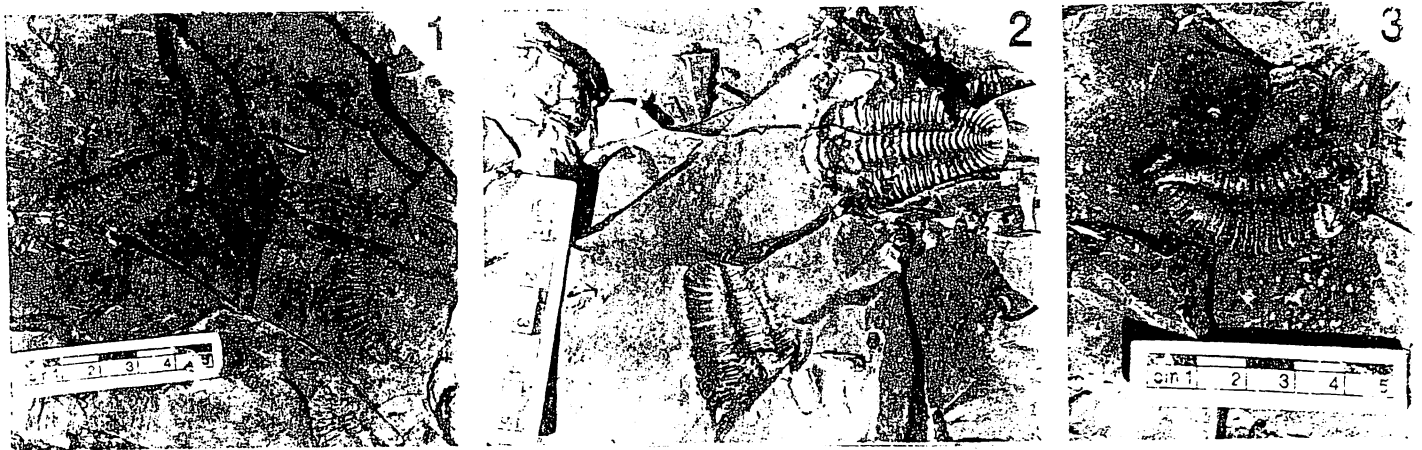


FIGURE 8—Specimens in the “granulosa” cluster at the time of collection. Scale bar is oriented north-south, with 0 cm at the north end. 1, Specimen on right is CMCP2517 situated orthogonal to bedding and showing dorsal flexure of the thorax, prone specimen at upper left is CMCP2515 and is dorsal upward. 2, Two inverted prone specimens, lower is CMCP2518, upper right is CMCP2519. 3, CMCP2527, inclined to bedding and showing dorsal flexure of the thorax.

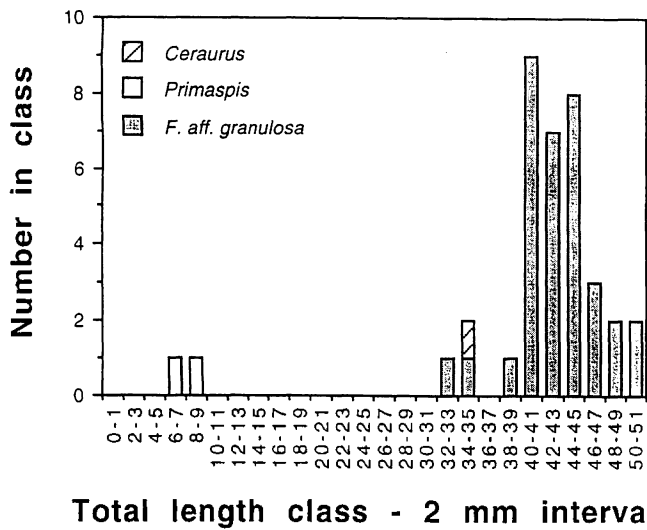


FIGURE 9—Size distribution of specimens within the “granulosa” cluster. *F. aff. granulosa* (Foerste) specimens are clustered at length of 4–5 cm. Note marked size-segregation is shown between *Primaspis* and *Flexicalymene*. n = 37.

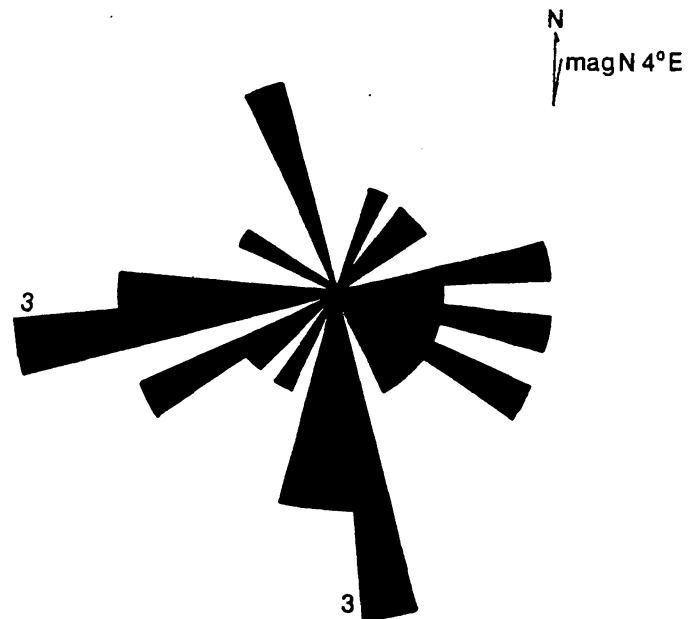


FIGURE 10—Orientation of specimens in the “granulosa” cluster. Note the lack of obvious preferred orientation.

A 250 cm² surface of the bed was prepared and systematically excavated to yield 39 articulated trilobites from the 750 cm³ of mudstone examined (Fig. 7, 8). Continued digging at the site revealed that the cluster extended slightly beyond this area, but that it was laterally restricted. Excavations of the same horizon conducted 150 cm northwest of the cluster exposed a sequence indistinguishable in bed thickness and sediment fabric from the "*granulosa*" layer. These beds yielded articulated crinoid stems but no trilobites. All trilobite specimens within the cluster were articulated and well preserved, showing fine details of surface ornament (Fig. 1.1- 1.9, 2.1- 2.13). Specimens collected included 35 *Flexicalymene* aff. *granulosa*, three *Primaspis*, and one *Ceraurus* sp. The cluster was approximately twice the thickness of the largest *F.* aff. *granulosa* specimens. A full set of data on attitude and orientation was recorded for all specimens except for CMCP2538, a *Primaspis* specimen, and CMCP2539, a *F.* aff. *granulosa* specimen recovered in the matrix after excavation, and specimens in the CMCP2281-2285 series, which were recovered on a previous occasion. While a broad range of trilobite sizes is present considering all taxa, there is marked size selectivity within *F.* aff. *granulosa* (Fig. 9).

Ceraurus specimen had a robust hypostome in place (Fig. 1.10), but the hypostome of *F.* aff. *granulosa* was relatively thin, and was forced into the glabellar cavity during compaction in some specimens (Fig. 6). The longitudinal axes of the trilobites lack preferred orientation within the sample (Fig. 10).

Many specimens show extensive pyritization (Fig. 1.4, 2.4, 6, 11). Pyrite is commonly present as filled burrows that converge on the specimens (Fig. 2.5, 11). These burrows have a constant diameter of about 2-3 mm, are convoluted, and are generally oriented sub-parallel to bedding. During excavation it was noticed that a complex of burrows about one *F.* aff. *granulosa* was linked by a single burrow some 6 cm long to a separate burrow complex associated with another trilobite specimen.

We use the term "cluster" to describe the assemblage because of the spatial restriction of the association to a defined area of relatively high concentration. Speyer and Brett (1985) suggested that clusters might be defined as having individuals of no more than 2 cm apart, but we did not find that definition to be useful in this study. A series of nearest-neighbor tests, computed using the Bio stat III statistical routine, failed to show that of either the distribution of *F.* aff. *granulosa* specimens or that of the entire trilobite sample within the excavated area was significantly subclustered. The Clark and Evans mean distance test, Campbell's goodness of fit, and William's G probability all implied a random distribution [see Pimentel (1994) for procedural details].

Nearest -neighbor test can be distorted by increased distances among specimens located near the boundaries (Foote, 1990), but as the distribution is random, end-effects appear to have been insignificant in this case. The mean distance among all specimens within the cluster was 4.4cm, which provides a measure of the overall density of the sample. Several specimens were found in point-contact within the cluster (Fig.8), but these cases do not form significant sub-clusters.

Specimens within the sample showed a wide range of attitudes with respect to bedding. Fifty-four percent of 37 specimens were inverted with the dorsal surface resting on the sediment, 14 percent were inclined to bedding, and 32 percent were in the dorsal-up attitude (Appendix 1) only *F. aff. granulosa* were inverted, but the small sample sizes of *Primaspis* and *Ceraurus* make the significance of the absence of inversion in these taxa questionable. Most *F. aff. granulosa* specimens show some degree of flexure, and a wide range of postures are seen within the sample (Fig. 1,2,12). Several of the prone specimens show slight ventral flexure of the Cephalon (Fig.1.1, 1. 4). a consequence of this flexure is that the free cheeks are partly obscured, causing the anterior cranial border to appear to jut forward of the margin of the free cheeks (Fig. 1.1 1.2). The anterior border is more even in specimens where the cephalon and thorax lie in the same plane (Fig. 1.3, 1.5). Rare specimens show a consistent pattern of either dorsal (Fig.2.7) or ventral (Fig. 1.9) flexure, although the degree of flexure varied along the axis. (Fig. 1.7, 2.1-2.6, 2.9- 2.13). For example, in CMCP2539 (FIG 1.7, 1.8) marked dorsal flexure in the middle to posterior part of the thorax is complimented by ventral flexure of the cephalon and anterior thorax, whereas in CMCP2503(FIG.2.3, 2.4) anterior dorsal flexure is complimented by slight posterior ventral flexure. Relatively short axial rings in the anterior part of the thorax, associated with long articulating half rings (Fig.6), may indicate that maximum dorsal flexure inflection point is commonly between the fourth and seventh thoracic segments (Fig.1.6 2.1 2.2 2.5-2.10). The degree of flexure was assigned to one of five arbitrary classes along a ranked scale, ranging from partially enrolled (seen in one dorsal-up specimen) through to specimens that show strong dorsal flexure (Fig.11). Just over 50 percent of the specimens show some degree of flexure, but the remainder (47 percent) are prone. Most flexed specimens show slight (Fig.1.6) to moderate dorsal flexure (Fig.2.7, 2.8), but there are some cases where dorsal flexure is extreme (Fig. 1.7, 2.4).

Data on the length, orientation, attitude, flexure, and torsion of *F. aff. granulosa* (Appendix1) were examined for patterns of covariation to explore possible controls on specimens disposition. Specimen length and orientation did not correlate with each other, or with any of the other three variables. There is no correlation between the attitude and flexure



FIGURE 11—X-ray radiographs of *Flexicalymene* aff. *granulosa* (Foerste), Kope Formation, Kentucky. 1, Dorsal view of strongly dorsally flexed specimen showing concentration of X-ray opaque material (white arrow) in pygidial and cephalic regions compared to the surrounding matrix. White areas within the exoskeleton are because the specimen is extremely thin in these areas, CMCP2539, $\times 1$. 2, Dorsal view of dorsally flexed specimen showing pyritized tubular burrows (white arrows) converging on the trilobite exoskeleton and fine, wispy, pyritic strands within the body cavity. Wispy pyrite at base of specimen (black arrow) fill the body cavity of another trilobite, CMCP2503, $\times 1$. 3, Left lateral view of dorsally flexed specimen. Note pyrite-filled burrows converging on the specimen, CMCP2517, $\times 1$.

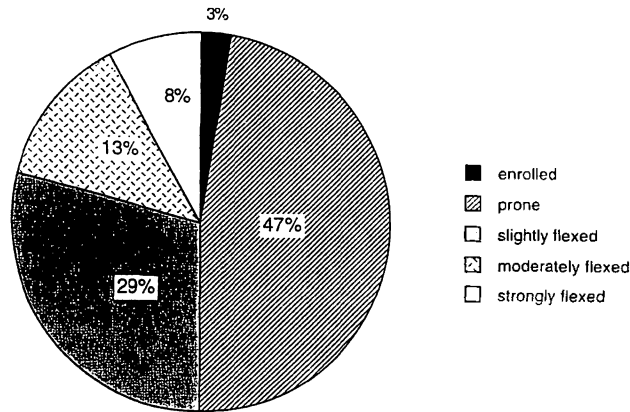


FIGURE 12—Patterns of flexure within *F.* aff. *granulosa* (Foerste). Specimens were assigned to five arbitrary categories ranging from partially enrolled (CMCP2530), though prone (e.g., CMCP2504), slightly flexed (e.g., CMCP2532), moderately flexed (e.g., CMCP2506), to strongly flexed (e.g., CMCP2503). $n = 35$.

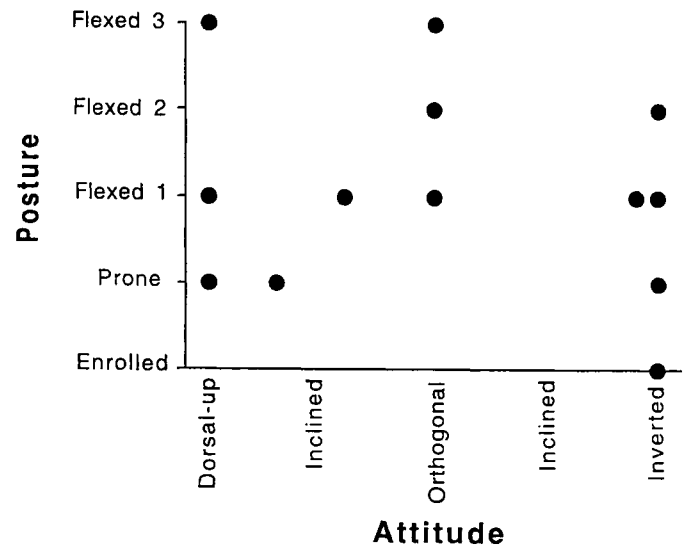


FIGURE 13—Relationship of degree of flexure to specimen attitude in *F.* aff. *granulosa* (Foerste). There is no obvious relationship between these attributes, suggesting that posture is largely independent of attitude. However, note that no inclined specimens were prone. $n = 34$.

pattern (Fig.13); both inverted and dorsal -up specimens show a variety of degrees and style of flexure. However, all specimens that were inclined to bedding show some degree of flexure (Fig.13). Specimens inclined to bedding also show torsion (Fig. 1.6, 2.10). Only flexed specimens show torsion, but as torsion is most obvious in specimens inclined to bedding it was likely caused by disturbance during compaction rather than by differential flexing of muscles on the right and left sides of the animal. Specimens inclined almost orthogonally to bedding show both compression and shearing (Fig.2.13). This shearing involved fracture of the exoskeleton and is distinct from torsion (e.g., Fig. 1.6, 2.8), in which thoracic pleurae are stacked on one side of the axis and splayed on the other side.

In several of the prone specimens, the distal pleural tips on one side of the thorax are fractured and obscured beneath the pleurae (Fig.1.1, 1.5, 1.6). This may be the result of compression of specimens that were slightly inclined to bedding prior to sediment compaction. In other cases compression may have exaggerated the natural flexure posture. For example, in CMCP2539 (Fig.1.7) the pygidium is parallel to bedding. given the angular disjunction between this structure and the dorsally flexed posterior thoracic segment, which has been thrust over the pleural region of the pygidium, we suggest that compression caused rotation of the pygidium into bedding-parallel orientation

THE "GRANULOSA" CLUSTER__INTERPRETATION

*Sedimentology.*__ The presence of lamination and normal grading in the upper 1.8cm portion of the 3cm zone containing the trilobites suggest that final burial was the result of obrution during rapid deposition from a pulsed or turbulent sediment-laden flow. As trilobites are also found in the 1.2cm, subtly graded, claystone unit below the upper level, it is possible that some animals were partially infaunal at the time of burial, or that there were two pulses of deposition that were separated by a time interval so short that trilobites in the lower layer were unable to extricate themselves from burial during the initial event before being swamped by the second event. The apparent unity of taphonomic features in both beds strongly suggest that the two layers were deposited in rapid succession, most probably as different phases of a single event . The laminated depositional fabric preserved in the upper mudstone unit suggest that the mud was coherent from the time of burial onwards, and that neither animal activity or dewatering significantly fluidized the sediment. Taphonomic features of the fossil suggest that burial took place over a short interval , such as that usually lasts less than one hour (see Allison and Brett, 1995).

The pattern of grading and minor lamination in these beds resemble that described in "unifites" by Myrow and Hiscott (1991), with

the lower layer resembling a Type 1B unifite, and the upper layer a Type 2 unifite. The various types of unifites represent different flow regimes that can pertain during a single gravity-flow event, such as may be generated by storms. The lower layer may represent the liquefaction of flowing mud, whereas the upper layer may indicate declining flow rates, the entrainment of water into the flow, and the increasing influence of turbulence. The "*granulosa*" beds are thin compared to typical unifites, and may represent the distal expression of these events. This could explain why the trilobite and crinoid fauna appears nontransported, in contrast to the pattern of faunal entrainment seen in comparable episodes of preservation, such as in the Burgess Shale (Allison and Brett, 1995).

The relative scarcity of trace fossils throughout the 13cm interval may indicate conditions of relatively low-oxygen within the sediment (Sarvrda and Bottjer, 1987), although the presence of nontransported trilobites and crinoids suggests that oxygenation above the sediment-water interface was normal, and the claystone is poor in organic material. Although minor pyrite does occur scattered throughout the mudstones, it is concentrated about the trilobites. If the sediment were at least partially oxidized at the time of soft-tissue decay, then concentration of organic matter around the trilobite carcasses would have generated an anoxic-microenvironment in that region, and soluble iron would have diffused toward the site of sulfate production, producing a pyritized carcass (Allison and Brett, 1995). The pyritization appears comparable to that reported in many other cases of the rapid burial of trilobites in muds (eg., Babcock and Speyer, 1987; Bruton and Haas, 1997; Speyer and Brett, 1986). The wispy pyritic infill of the body cavity of many specimens suggest that decaying softparts of *F. aff. granulosa* may have been pyritized in situ. The blocks of pyrite beneath the thoracic segments might represent the positions intersegmental bars known in other trilobites, which are known to have been relatively resistant to decay (Whittington, 1993a). Masses of framboidal pyrite are apparently similar to the "liner pyrite" described by Babcock and Speyer (1983). The decaying body apparently attracted infaunal organisms, evinced by the pyrite-filled tubes (Fig. 2. 5, 11.2, 11.3). The constant diameter of these tubes, their convolution, and their predominantly subhorizontal orientation except when associated with a trilobite, all demonstrate that they are organic in origin, and precludes their interpretation as gas escape structures. Pyritization obviously took place shortly after burial, before organic tissues had decayed completely.

The constant thickness (at the meter-scale) and sediment fabric of the 13 cm mudstone interval containing the assemblage, coupled with the lack of preferred specimen orientation, suggest that the cluster was

not the result of the physical concentration of specimens in a channel. This interpretation is supported by the pattern of specimen size distribution and of posture within the sample. The broad range of sizes among taxa, but constancy within taxa, precludes a mechanical explanation for the association of trilobites because it is hard to conceive of a physical mechanism that could size select only large *F. aff. granulosa* while also incorporating the much smaller *Primaspis*, and complete, articulated crinoids. Furthermore, if flexure pattern were flow-related we might expect to find comparable numbers of enrolled and dorsally fixed specimens, but this is not the case. Rather the taxic, size, and physical distribution all suggest that the cluster represents a congregation of trilobites that assembled during the lives of these animals. We consider the assemblage to be a "type 3" or "thick mud tempestite" obrution deposit that formed slightly below storm wave base (Brett et al., 1997), and one that is comparable to trilobite taphofacies 3A and 4B of the Speyer and Brett (1986) scheme. This deposit represents an instant in time, with events related to the death of the trilobites recording a timescale of minutes to hours, and pyritization within hours to days of death.

Although the specimens have been vertically compressed, the contiguous nature of sclerite boundaries in all prone specimens argues against their molted exuviae in which open sutures had subsequently re-closed during compression (see Whittington, 1990). Furthermore, the pattern of flexure suggest that the animals possessed hydrostatic turgor and structural integrity at the time of preservation, rather than being empty exuviae. The presence of scavenger burrows, pyritization of decaying soft-parts, and lack of disarticulated sclerites confirm that the animals were intact at the time of preservation.

Size range and clustering behavior.---The assemblage of *F. aff. granulosa* could represent either a single cohort that remained associated since birth or a congregation that assembled on the basis of size-selection. The rarity of size-segregated clusters in the trilobite fossil record (Speyer and Brett, 1985) argues against the common association of cohort members to the exclusion of members of other cohorts [although it is possible that in some cases mixing of sizes can be diagnostic of time -averaging even in well preserved assemblages (e.g., Sheldon, 1988), even though a spread of sizes has been considered diagnostic of autochthonous assemblages (Fortney, 1975)]. The range in overall length between the smallest and largest *F. aff. granulosa* within the sample is 45 percent of the length of the smallest individual. This may suggest that the cluster contains more than a single molt stage of *F. aff. granulosa* because it exceeds that normally seen within members of a single cohort of moderately-sized marine arachnomorphs that have experienced similar environmental conditions during growth (Sekiguchi et al., 1988, p. 192). Arthropod growth is sensitive to

environmental fluctuations (e.g., Hartnoll, 1978, 1982), and it is possible that all *F. aff. granulosa* were of similar age, even if they had not been associated since birth, but had gathered together from different populations. Alternatively, there may have been sex-related differences in the size of individuals from a single cohort, but this seems less likely because the length distribution is not bimodal.

The podlike nature of the cluster suggest that aggergation had some specific biotic function. Possible reason for congregation (all known to cause clustering in various extant marine arthropods) include feeding, a responce to environmental disturbance, or mating behavior. *Flexicalymene* from the Cincinnati is one of the few trilobites known in direct association with a trace fossil, in this case the burrow *Rusophycus* (Osgood, 1970), a trace fossil that has been interpreted as a feeding trace in some conterminant trilobites (Bergstrom, 1973; Brandt et al., 1995; Jensen, 1990). Although *Rusophycus* burrows were found a few centimeters above the "*granulosa*" cluster (Fig.4). no *Rusophycus* have been recorded within the bed, and no evidence for any food source concentrated in this area had been preserved. The size distribution of individuals questions this association being feeding-related (or disturbance-related), because it is unclear why only *F. aff. granulosa* of a particular size range should have congregated if this were the case. The complete specimens of *Primaspis* are similar in size to each other, but a specimen damaged during collection was apparently a few millimeters longer. Whatever was responsible for stimulating the individuals to congregate attracted more than a single taxon and, given the size difference between *F. aff. granulosa* and *Primaspis*, ecological roles within the cluster were apparently partitioned among taxa.

Exceptionally well-preserved trilobite clusters in the Middle Devonian of New York have been interpreted to be related to molting and copulation (Speyer and Brett's (1985) study, assemblages of similarly-sized articulated specimens were reported to be close to assemblages of molted exuvae belonging to similarly-sized individuals found close-by on the same bedding planes. these two clustering patterns were interpreted as assemblages preserved pre-molt (body clusters), and post-molt (molt clusters) respectively. The "*granulosa*" cluster is similar to the body cluster of Speyer and Brett (1985) in terms of size-selectivity and the predominantly inverted attitude of the specimens; however, it is lower in density than the Hamilton Group clusters, shows no evidence of specimen-pairing within the sample, and is polytaxic (other clusters in the Hamilton Group are polytaxic) (C. E. Brett, personal commun., 1998).

Like the "*granulosa*" cluster, Middle Devonian trilobite clusters from Iowa and Illinois are also polytaxic and show a similar pattern of size distribution (Hickerson, 1997). Polytaxy suggested to Hickerson that

the clusters were unrelated to reproduction. We have no new evidence in this regard, but do not consider that polytaxy precludes a reproductive cluster in the case of *F. aff. granulosa*. It is possible that a common environmental cue triggered mating behavior in a variety of species simultaneously. Given that a number of crusteans from size-selective congregations in relation to mating behavior (see Speyer and Brett, 1985), it is interesting to note that while all specimens of *F. aff. granulosa* are holaspides and therefore likely adult (Hughes and Chapman, 1995), there is no obvious dimorphism among them (also see Hughes and Fortey, 1995; Speyer and Brett, 1985; Fortey and Hughes, 1998). The "*granulosa*" cluster is more discrete and uniform than accumulations with varied articulation patterns such as those from the Upper Cambrian, McKay Group of British Columbia (Chatterton and Ludvigsen, 1998), or the Silurian *Aulacopleura* shales of the Czech Republic (Hughes and Chapman, 1995). In those examples, bedding plane assemblages likely represent hours to months of accumulation, and so are more time-average than the "*granulosa*" assemblage.

Attitude and posture .----- Regardless of the reason for the clustering, the disposition of specimens within the cluster, and the postures in which they were preserved, are likely attributable to the events related to their deaths. Both sedimentary features and the excellent specimens preservation indicate that they were buried quickly without significant transportation, but any more detailed explanation of their preservation must account for two important observations: 1) that the majority of the specimens are inverted and; 2) that many of the specimens show complex patterns of flexure. Given that postures are not the result of transportation, and that compaction has merely modified original stances, flexure and inversion patterns are either due to 1) the movement of live animals suddenly smothered by the rapid deposition of mud; or 2) biotically-related taphonomic influences acting on carcasses of trilobites killed shortly prior to burial.

Data on specimen posture are critical for resolving between these two possibilities. The structure of the thorax appears similar to that illustrated in *F. senaria* (Walcott, 19214, pl 96, fig.3; pl 101), particularly in the possession of a deep articulating furrow (Fig. 2. 4, 6) that accommodated the posterior margin of the axial ring of the preceding segment during dorsal flexure. The combination of the depth of this furrow with the short sagittal length of the axial rings (Fig. 1.1-1.6), permitted considerable dorsal flexure. Axial ring morphology varied along the thorax, with anterior segments characterized by rings that shorten axially because the concavity of the posterior margin exceeds the convexity of the anterior margin (Fig. 1.1-1.5). Posterior segments have longer rings with a more uniform shape, and a greater degree of anterior arching (Fig. 1.1-1.5). Variation in arching of axial rings

correlates with more strongly arched pleurae in posterior segments and the consequent sagittal shift in the position of the fulcrum (Fig. 1.1-1.3). Although compaction-related breakage and shear of the exoskeleton has occurred in some cases, and thin sections of the exoskeleton shows considerable fracturing (Fig. 6), most *F. aff. granulosa* postures represent movements of the body that were governed by exoskeletal architecture, indicating that they could have been assumed by live animals.

Given that the movements are physically possible for *F. aff. granulosa* both inversion and flexure could reflect the movements of live animals, recording their final postures before succumbing to the conditions that lead to their deaths. Specimens may have inverted prior to burial, or as a response to the onset of burial. The former appears more likely if some specimens were partially infaunal prior to burial (see above). Hickerson (1997) recorded that specimens inversion was common within midwestern Devonian trilobite body clusters, and Speyer (1985) noted that the great majority of specimens were inverted in body clusters of the co-occurrent taxon *Greenops boothi*. This difference was attributed to contrasting patterns of molting in the two species. The similarity between the "*granulosa*" cluster and the body clusters found in the Hamilton Group is striking, particularly in the size-selective aspect. On the basis of analogy (and possibly behavioral homology) with the Hamilton clusters we suggest that inverted postures in *F. aff. granulosa* could represent the initial phases of molting, as in *Phacops rana* and possibly also of other trilobites (Chatterton and Ludvigsen, 1998). Alternatively, inversion might reflect a posture adopted in the early stages of sudden burial, related either to enrollment or to escape strategy. The varied flexed postures, if the result of a live animal, indicate vigorous activity associated with the animal trying to free itself from a thixotropic medium. This is supported by the lack of lamination in the muds encasing the trilobites (Fig. 6), despite clear lamination in adjacent muds (Fig. 5). Dorsal arching of the thorax would provide increased exposure of the underlying appendages, which could have maximized surface area for pushing against the mud, or for breathing in conditions of reduced oxygen availability. The observation that all specimens inclined to bedding show flexure is important in this regard. Dorsal-up or inverted specimens may have been killed shortly after burial, but those that were inclined were preserved in escape posture.

Alternatively, death of the animals shortly prior to burial might also account for both inversion and flexure patterns. Actualistic observations of arthropod necrosis suggest that carcasses may invert during decay due to the buildup of gasses in the body cavity [see Speyer (1997) for a detailed discussion of inversion]. If this were the case, the "*granulosa*" assemblage would have had to have been buried during a critical interval just

as specimens began to invert but before they started to disarticulate or to disperse due to buoyancy. In this case, necrolysis could not have progressed far, because the pattern of flexure seen in all specimens of *F. aff. granulosa* is consistent with the inferred musculature and known constraints of skeletal architecture, and the natant hypostome of *F. aff. granulosa* is approximately at its life position at least in some specimens. Flexure in *F. aff. granulosa* might represent a rigor mortis posture related to continued necrotic decay of soft tissues following final burial, as has been suggested for the partially enrolled stance of some *Phacops* (Babcock and Speyer, 1987). Slight dorsal flexure of the thorax, accompanied by ventral tilting of the Cephalon and pygidium, is a common stance in calymenids (Chatterton and Campbell, 1993; Thomas and Lane, 1984, fig. 2A, 2 E) and in some other trilobites (e., g., Bruton and Haas, 1997; Zell, 1988) and could be a decay-related posture. Marked dorsal flexure is also inferred to have occurred in illeanid trilobites, but the structure of the thoracic axis was unique in this group (Whittington, 1997), and not directly comparable to that seen in *F. aff. granulosa*. Without a full knowledge of trilobite musculature and associated ligaments and tendons it is difficult to assess whether the posture found in the "*granulosa*" cluster could be the result of necrolysis, but if that were the case we might expect a more consistent pattern of flexure throughout the sample. Furthermore, if dorsal flexure were a decay posture it should be a widespread stance among *Flexicalymene* specimens collected from other localities, and this is not the case. Nor is there correlation between attitude (dorsal up, inclined, or dorsal down) and posture, as might be expected if posture were determined by decay. A range of degrees of flexure occurs in each of the three attitude categories (Fig. 13). Burrowing activity is unlikely to have produced the posture seen because the degree of bioturbation is low and the size of the burrows small. Animals large enough to physically cause the flexure seen would have left larger trails, and would likely have resulted in partial disarticulation of the carcasses.

Based on the evidence presented above we considered the cluster likely to represent animals buried alive and whose stances are escape postures. If this is correct then the internal musculature of *F. aff. granulosa* must have permitted simultaneous dorsal and ventral flexure at different portions of the exoskeleton. The muscles of *F. aff. granulosa* remain unknown, but were likely similar to those found in a variety of polymerid trilobites that share similar overall thoracic architecture (Whittington, 1980), particularly to those of other calymenid trilobites, such as *Trimerus* (Whittington, 1993 b), that also show dorsal flexure. In these forms flexure is thought to have been facilitated by two antagonistic sets of longitudinal muscles situated above and below the hinge line respectively. These muscles were arranged as bands that extended from the cephalon to the pygidium (see Campbell, 1975;

Cisne, 1981 Raymond, 1920 Whittington, 1993a) and were aided by additional muscles dorsoventral muscles. Simple ventral flexure, such as seen in CMCP2530 (Fig.1.9), could have been achieved by the contraction of the ventral longitudinal muscle, situated below the fulcrum, and relaxation of the dorsal longitudinal muscles, situated above the fulcrum. Reversal of this pattern could in the pattern of simple dorsal flexure seen in CMCP2506 (Fig. 2.7, 2.8), Complex patterns of flexure, combining

dorsal and ventral rotation indicate that the animal could contact some portion of a longitudinal muscle while relaxing other portions. This suggests that the longitudinal muscles were made up of a series of muscular bands [as in the *retractor dorsalis* in the milliped *Sphaerotherium* (Manton, 1977)], that could act independently at different points along the body. Dorsal flexure would result in an increase in hydrostatic pressure above the hinge line. The most profoundly dorsally-flexed specimens also show ventral flexure at other points of the exoskeleton. This complex posture may have helped equilibrate pressure throughout the body. The pattern of flexure contrast markedly with the enrolled condition common in *F. meeki* from higher in the Cincinnati (Brandt, 1985), in which enrollment likely protected the animals by creating a sealed microenvironment around the soft tissues (Babcock and Speyer, 1987; Bruton and Haas, 1997). Although one specimen of *F. aff. granulosa* shows partial enrollment, we suggest that whatever conditions pertained during the swamping of this assemblage resulted in the majority of animals trying to escape by vigorous movement, rather than enrolling. If this is the case, this is a behavioral response that had not been previously documented in trilobites. the question of why trilobites in the "*granulosa*" cluster chose to flex rather than enroll is not answered by our analysis. Enrollment is more common in shallow water deposits (Chatterton and Ludvigsen, 1998), and preliminary observations of a deposit containing numerous enrolled *Flexicalymene meeki*, dated later in the Cincinnati from near Monroe, Ohio, shows that the grain size of the enclosing matrix is slightly courser, perhaps suggesting a more proximal, and possibly better oxygenated setting. When compared to the "*granulosa*" cluster, most beds containing abundant enrolled *F. meeki* are lower density, thicker, possibly of more homogeneous sedimentary fabric and contain a resident infauna of Bivalves (Brandt, 1985).

DISCUSSION

At the meter scale, the distribution of trilobites in the "*granulosa*" assemblage is localized. It remains to be seen whether this horizon contains other clusters that can be traced regionally, as is characteristic of beds showing clustering within the Hamilton Group (Babcock and Speyer, 1987, Speyer and Brett, 1985, within other horizons showing

extremely well-preserved trilobites both within the Cincinnati (Brandt, 1985; Schumacher and Shrake, 1997. or other units (Hickerson, 1997). The unique attributes of this cluster make its horizon a good target for lateral tracing

The number of detailed taphonomic analyses of trilobite body clusters described to date is very limited, and molt clusters, and which parameters are critical for describing and distinguishing clusters (see the variety of approaches used in Hickerson, 1997; Schumacher and Shrake, 1997; Speyer and Brett, 1985, 1986). Nevertheless given the diversity and complexity of both sedimentary environments and trilobite exoskeletal architectures, it is remarkable that broadly similar patterns of trilobite behavior and preservation can be inferred in species separated by significant taxonomic distance (Fortey, 1990) and a 60 million year interval.

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APPENDIX I

Specimen number	Taxon	Length (mm)	Long axis orient.	North	East	Attitude	Flexure	Tortion
CMCP2501	<i>F. aff. granulosa</i>	50	35	42	32	0.0	2	1
CMCP2502	<i>F. aff. granulosa</i>	42	230	30	44	1.0	3	1
CMCP2503	<i>F. aff. granulosa</i>	40	260	43	37	0.0	4	0
CMCP2504	<i>F. aff. granulosa</i>	50	120	50	33	1.0	1	0
CMCP2505	<i>F. aff. granulosa</i>	45	100	42	44	1.0	2	0
CMCP2506	<i>F. aff. granulosa</i>	42	110	45	37	1.0	3	1
CMCP2507	<i>Ceraurus sp.</i>	35	0	50	42	0.0	1	0
CMCP2508	<i>F. aff. granulosa</i>	41	230	50	42	0.2	1	0
CMCP2509	<i>F. aff. granulosa</i>	32	255	30	12	1.0	3	1
CMCP2510	<i>F. aff. granulosa</i>	49	335	20	-8	1.0	1	0
CMCP2511	<i>P. cf. crosotus</i>	7	170	8	-6	0.0	1	0
CMCP2512	<i>F. aff. granulosa</i>	46	130	2	-8	0.5	3	0
CMCP2513	<i>F. aff. granulosa</i>	41	255	5	-12	1.0	2	1
CMCP2514	<i>F. aff. granulosa</i>	41	135	4	-12	1.0	1	0
CMCP2515	<i>F. aff. granulosa</i>	44	95	0	-12	1.0	2	0
CMCP2516	<i>P. cf. crosotus</i>	11	85	20	2	0.0	1	0
CMCP2517	<i>F. aff. granulosa</i>	38	335	35	22	0.0	2	0
CMCP2518	<i>F. aff. granulosa</i>	44	160	30	34	1.0	1	0
CMCP2519	<i>F. aff. granulosa</i>	46	250	32	36	1.0	1	0
CMCP2520	<i>F. aff. granulosa</i>	40	70	28	35	0.0	2	0
CMCP2521	<i>F. aff. granulosa</i>	35	70	32	38	1.0	1	0
CMCP2522	<i>F. aff. granulosa</i>	40	290	32	38	1.0	1	0
CMCP2523	<i>F. aff. granulosa</i>	41	290	34	20	0.0	2	0
CMCP2524	<i>F. aff. granulosa</i>	44	90	23	20	0.5	4	0
CMCP2525	<i>F. aff. granulosa</i>	46	220	34	20	1.0	1	0
CMCP2526	<i>F. aff. granulosa</i>	44	270	25	20	0.0	1	0
CMCP2527	<i>F. aff. granulosa</i>	48	160	20	28	0.3	2	1
CMCP2528	<i>F. aff. granulosa</i>	41	165	20	28	1.0	1	0
CMCP2529	<i>F. aff. granulosa</i>	44	45	20	28	1.0	3	0
CMCP2530	<i>F. aff. granulosa</i>	42	140	20	13	1.0	0	0
CMCP2531	<i>F. aff. granulosa</i>	45	10	2	10	0.0	2	0
CMCP2532	<i>F. aff. granulosa</i>	42	170	10	20	1.0	2	1
CMCP2533	<i>F. aff. granulosa</i>	43	185	6	14	0.5	2	0
CMCP2534	<i>F. aff. granulosa</i>	42	110	31	52	1.0	1	0
CMCP2535	<i>F. aff. granulosa</i>	44	260	58	59	1.0	1	0
CMCP2536	<i>F. aff. granulosa</i>	40	200	6	26	0.0	1	0
CMCP2537	<i>F. aff. granulosa</i>	42	185	6	22	1.0	2	1
CMCP2538	<i>P. cf. crosotus</i>	8					1	
CMCP2539	<i>F. aff. granulosa</i>						3	

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Trilobite Tales (pygidia?)

First of all this article is not a research paper with pictures, diagrams and references. This is a recounting of some unusual, to say the least, trilobite discoveries over a lifetime of collecting. This has all come about because of recent discussions with a fellow paleontologist. After a few glasses of Cynthiana, tales of great discoveries would flow, the retelling of which would have us reeling with delight and amusement. Add the classical music and we were in a paleo-cloud (fog?).

So here my fellow trilobitologists are just a few happenings I have been fortunate enough to experience, though they may not be in exact chronological order.

Going back to my childhood I remember walking the shoreline of Lake Champlain, N.Y., near the Canadian border, and finding parts of *Isotelus*¹, *Flexicalymene*, *Bumastus* and *Triarthrus* from Ordovician formations. Mind you, I collected lots of other fossils too, especially *Maclurites* (gastropods), from a world class locality near Chazy, N.Y. My family has a summer home on the lake near Chazy.

Fast forward now to the University of Rochester where I graduated with a degree in Geology. My professor of paleontology was doing research in silicified Ordovician trilobites and co-authoring papers with the great Harry Whittington (renown expert on trilobites). From that point on I was enthralled with collecting trilobites.

Well, back to "tales". How about finding *Odontocephalus* in the old railroad grade along Cayuga Lake, N.Y., or finding large *Phacops* at the very top of a high waterfall behind Wells College.

Trenton Falls Gorge, N.Y. brings back memories of danger and exhilarating finds. I was on the wrong side of the creek with a solid wall behind me when the siren sounded and the water was rising fast; barely made it to the other side to safety. **Don't go there without permission!** I had two outstanding finds there thirty years ago. The first was finding an eight inch *Isotelus* black beauty, when a young boy led me to the spot and said, "take it, it's yours". It was still in situ and covered by a volcanic ash deposit. The second was a discovery as I was climbing out of the gorge and I happened to place my hand on a ten inch *Isotelus*, half exposed. Though the formation here is hard as concrete, I was able to extract it with patience.

¹ In this article I will only use genus names and not species.

One of the strangest coincidences was the discovery of a great stash of *Dipleura*, unknown the time to anyone other than the original finder. I'm sure most collectors of trilobites know of a location in Madison County, N.Y. There is a road there that cuts a high hill with a beautiful valley below. By some luck and perseverance I happened to meet the person who blasted and dug the rubble for the construction of the road. Believe it or not, from right after the blast he picked up a dozen gorgeous perfectly preserved *Dipleura*, seven to eight inches long and many enrolled specimens. He was not a collector but knew he really had something special. He was kind enough to let me have some of these. To say the least I was flabbergasted!

How about finding perfectly outstretched large *Synphoria* and *Homalanatus* in the blocks of an old mill? These blocks were quarried from a lower Devonian formation nearby. The walls of the mill (over 100 years old), fell down during a storm and became a treasure for collectors. The masons had no idea when they built this mill that any fossils were present. Over 100 years of weathering finally exposed these beauties.

Looking for an outcrop of Middle Ordovician in Chazy, N.Y., I was driving down a dirt farm road with corn fields on both sides. Rocks were scattered in between the rows. These rocks just happened to be filled with *Isotelus*. I stopped the car, opened the door and right there below my feet on the side of the road was a beautiful enrolled black *Isotelus*. By the way, I found more of these trilobites while picking the corn.

Not too far south of Chazy, at Long Point on the Lake Champlain shoreline, I was hiking and decided to take a swim. The rocks are all broken and split by faulting (Cumberland Head Argillite - Upper Ordovician). The view is absolutely outstanding. To my surprise, as I was getting out of the water, I spied a perfect seven inch *Isotelus*. But to get it out took over three hours, with about 40 pieces glued together. This area is now a state park and "no collecting".

Within the last eighteen years most of my great finds have been at localities in Pike and Lincoln County, Missouri. I have had so many weird occurrences with trilobites it's hard to recount all of them. However, here are a few. While searching for trilobites in the Plattin Formation (Middle Ordovician), at a spot in Lincoln County, I noticed what looked like the stem portion of a crinoid and in a hurry tossed it in my collecting bag to take home. Once home, it became apparent that this was not a crinoid, but a beautiful *Cerarus*. All but the axial lobe was covered, the rest was easily removed to show a complete specimen over two inches long.

I like telling the story of my wife finding a ten inch *Isotelus* that was in a large concretion. She has had incredible luck finding some really nice specimens. I often accuse her of being able to

"smell" them. This particular time, she was trying to split open a large fifteen inch round concretion where she had exposed parts of a large cephalon, but the concretion was very hard and she didn't seem to be getting very far in splitting it. I told her it was likely only a part of the head and to let it go. The rock was so hard it was not worth it. But she insisted that we keep trying. I took my larger chisel and gave it a good whack. She was really upset with me for hitting it so hard and chance damaging a potentially nice specimen. Wow, two-thirds of a ten inch trilobite split off and flipped end over end about three feet above my head. I can still see it now spinning, with the sunlight flashing off of it. I couldn't even speak for a moment or so and could hardly catch my breath. What a surprise!

I've walked the creek where there is an outstanding obrution deposit (distal tempestite) in the Maquoketa Shale (Middle Ordovician) in Pike County. At least a half dozen times, at the end of the day and very tired, I would kick rocks to over turn them on the way back to the car. I have been lucky enough to have them split open to expose a complete *Isotelus*! Janet also has found some of her best specimens on the way to the car at the end of the day.

There is only one other person who knows my *Isotelus* site besides my wife -- except for one person I blindfolded! The first time I took my friend there, I made it known that he couldn't expect a great specimen on his first trip and swore him to secrecy on penalty of death at dawn if he disclosed it to anyone. This is actually what happened. He got out of the car, crossed the creek and broke open his first rock without turning it over first. The rock split in half, he turned it over and found a beautiful eight inch *Isotelus*, fortunately undamaged. He went ballistic and became a true believer! About a year ago during an August dry spell, all the creeks in this area were dry, so I told my friend he ought to go look for the "big one". Ha! I should have known better. I could not go on this trip. When I visited him the next week, he welcomed me with the biggest smile I ever saw, presented me with an eight inch *Isotelus*, and then told me this story. The creek was dry and after walking about 50 yards down the creek, he found a beauty -- outstretched, dorsal side up looking at him and saying, "here I am, I'm yours". Jealousy!!! Oh well, I've had so many great finds, I can't complain.

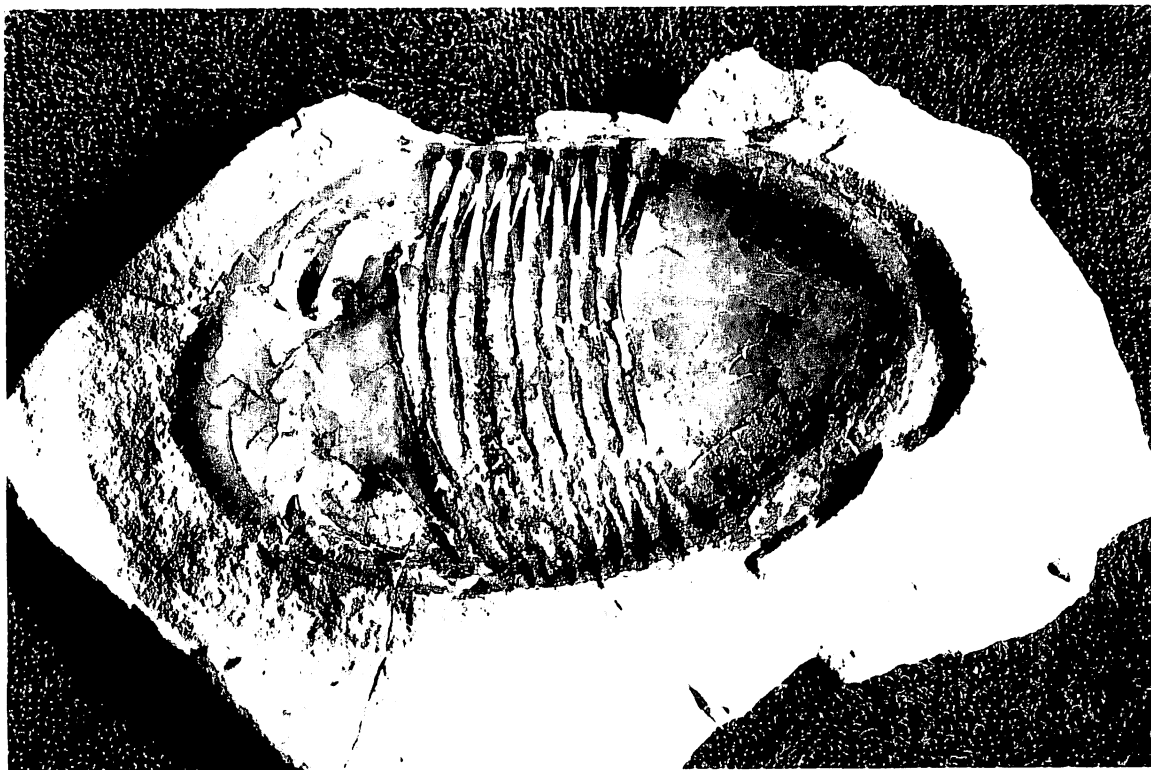
Many times I will bring home a nice *Isotelus* only to find in preparing it that there are several others, also complete in the same rock. Finding suites of *Isotelus* is not easy, but I've found a few over the years .

One of my greatest surprises was discovering a large *Isotelus* at the exact spot I had researched by carefully checking every resource possible. After pin pointing this area, my wife and I hiked a half mile down an abandoned county road, followed a stream bed to the first outcrop in sight and

bang!! A large tree had fallen across the creek and propped up against the tree was this outstanding eight inch *Isotelus*. This was the first time I had ever been to this place and the very first fossil I see is just staring up at me. I did not have to do anything but pick it up. Right then and there we decided to celebrate and opened a bottle of Champagne. Back then, we always had some sort of refreshment besides water, just in case there was a surprise find.

I will end this with two recent discoveries last summer, my friend and I found by chance a great location for *Ampyxina*. These come from plates of Maquoketa Shale, some three feet by three feet, covered completely with these little trilobites. Right around the corner, within a half mile, is a location for the largest complete *Isotelus* ever found in Missouri. And on our last trip this fall, my wife and I discovered a terrific *Isotelus*, eight inches long with full definition (not flattened). It now sits on top of one of my speaker cabinets, next to a seven inch enrolled *Dipleura* and large pyritized ammonite from Russia..... These are all next to a media cabinet loaded with other great fossils. They all bring back memories of great trilobite finds.

Now I am dreaming of adventures to come next summer, and of course the our trip to the Valhalla of fossildom, Tucson!



Isotelus iowensis 6in. long (M.Ord.)
Pike Co Missouri, Maquoketa Shale

EARLY CAMBRIAN TRILOBITES OF WESTERN NEVADA AND CALIFORNIA

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One of the more exciting subjects in paleontology today is the so-called Cambrian explosion in which fundamental groups of marine animals appeared in a very short time around the beginning of the Cambrian. Trilobites were among the most advanced of these early arrivals. They appeared in abundance and achieved an amazing diversity by the second half of the Cambrian. The Cambrian began 544 million years ago, give or take a million years or so, according to the best uranium-lead clock available, and lasted for 55 million years, a relatively short time for all of the events of this geologic period. Here we will look at the variety of trilobites that occur in the early Cambrian rocks of western Nevada and adjacent areas of California.

Charles Doolittle Walcott, the prominent American paleontologist, visited the great Cambrian rock exposures of western Nevada and eastern California several times from 1894 to 1897. Considering this area to have the thickest and most fossiliferous early Cambrian section in the country, he proposed the name Waucoban Series for the trilobite-bearing part of the Cambrian, named for the well exposed section at Waucoba Spring, California. Around the middle of the 20th century, scientists in the Soviet Union and elsewhere began to recognize small shelly fossils, some of which are tiny mollusks, in the rocks below the trilobites and brachiopods, so they began pushing the base of the Cambrian (still thought to begin with the oldest "normal" marine life) to earlier and earlier dates. Finally, the "official" base was finally set in Newfoundland in 1991 at the first appearance of the trace fossil *Treptichnus pedum* (Seilacher, 1955). The small shelly and trace fossil part of the Cambrian was thus determined to be about 22 million years leaving a short span of 33 million years for the tremendous variety of Cambrian trilobites to appear, evolve, and for many groups to go extinct.

Figure 1 shows the series and stage names that have been proposed for the Cambrian of the North American continent (Palmer, 1998). The Begadean Series is based on a section in northwestern Canada. Walcott's name Waucoban was resurrected for the trilobite-bearing early

SUBDIVISIONS OF THE CAMBRIAN OF NORTH AMERICA



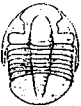
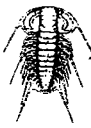




Million years ago	System	Series	Stage		
489	C A M B R I A N	Millardan	Sunwaptan	 <i>Saukia</i>	
495			Steptoean	 <i>Pterocephalia</i>	
500		Lincolnian	Marjuman	 <i>Cedaria</i>	
507 510			Delamaran	 <i>Albertella</i>	
517		Waucoban	Dyeran	 <i>Olenellus</i>	
522			Montezuman	 <i>Nevadaia</i>	
		Begadean	(unnamed)	 <i>Fallotaspis</i>	 <i>Nevadaia</i>
544				Pre-trilobite - small shelly and trace fossils	

Figure 1. Stage and series subdivisions of the Cambrian for the Laurentian Continent (ancient of North America).

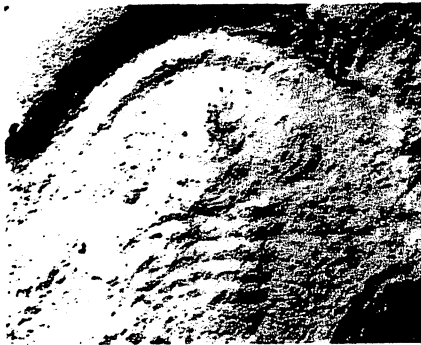
Cambrian. This series includes two stages named for sections in western Nevada based in part on the work that Bill Fritz, paleontologist at Geological Survey of Canada, and I have been doing for the past decade. The Montezuman Stage includes the *Fallotaspis* and *Nevadella* zones and the Dyeran Stage includes all of the *Bonnia-Olenellus* Zone as these zones were proposed by Fritz (1972).

In Nevada and California there are long sections of early Cambrian rocks which in western Nevada total about 10,000 feet (3000 meters) in thickness. Thus this region along with northwestern Canada has some of the thickest, most continuous, and most fossiliferous early Cambrian sections in the world. Here the first trilobite appears after about 3300 feet (1000 meters) of Cambrian sediment had been deposited. From that point to the end of the Waucoban, trilobites are more or less common. The three trilobite zones covering the early Cambrian, the *Fallotaspis*, *Nevadella* and *Bonnia-Olenellus* zones, are present but a more detailed zonation may eventually be proposed. The taxonomy of many of these trilobites is under study so uncertain or new forms are left in open nomenclature, for example: "cf. *Repinaella*" means a form similar to but not identical with the genus *Repinaella*. Families, suborders and orders are commonly mentioned in an informal manner, so that a member the suborder Olenellina becomes an olenelline.

***Fallotaspis* Zone – Montezuman Stage**

The oldest named trilobite zone in North America occurs in about 140 meters of shaly siltstone with the base marked by a 30-cm. interval with abundant heads (cephala) of cf. *Eofallotaspis* (Figure 2.1), an unnamed form resembling the trilobite *Eofallotaspis* found in Morocco. This species is fully-formed olenelline trilobite with eyes, a wide cephalon with long genal spines and a slightly enlarged third thoracic segment. A few meters higher, species of *Fallotaspis* and, higher, *Parafallotaspis?* appear (Figures 2.2, 2.3 and 3.2). Some of these closely resemble *Fallotaspis* species in Morocco. Locally a couple of quite different trilobites are found. They are small and have tiny genal spines giving the appearance of little circle-heads (Figures 2.4 and 3.3). The thorax of one of these species was quite narrow with a strongly arched axis suggesting that this species was a swimmer rather than a bottom dweller.

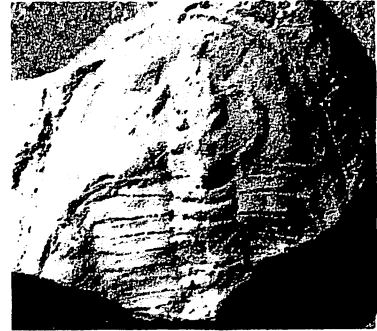
Before moving higher in the *Fallotaspis* Zone, we need to consider the earliest trilobites now known in North America which are not included in the *Fallotaspis* Zone. For 130 feet (40 meters) below the narrow occurrence of cf. *Eofallotaspis*, no body fossils are found – and only a relatively few trace fossils. Below that for the next 200 feet (60 meters) or so, trace fossils are common and diverse. With diligent searching, we have found 25 trilobite heads and a few hundred brachiopods near the base of this interval. Below, trace fossils are less diverse and body fossils are limited to hyoliths. The trilobite found here is a circle-headed form with a tiny genal spine that resembles a Siberian trilobite *Repinaella* (Figure 3.1). Even though we don't know what the complete trilobite looked like, it seems to be a fully-formed olenelline trilobite.



2.1 X 2
cf. Eofallotaspis sp.



2.2 X 2
Fallotaspis
cf. bondoni



2.3 X 2
Parafallotaspis? sp.



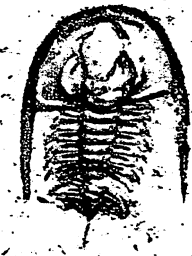
2.4 X 3
"Cirquella" sp.



2.5 X 2
Bradyfallotaspis sp.



2.6 X 3
"pre-Nevadia" sp.



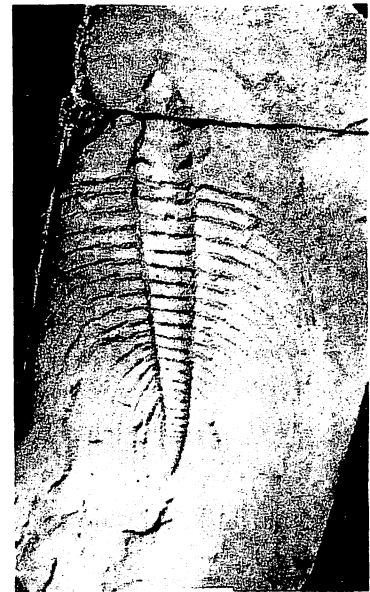
2.7 X 2
Palmettaspis
parallela



2.8 X 3
Esmeraldina?
cometes



2.9 X 0.5
Nevadia weeksi



4.10 X 1
Nevadia n. sp.

Figure 2. Lower Cambrian trilobites from the Montezuman Stage (Montenegro Member of the Campito Formation) in Nevada and California. 2.1 Cephalon and partial, displaced thorax. 2.2 Whole trilobite. 2.3 Cephalon and partial thorax. 2.4 Cephalon. 2.5 Cephalon. 2.6 - 2.10 Whole trilobites, 2.7 lacks the last few thoracic segments and the pygidium. 2.10 latex cast.

Photo 2.9 courtesy Carl Locker.

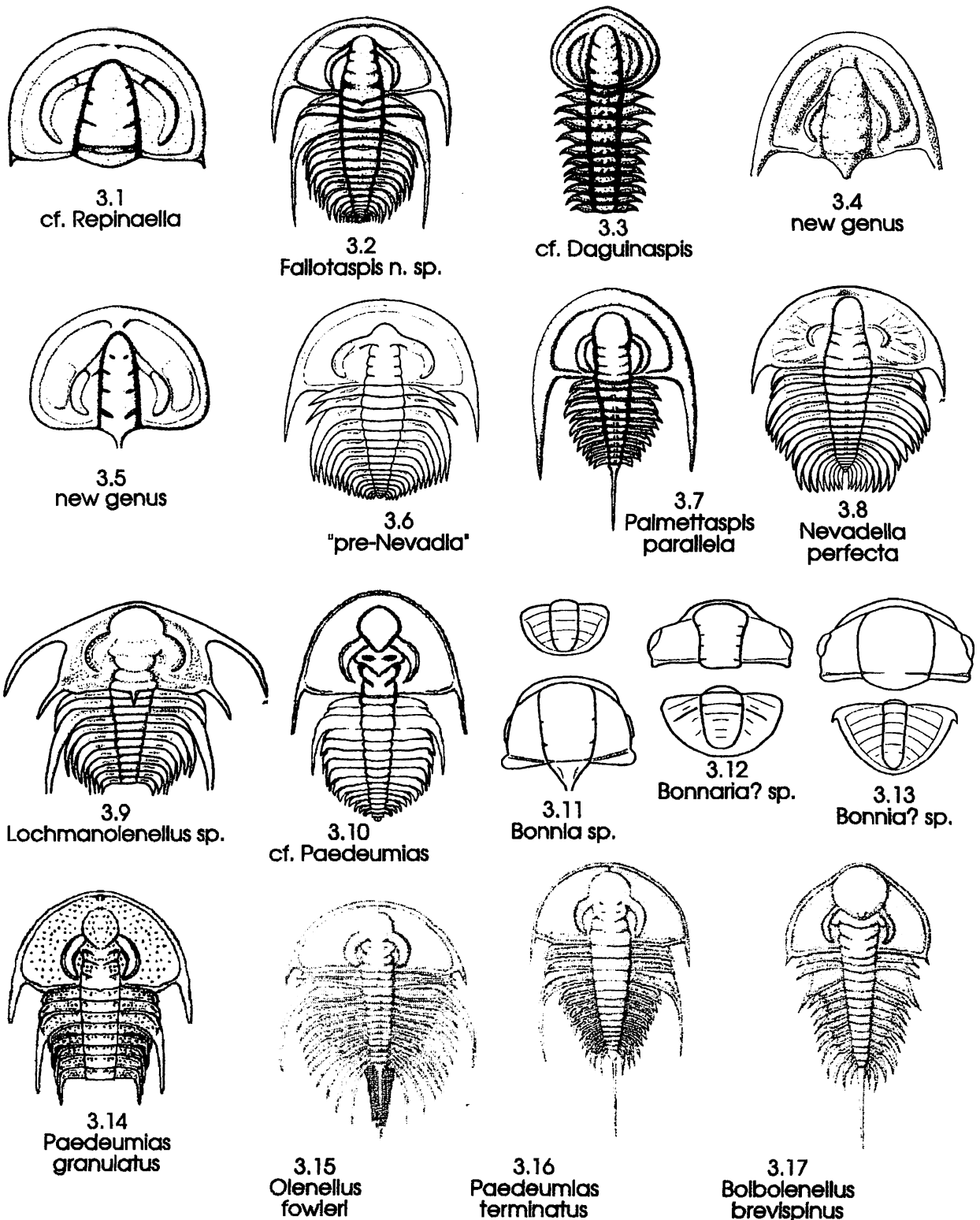


Figure 3. Sketches of Lower Cambrian trilobites from Nevada and California. 3.1, Begadean Series, Andrews Mountain Member of the Campito Formation. 3.2-3.8, Montezuman Stage. 3.2-3.7, Montenegro Member of the Campito Formation. 3.8, Poleta Formation. 3.9-2.17, Dyeran Stage. 3.9, Poleta Formation. 3.10-3.14, Harkless Formation. 3.15-3.17, Pioche Formation.

Sketches 3.15 - 3.17 courtesy Carl Locker.

We also don't know what the pre-trilobite animal looked like. The environmental conditions were apparently unfavorable in the immediate area of western Nevada for some time before trilobites appeared so even tracks are absent. At the base of the Cambrian, though, the silty rocks preserve faint scratch marks probably made by some early arthropod that lacked a hard shell (Figure 4).

Back to the *Fallotaspis* Zone. In the upper part of the zone, *Fallotaspis* is accompanied by a variety of new trilobite forms, *Bradyfallotaspis* (Figure 2.5), *Paranevadella*, and a couple of new genera (Figures 3.4 and 3.5). Almost all of these *Fallotaspis* Zone trilobites are also found in the White-Inyo Mountains of California. In the Rocky Mountains of Canada, only the topmost forms are present except at one locality in the Mackenzie Mountains of northwestern Canada where a variety of *Fallotaspis* species are found.

***Nevadella* Zone -- Montezuman Stage**

As the shallow ocean got deeper in western Nevada, the trilobites changed rapidly over a short interval. Two new genera appeared that resemble their descendants in the *Nevadella* Zone. The "pre-*Nevadia*" (Figure 2.6) has a long third thoracic segment, but the pleural tip drapes backward like *Nevadia*, and the early *Esmeraldina? cometes* Fritz, 1995, has a narrow thorax with the third segment only slightly enlarged but with one long axial spine on the 13th segment (Figure 2.8 does not show the spine). These forms stayed around a very short time, 50,000 years or so with only one species surviving longer, *Palmettaspis parallela* Fritz, 1995 (Figure 2.7).

Through the middle and upper parts of the Cambrian, trilobite zones average about one million years per zone. The three named trilobite zones of the early Cambrian combined span about 12 million years. The *Fallotaspis* Zone probably lasted a little over a million years, but the *Nevadella* and *Bonnia-Olenellus* zones were much longer than the average Cambrian trilobite zone suggesting that they should be subdivided. In the following discussion, you can see some of the possible subdivisions of these broad zones.

The two distinctive forms in the lower part of the *Nevadella* Zone are the stout and vigorous *Esmeraldina rowei* (Walcott, 1910) that was probably a predator (Figure 5.1) and the beautiful and delicate species of *Nevadia*, *N. weeksi* Walcott, 1910, and *N. n. sp.* both deposit-feeders (Figures 2.9, 2.10). These creatures lived on the muddy bottom of a fairly deep ocean shelf along with a few brachiopods, hyoliths, and probably a variety of worms. Several species of *Esmeraldina* and *Nevadia* appear at higher levels in the Montezuman Stage. About the middle of the stage, *Esmeraldina rowei* is replaced by a related holmiid that has the third glabellar lobe incorporated in an inflated anterior lobe, *Esmeraldina? argenta* (Walcott, 1910) (Figure 5.2) which we called "Big nose" in the field. Another interesting holmiid in this interval is *Holmiella* sp. with an extremely advanced genal spine (Figure 5.3). Only one specimen of this rare species

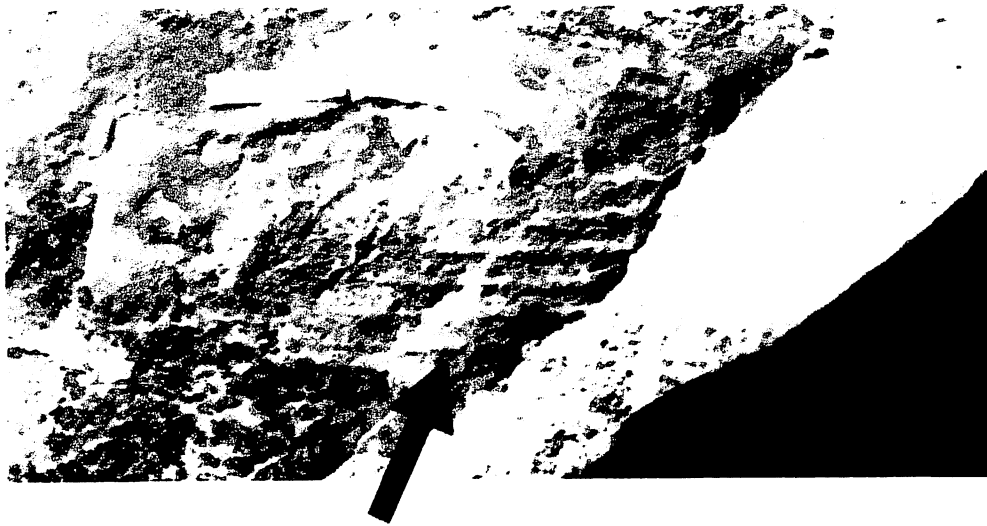


Figure 4. Arthropod? scratches in fine siltstone from near the base of the Begadean Series, Deep Spring Formation, Esmeralda County, Nevada, scale bar 1 cm.

has been found. Various species of *Nevadia* remain common through most of the Montezuman, but an unusual circle-headed form called *Cirquella* (Figure 5.4) marks a restricted zone above the middle; none of these have been found complete. The topmost beds are distinguished by species of *Nevadella* (Figure 3.8). This genus differs from *Nevadia* in having the glabella extended to the front border. Thus calling this long interval the *Nevadella* Zone is a bit of a misnomer.

During the later part of Montezuman time, the seas were warmer and limestones were deposited instead of shales. Reef mounds supported by branching coral- or sponge-like archaeocyaths were common on the sea floor. Small trilobites fed around these mounds - the corynexochid *Sekwiaspis* and the ptychopariid *Keeleaspis*.

The Montezuman Stage ended with an abrupt extinction of the nevadiid trilobites and presumably of the holmiid trilobites as well, at least in North America. I have termed this the *Nevadella* Extinction (Hollingsworth, 1997).

The *Nevadella* Zone can also be recognized in the Caborca area of Sonora, Mexico, in the Death Valley region, in northeast Washington, in British Columbia and the Northwest Territories of Canada.



5.1 X0.5
Esmeraldina rowei



5.2 X1
Esmeraldina?
argenta



5.3 X0.4
Holmiella sp.



5.5 X1
New wanneriid genus



5.4 X2
Cirquella
nummularia



5.6 X8
Ekwipagetia sp.



5.7 X1
Gabriellus sp.



5.8 X2
Polliaxis sp.

Figure 5. Lower Cambrian trilobites from Nevada. 5.1-5.4, Montezuman Stage. 5.1, Whole trilobite, Montenegro Member. 5.2, Partial cephalon, Poleta Fm. 5.3, Large, whole, tectonically distorted, Montenegro Member. 5.4 Cephalon, Poleta Fm. 5.5-5.8 Dyeran Stage. 5.5 Whole, Poleta Fm. 5.6 Cranidium and pygidium, missing spine, Poleta Fm. 5.7, Nearly whole, Poleta Fm. 5.8 Nearly whole, Poleta Fm.

Photo 5.1 courtesy Carl Locker. Photo 5.6 courtesy Lisa Bohach

***Bonnia-Olenellus* Zone - Dyeran Stage**

This zone begins immediately following the *Nevadella* extinction with the appearance of a new wanneriid genus (Figure 5.5) containing several species. Bohach (1996) and others have assigned these to the genus *Elliptocephala*. This new genus is a robust trilobite, lacking any enlarged third thoracic segment and having rather droopy thoracic tips. *Lochmanolenellus* (Figure 3.9) with two obvious pairs of spines on the cephalon occurs in the upper part of the range of this new wanneriid.

The *Bonnia-Olenellus* Zone was named by Rasetti in 1952 based on his work in southern British Columbia and Fritz (1972) continued the use of the name. *Bonnia* is a deep shelf trilobite while *Olenellus* generally preferred shallow water. The two occur together in some places but not often. Unfortunately neither form appears at the bottom of the zone as we now know it in western Nevada. The *Bonnia-Olenellus* Zone covers the longest span of time of any Cambrian trilobite zone and is represented in western Nevada by about 5400 feet (1650 meters) of sediment. Several attempts have been made to subdivide this zone. The new wanneriid genus mentioned above will constitute one such subdivision.

The next, fairly short interval is characterized by species of *Gabriellus* (Figure 5.7) with *Mesolenellus*. At this time there was a brief period when fairly deep ocean currents swept strange new trilobites into this region including *Labradoria* and *Polliaxis* - corynexochiids (Figure 5.8), and *Ekwipagetia* (Figure 5.6) - the first eodiscid to appear in this region. They are joined by another species of *Keeleaspis* (Figure 6.1).

After an interval of limestone deposition, the water depth increased and another unusual fauna briefly appeared: *Oygopsis batis* Walcott, 1916 (Figure 6.2), a fairly deep water corynexochid, and *Perissopyge* (Figure 6.3), an unusual form that may be a protolenid. A *Paedeumias*-like trilobite with unusual eye lobes also occurs in these beds (Figure 3.10). Several species similar to this form occur rarely in the lower part of the Harkless Formation.

The Saline Valley Formation of California and its equivalents in the upper part of the Harkless Formation in Nevada contains another distinctive trilobite fauna characterized by *Paedeumias transitans* Walcott, 1910, but including deeper water forms such as *Bonnia* (Figures 3.11-3.13) and the early oryctocephalid *Goldfieldia* (Figure 6.4). One large collection from this interval was described by Pete Palmer in 1964 as an "unusual" Lower Cambrian fauna. The term unusual referred to the relatively large diversity of trilobites found in a single collection (Figures 3.14 and 6.6 are from other localities): *Paedeumias granulatus* Palmer, 1964; *Wanneria* cf. *W. walcottana* (Wanner); *Bonnia caperata* Palmer, 1964; *Olenoides* ssp.; *Oygopsis batis* (Walcott, 1916); *Goldfieldia pacifica* Palmer, 1964; *Stephenaspis? avitus* Palmer, 1964; *Zacanthopsis contractus* Palmer, 1964; *Zacanthopsina eperephes* Palmer, 1964; and *Syspacephalus? sp.* This interval can be identified at many locations along the western side of North America. The Kinzers Shale of Pennsylvania probably correlates with this interval.

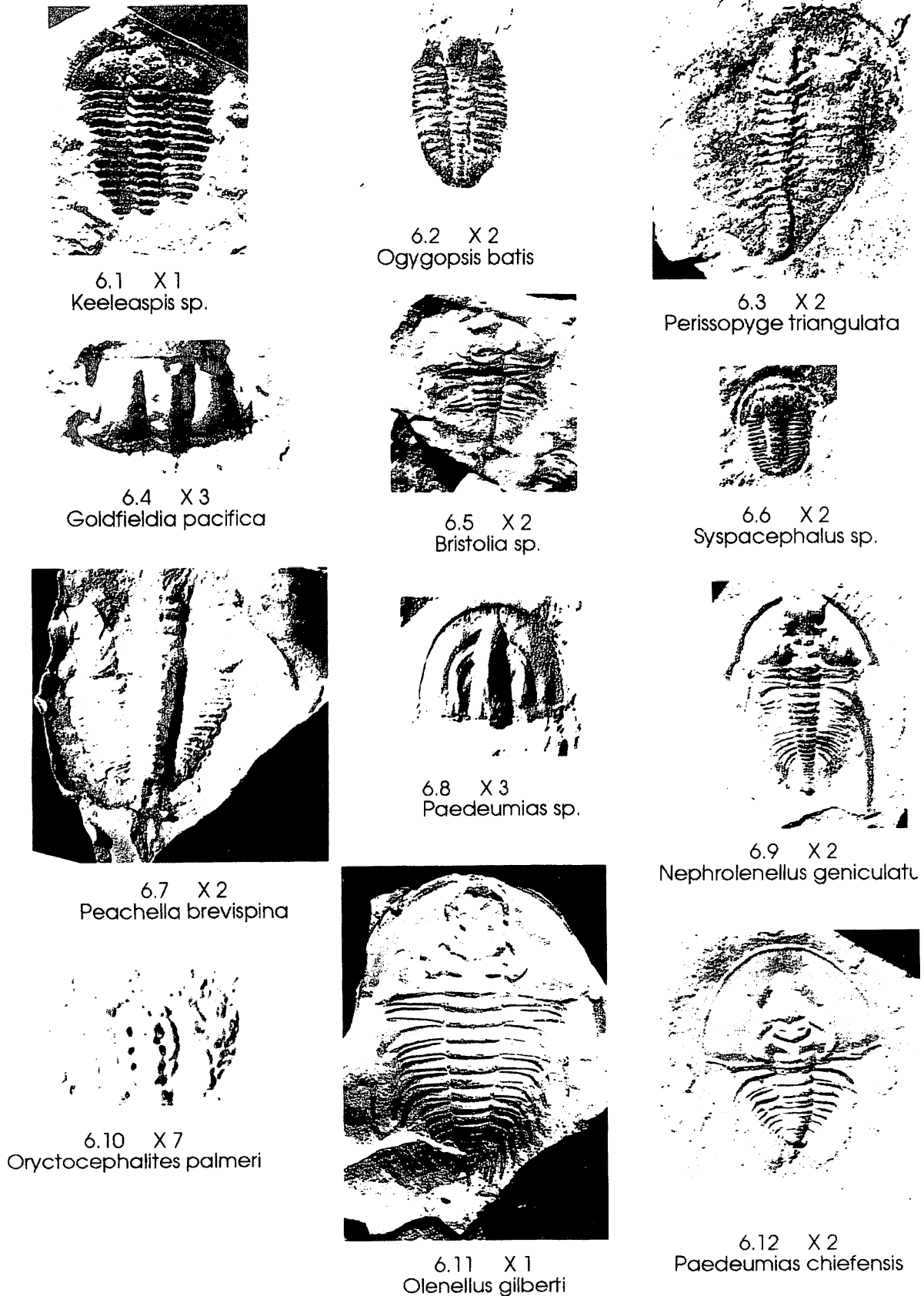


Figure 6. Dyeran (Lower Cambrian) trilobites from Nevada and California. 6.4 and 6.10 are cranidia only. 6.7 is thorax showing greatly enlarged third segment. 6.1, Poleta Fm. 6.2 - 6.4 and 6.6, Harkless Fm. 6.5, 6.7 and 6.8, Carrara Fm. 6.9-6.12 Pioche Fm.

The next interval of common trilobites has been designated the *Bristolia* faunule by Palmer and Halley (1979). This interval includes the well-known collecting localities in the Latham Shale of southern California as well as parts of the early Cambrian faunas of the Carrara and Pioche, formations in California and Nevada. In addition to *Bristolia* (Figure 6.5), there are species of *Olenellus*, *Peachella* (Figure 6.7), and *Arcuolenellus*. Trilobites of the subfamily Biceratopsinae, such as *Bristolia*, *Peachella*, and *Nephrolenellus*, are characterized by the extreme enlargement of the third thoracic segment. In one California section, Ed Fowler (1999) recognizes many new species in this upper part of the Waucoban, and he suggests dividing this 110 meter interval into 13 zonules. The next subzone is defined by *Nephrolenellus multinodus* Palmer, 1979.

The highest subzone in the Dyeran is the *Nephrolenellus geniculatus* Subzone which is present at the famous Ruin Wash locality near Caliente, Nevada. Here an unusually diverse fauna of olenelline trilobites are commonly found articulated: *Olenellus gilberti* (Meek, 1874) (Figure 6.11), *O.?* *fowleri* Palmer, 1998 (Figure 3.15), *Paedeumias chiefensis* Palmer, 1998 (Figure 6.12), *P. terminatus* Palmer, 1998 (Figure 3.16), *Nephrolenellus geniculatus* Palmer, 1998 (Figure 6.9), *Bolbolenellus brevispinus* Palmer, 1998 (Figure 3.17), and two rare forms. Working with this fauna demonstrated how important the features of the thorax are in the classification of olenelline trilobites (Palmer, pers. comm., 1996). Mark Webster is using this fauna to study the ontogenetic development and compaction (Webster and Hughes, 1999) of these trilobites. *Orytocephalites palmeri* Sundberg and McCollum, 1997 (Figure 6.10), *Zacanthopsis* sp. and *Crassifimbra?* sp. are also present. All of these occur in a 50-cm interval just below an extinction event which wiped out the olenelline trilobites. A low diversity Middle Cambrian trilobite fauna appears just above the extinction. Nearby localities have *Bathynotus*, an unusual trilobite that also marks the latest Lower Cambrian in China. The *Nephrolenellus geniculatus* Subzone has been found in the Death Valley region, but it is apparently not widespread in western North America. The olenellid fauna of the Parker Shale of Vermont appears to correlate with this interval.

Summary

The early Cambrian of western Nevada and California thus has an impressive record of trilobite evolution during the Cambrian explosion. Many species are known and current field work and taxonomic studies are sure to identify more. Eventually a more detailed zonation of the early Cambrian of this area will be developed. Correlation with rocks of similar age in other continents is still uncertain but progress is being made.

Acknowledgments

I am indebted to W. H. Fritz, R. Garney, and A. R. Palmer for their helpful comments and review of this manuscript. Many discussions with and guidance from W. H. Fritz greatly influenced this project and are appreciated. My wife, Mary, found many of the specimens shown here and considerably improved the manuscript.

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Web Site

Some of these same trilobites can be seen at a web site maintained by Brian Holt and Cheri Taylor of the White Mountain Research Station, Bishop, California: < www.wmrs.edu/trilobites >.

An exceptionally well preserved Phacopidae from Ontario

Wolfgang Vogel, Toronto/Canada and Frankfurt/Germany

In Southern Ontario, the Hamilton Shale of Devonian age has been a rich source for complete trilobites. Devonian strata surface also in Northern Ontario in a huge area of the Hudson Bay Lowlands. An exceptionally well preserved Phacopidae from the Kwataboahegan Formation (middle Devonian) is described here.

The Kwataboahegan Formation is highly fossiliferous and has been correlated with the Amherstburg Formation in Southern Ontario. The fauna consists of tabulate and rugose corals, stromatopores, brachiopods and various moluscs, including large nautiloids. The most common trilobite is *Calymene platys* GREEN. Furthermore, fragments of *Dalmanites*, *Proetus* and *Terataspis grandis* have been reported (5). In the Kwataboahegan Formation of the Moose River Basin (Cochrane District, Northern Ontario), a complete Phacopidae was found and tentatively assigned as *Eldredgeops* sp. (see Figures). When it was collected, the specimen was almost entirely enclosed by yellowish brown limestone. I am very grateful to Bill Hessin (Qualicum Beach, B.C. Canada) for the preparation, preliminary analysis and photography of the trilobite. Bill did a superb job in displaying the specimen in such a way that it stayed attached to the matrix.

The glabellar ornaments and the vincular furrows suggest that the specimen is related to *Eldredgeops* (*Phacops*) *cristata* HALL (1, 4, 6). It differs significantly from the lens file pattern of *Eldredgeops* (*Phacops*) *rana* (2, 3). A larger number of specimens will be necessary to define the systematic relationship more precisely.

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Fossil Collecting for Trilobites in Texas

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Texas has never been known for its trilobite collecting. Lower Paleozoic exposures with formations suitable for the preservation of trilobites are few and far between. Generally, the Ordovician through Devonian age sediments that produce so many trilobites in Oklahoma are not exposed or are of an original environment of deposition that was not conducive to preserving trilobites. The upper Paleozoic Pennsylvanian system of north-central produces more trilobites but the variety is limited. I will discuss four localities in Texas where I have personally collected trilobites with varying degrees of success.

The locations I will be discussing are nearly at opposite ends of the state. The lower Ordovician section at the south end of the Franklin Mountains is in El Paso County in extreme west Texas. The upper Pennsylvanian localities are in Palo Pinto, Wise and Eastland Counties respectively in north-central Texas. Figure 1 is two pertinent stratigraphic columns for the formations discussed in the text.

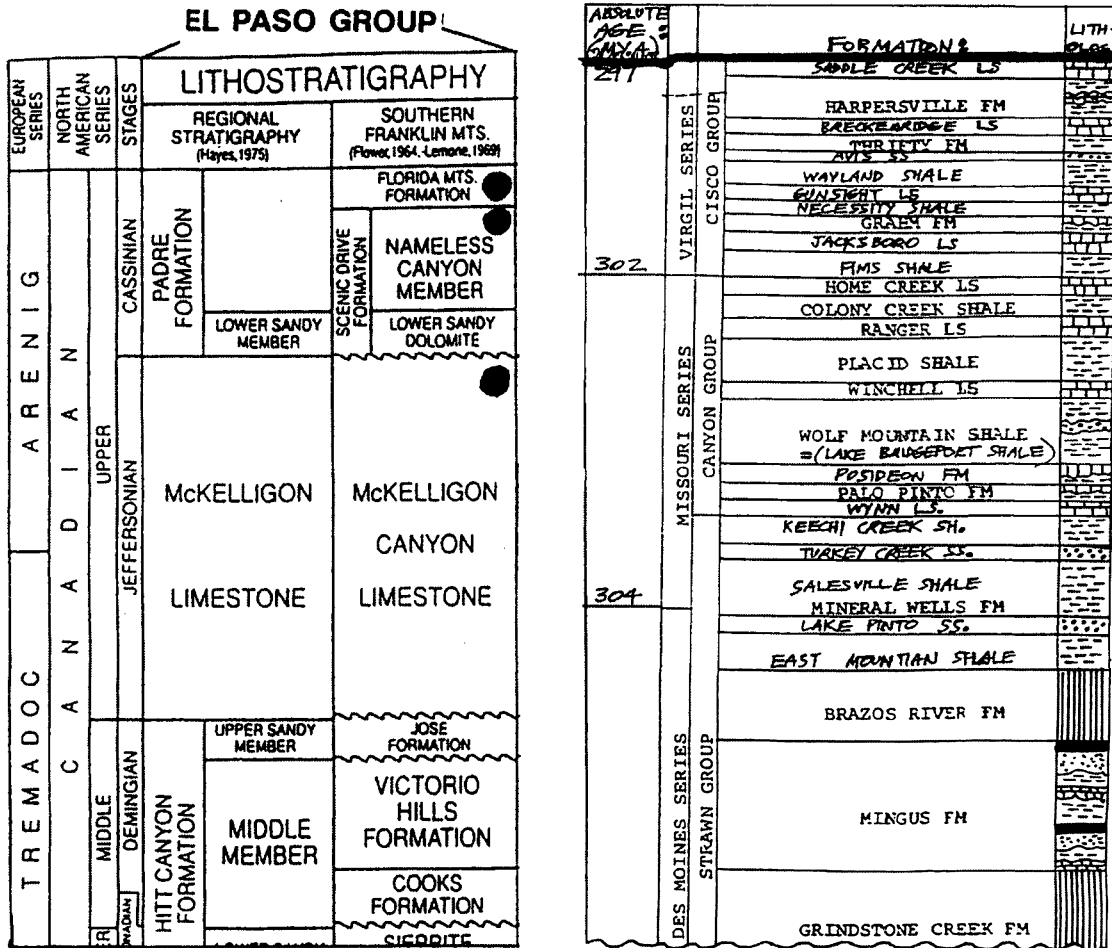


Figure 1 - Stratigraphic columns for the lower Ordovician of west Texas and the upper Pennsylvanian of north-central Texas. Circles indicate formations I discuss that produce trilobites.

Locality 1 – Lower Ordovician Section in the Franklin Mountains, El Paso County, Texas

The most complete section of early Ordovician rocks in the entire southwestern United States is located at the Franklin Mountains of extreme west Texas and south-central New Mexico. The Ordovician section here is divided into the lower Ordovician El Paso Group, and upper Ordovician Montoya Group.

The El Paso group is divided into the following formations in ascending order from oldest to youngest; Bliss Sandstone, Sierrite, Cooks, Victorio Hills, Jose, McKelligon Canyon, Scenic Drive and the Florida Mountains formations (see Figure 1).

The carbonates of the El Paso Group represent very shallow water deposition on an extensive low angle continental shelf. They are composed of a series of alternating limestones and dolomites with thin shale partings that get progressively more dolomitic towards the top. The limestones are primarily biomicrudites, biomicrites, and micrites that are inequigranular. Numerous bedding surfaces contain abundant fossil debris; usually thumbnail size or smaller and dominated by incomplete fragments of trilobites and echinoderms. The limestones are mottled dark gray and contain yellow to buff sandy layers.

Some bedding planes are termed "flat pebble conglomerate" beds (FPC). A FPC is a fine-grained matrix limestone containing large tabular lime intraclasts of various shapes and sizes deposited in a chaotic mess with little or no sorting. Echinoderm debris and trilobite molts are common among the limestone chip intraclasts. This represents a very high-energy deposit and therefore complete trilobites are rare. Table 1 lists some of the reported trilobites from the Florida Mountains Formation of the El Paso Group.

Table 1. – REPORTED TRILOBITES FROM THE EARLY ORDOVICIAN EL PASO GROUP - FLORIDA MOUNTAINS FORMATION

Asaphus aff. curiosus
Bathyurus sp.
Cybeloides primus
Isoteloides whitfieldi?
Cybelopsis cf. speciosa
Goniotelus brighti
Kirkella sp.
Pliomerops nevadensis?
Psuedocybele nasuta
Psuedomera cf. insolita

Figure 2 is a locality map of the southern end of the Franklin Mountains overlooking downtown El Paso to the south. You can legally collect in the area below the observation point on Scenic Drive and above street level of Murchinson Drive (and north of the Sierra Madre Hospital). There is a retirement apartment center at the base of the mountain on the north side of Murchinson Drive. The upper formations of the El Paso Group are exposed here. There are literally hundreds of vertical feet of section with most of the beds lying at a 60-70 degree angle to horizontal. Collecting can be dangerous due to the steep nature of the cliff walls. Hunt bedding planes and the talus slopes at the base of the mountain. Even though it looks inviting, you **CANNOT** collect along Scenic Drive! In addition to trilobite specimens, you can occasionally find complete echinoderms. Figures 3 - 10 are various trilobites from the El Paso Group. All specimens collected by the author.

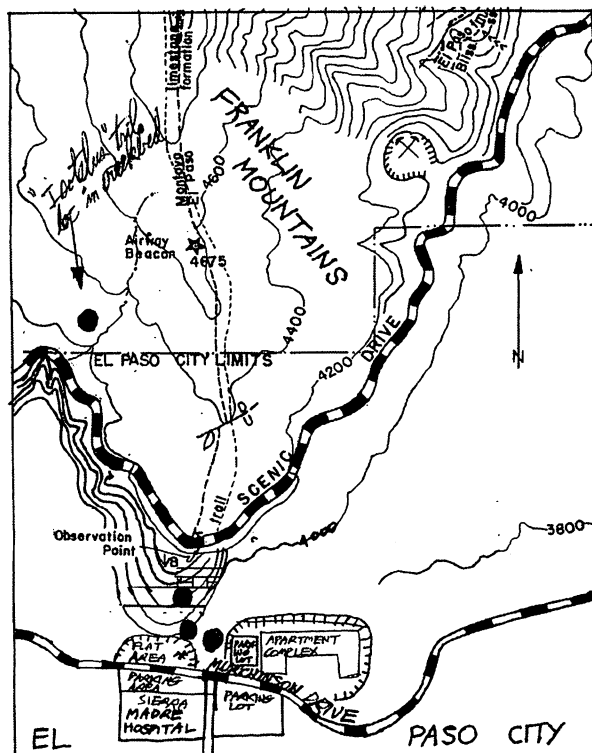


Figure 2 – Locality map for the El Paso Group section at the southern terminus of the Franklin Mountains, El Paso County, Texas. Circles indicate areas where I have collected trilobite specimens.



Figures 3 - 6 - Pygidiums of the trilobites *Pseudocybele insolita*, *Cybeloides primus*, *Pliomerops nevadensis* and *Isoteloides whitfieldi*. Scale bar in millimeters.



Figures 7 - 10 – Incomplete specimen of *Pseudocybele insolita* and three specimens of *Pliomerops nevadensis*.

Locality 2 – Basal Upper Pennsylvanian Keechi Creek Shale locality outside of Mineral Wells, Palo Pinto County, Texas

North-central Texas is famous for its numerous exposures of upper Pennsylvanian cyclotherm sequences containing alternating marine and deltaic deposits. The marine portion of the cyclotherms can be quite fossiliferous. One of the better localities for collecting a variety of marine invertebrate fossils is the Keechi Creek Shale and the overlying Wynn Limestone at the “old dump” locality west of Mineral Wells in Palo Pinto County, Texas (Figure 11).

Take US 180 west out of Mineral Wells and past the Hwy 337 N junction. You are now heading towards the Brazos River Valley. Take the paved road straight when US 180 curves to the left. After ¼ mile you will turn right (north) at the intersection with Indian Creek Road. Follow this road for 2.5 miles and past the Mineral Wells shooting range. Look for the abandoned landfill notice sign at a 90 degree turn in the road. Park here and walk in.

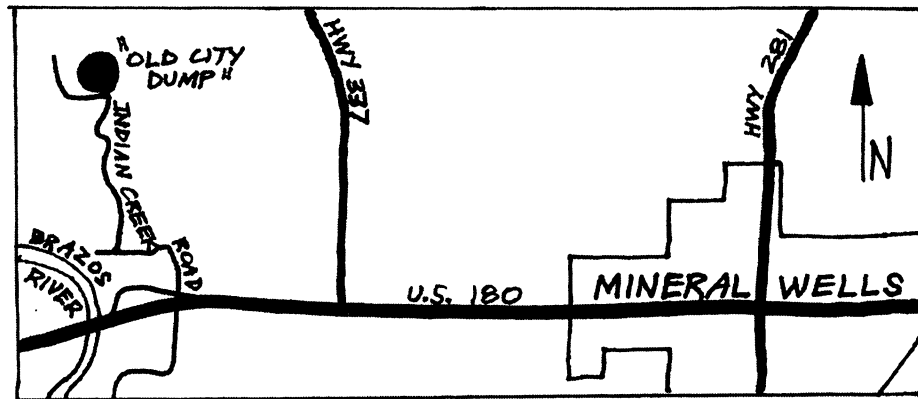


Figure 11 – “Old Dump” locality west of Mineral Wells and off Indian Creek Road in Palo Pinto County, Texas.

This site is an old landfill whose excavation has exposed the basal Missourian Stage of the late Pennsylvanian (see Figure 1). The Keechi Creek Shale is a dark gray, slightly phosphatic shale that is extremely fossiliferous. The only two species of trilobites found at this site are the smaller *Ditomopyge scitula* and the larger *Amuera major* as shown in Figures 12 - 15. *Ditomopyge scitula* is commonly found in red phosphatic nodules as groups or individual molts. *Amuera major* is usually found as individual enrolled specimens in the shale itself.



Figures 12 - 15 – Figures 12 & 13 are two views of a large enrolled *Amuera major*. Figures 14 & 15 are two views of different *Ditomopyge scitula* specimens from the Keechi Creek Shale in Palo Pinto County, Texas. Scale bar in millimeters.

Locality 3 – Upper Pennsylvanian Lake Bridgeport Shale locality at Run-Away Bay on Lake Bridgeport, Wise County, Texas

The third locality is located 7.5 miles west of the junction of Highways 114 and 380 in Bridgeport, Wise County, Texas (Figure 16). Take Highway 380/114 over the arm of Lake Bridgeport known as Run-Away Bay. After crossing the water there will be two gas stations on both sides of the highway. Continue another quarter mile and there will be a turnoff to your left (south) into the Run-Away Bay subdivision. Take this to the right for one block. Just past the church and to your right will be a 12-foot vertical outcrop just below the white picket fence at highway level. Park here and collect.

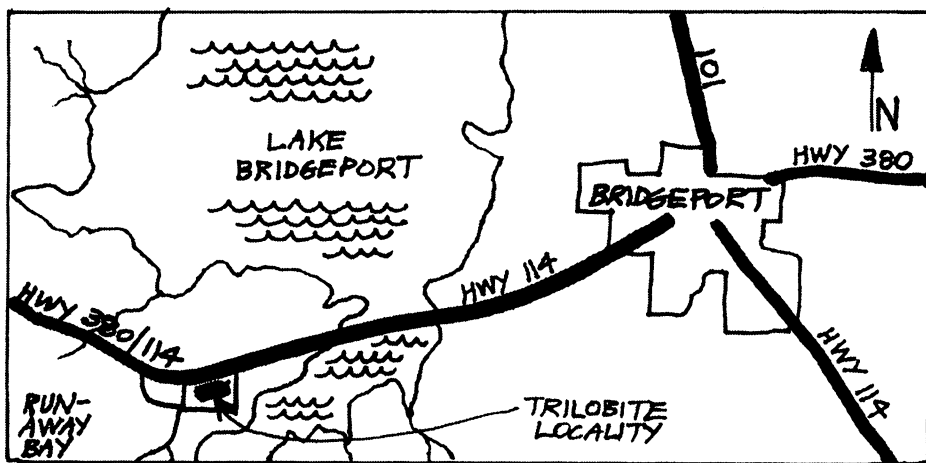


Figure 16 – Locality map to the Run-Away Bay site on the south side of Hwy 380/114 at Lake Bridgeport, Wise County, Texas.

The Lake Bridgeport Shale is an old formation name and is now termed the lower Wolf Mountain Shale. The outcrop here exposes a grey shale section that is loaded with red ironstone and phosphatic nodules. The trilobites are found by inspecting broken nodules for a gleam of the black carapace. Usually just a portion of the trilobite will be showing and you will need a rock hammer and chisels to prep out the trilobite at home later. There is only one common trilobite here and that is *Palladin morrowensis* (Figures 17 and 18). The trilobites are rare but beautiful with a black finish on a rust red matrix. The only other common fossils at this site are the large gastropod *Treospira discoidalis* and the solitary horn corals *Bradophyllum* and *Lophophyllidium*. These fossils weather out of the nodules a chalky white.



Figures 17 & 18 – Different specimens of the trilobite *Palladin morrowensis* from the Lake Bridgeport Shale from Wise County, Texas. Figure 18 reprinted with permission of the author from “A Field Guide to Fossils of Texas” (1989) and collected by Fred Wessman. Scale bar in millimeters.

Locality 4 – Uppermost Pennsylvanian Harpersville Formation locality north of Cisco in Eastland County, Texas

The final locality is located north of Cisco in Eastland County, Texas as shown in Figure 19. Take Highway 6 north out of Cisco 7.5 miles from the junction of Highways 6 and 183 in town. You will pass the Lake Cisco spillway at Sandy Creek after 3.5 miles. At the top of a slight hill will be roadcuts on both sides of the highway extending for $\frac{1}{4}$ mile. Park here and collect.

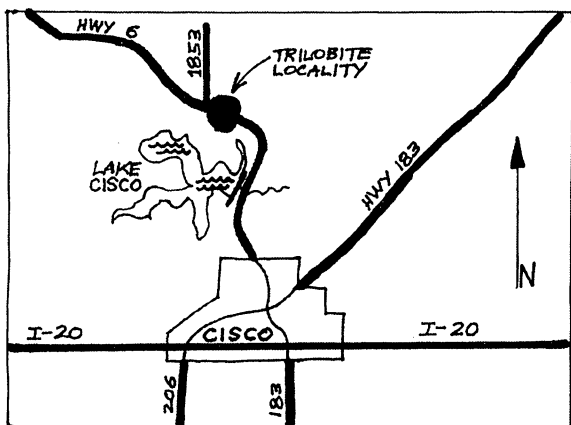


Figure 19 – Locality map for the trilobite site north of Cisco in Eastland County, Texas.



Figure 20 – Three different specimens of the trilobite *Delaria antiqua* from the Harpersville Formation.

The roadcut here consists of a basal light gray to off white shale unit that forms a recessive slope beneath a off-white to blue gray, sandy, fossiliferous limestone bed. This limestone is a few feet thick and forms a prominent ledge wherever it is exposed. Above this limestone marker is a sequence of interbedded red shales and limestone lenses. These are also fossiliferous and you can collect various invertebrates loose in the shale. This whole roadcut is an exposure of the Harpersville Formation at the top of the Cisco Group (see Figure 1). It represents the upper Virgillian Stage of the very latest Pennsylvanian and is the youngest of the three Pennsylvanian localities discussed.

Rare trilobites can be collected from the lower shale unit in the first foot or so below the base of the overlying ledge-forming limestone. These are very small trilobites and are commonly enrolled. In Moore and Plummer (1921) these are referred to as *Griffithides* (= *Ditomopyge*) *scitula*. Recent literature refers to them as *Delaria antiqua*. However, I do not see major differences between these trilobites and *Ditomopyge scitula* and I imagine a revision of this genus is in order.

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***Paradoxides harlini* Green: A Massachusetts' Gem**

By Allan P. Russell, Ed.D. Russell's Fossil Museum, P.O. Box 593, Barre, Massachusetts 01005 email: drfossil@gis.net

We call this group of arthropods TRILOBITES, that is, Tri (Latin for three) lob (Greek for a lobe) and ite (English for fossil). Some people pronounce it: Tril-o-bite, or Tril-a-bite, but they should pronounce it Tri-lob-ite to have any true scientific meaning. These interesting creatures are now extinct and are known only through their fossil remains. The time of their existence is now interpreted as being from the Lower Cambrian Period to the Upper Permian Period. This is the entire extent of the Paleozoic (Ancient Life) Era of the Phanerozoic (Evident Life) Eon. Their existence probably started within the Precambrian as evidenced by the occurrence in the Ediacarian fauna of *Spriggina floundersi* Glassner (see Fig. 1). This worm-like creature has a curved anterior margin similar to that found in trilobites. It also has a bulge suggesting the origin of the glabella. The segmentation of the body is seen as the axial lobe of trilobites with the curved end suggesting the pleural lobes. The current theory of the origin of trilobites suggests a widening and assimilation of several anterior segments (somites) of an earthworm-like creature into the cephalic region. This would be covered, as well as the main part of the body and tail, by a mineralized integument called the carapace (dorsal exoskeleton).

If you were to look at the modern sea worm, *Nereis virens* (see Fig. 2), you would see a possible rendition of what the animal may have look like previous to *Spriggina*. Here is a long worm with legs (parapodia) associated with each segment and a defensive set of mandibles. If you were to assimilate several anterior segments together and develop an exoskeleton of mineral salts to cover the entire body and legs, making appropriate breaks in the exoskeleton to achieve flexibility, you would have a trilobite with minor adjustments.

Within this group of interesting and collectable creatures is a group of trilobites that are considered index (guide) fossils. They have been found in many areas of the world (North America, Europe, Northern Africa and other questionable areas like Australia). They lived only for a short period of geologic time (Upper part of the Lower Cambrian to the ending of the Middle Cambrian). Their body shape makes them easily recognizable by the amateur and professional collector (see Fig. 3). This is the Family: **Paradoxididae** described by Hawle & Corda, 1847.

A member of this Family is the subject at hand, *Paradoxides harlini* Green. This wonderful fossil has been one of the most interesting fossil finds in Massachusetts since it was located within the Braintree Slate formation in 1856. Specimens are from a few inches to more than a foot long and its size variation illustrates a population with juvenile members as well as adults. The numerous specimens found were once the pride of the Boston Natural History



Fig. 1 *Spriggina flouderesi* (Flint, 1973)

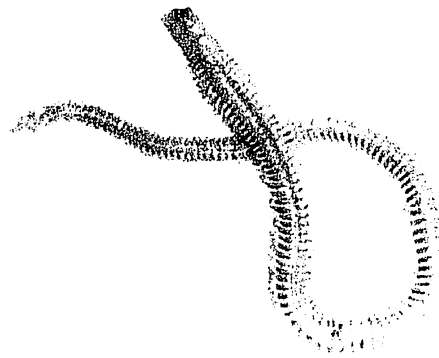


Fig. 2 *Nereis virens*

Society, but when the Society dissolved, most of the specimens were reclaimed by their collectors and have now been dispersed throughout the country.

Collecting originally was associated with the Ruggles and Hayward Creeks in Quincy and the Monatiquot Brook in Braintree, which was the site that gave the rock layers their formation name. A site around the shores of the Fore River in Braintree and Weymouth was also productive. Another outcrop of the formation is today on federal property (the Boston Naval Shipyard) which is inaccessible to collectors, except by a federal permit. Collecting has, however, continued in the Quincy City Dump. Rock taken from the quarry on the south bank of Haywood Creek, which was considered one of the classic localities in American paleontology, was used for fill. The remainder of an unused load was brought to the Quincy dump and deposited in an area just to the left (about $\frac{1}{4}$ mile) as you entered the dump.

I have collected there myself in past years, but a friend, Dr. Guido "Rocky" Del Gizzi, had great luck in the dump area and obtained a number of fine partial specimens. Unfortunately, Dr. Del Gizzi died in 1999, decreasing the number of collectors obtaining these specimens. As a tribute to my friend and others, like Mr. & Mrs. William Kelley of Stoneham, Massachusetts, I offer this brief description of this wonderful fossil.

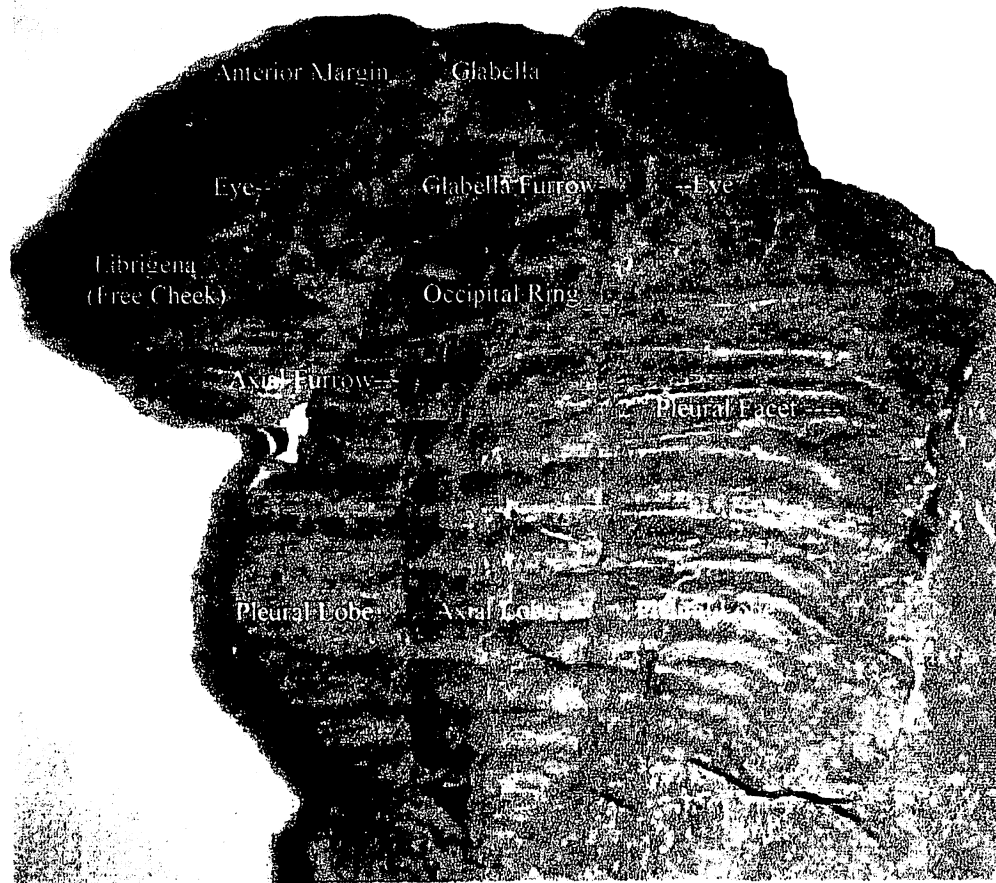


Fig.3 *Paradoxides harlini* from the collection of William Kelley

First notice that the fossil is divided into three parts, head (cephalon), body (thorax), and tail (pygidium), but these are not the three parts which give the fossil its scientific name: trilobite. The three lobes are described as the axial lobe (the central lobe) and the right and left pleural lobes (see Fig. 4). Notice also that the pleural lobes have endings of each segment which end in a point called the pleural facet. The pleural lobe extensions covered the biramous legs. Each leg was a jointed appendage called the telopodite or walking leg, which the trilobite used to crawl over the bottom on the ocean floor. The other portion of the biramous leg being associated with a gill to extract the oxygen from the water and called an pre-epipodite. It has also been suggested that this pre-epipodite could have been used for swimming. I have not been able to find any specimens or descriptions of the Massachusetts fossils having either of these remains preserved.

Starting with the cephalon (see Fig. 4) observe the bulbous glabella, which probably housed the stomach. Surrounding the stomach area were the glandular diverticules whose secretions were used to digest the food taken into the body. The mouth was an opening on the ventral (belly) side that had a covering called the hypostoma (see Fig. 5 & 5A). The liver, which was probably part of the glandular diverticules, would have been used to detoxify any ingested toxic materials. The intestine would have passed posteriorly through the center of the axial lobe to end in the pygidium.

Returning to the cephalon, notice that there is an area just in front of the glabella, the anterior margin that is similar to that of *Spriggina*. On the glabella are the glabellar furrows separating the glabellar lobes. Surrounding the glabella is the facial suture, which separates during molting. Lateral to the glabella are the compound eyes. These eyes were located at the junction of the free cheeks and the cranidium (the fixed portion associated with the centrally located glabella see Fig. 4). It has been determined that these eyes would “see” a multitude of images, which the brain would piece together. The ventrally located brain would have its optic nerves passing laterally (sideways) along the lower side of the stomach to the eyes. It would also have an extension passing posteriorly with lateral connections with each somite (segment).



The Cephalon (Russell's Fossil Museum RFMtr-102)

The other distinguishing features of *Paradoxides* are the slightly enlarged pleural facets associated with the second body section, particularly in a juvenile form and can usually be seen as large spine-like extensions (see Fig. 4 & 7). The pleural facets become elongated just before the pygidium and extend posteriorly beyond the pygidium. There are 19 individual segments making up the body of *P. harlini*. This body tapers toward the button-like pygidium (see Fig. 7). In Index Fossil Of North America there are several possible descriptions of the *P. harlini* pygidium. It has been suggested that it could look like a button, or like an elongated or wide spatula. All *P. harlini* pygidia that I've seen are button-like.

The suture lines on the cephalon and down on either side of the axial furrow were used by the trilobite to shed its carapace during molting (ecdysis). This is the way trilobites and other arthropods grow in size. What seems to happen is a new exoskeleton forms under the old one under the influence of hormones. A slight amount of fluid forms between the two exoskeletons and slowly increases in amount until it dissolves and cracks open the old exoskeleton. The trilobite would then crawl out of the old exoskeleton with its new soft and flexible exoskeleton in place. Blood flow carrying with it excess fluids helps expand the trilobites' body to enlarge the new exoskeleton to its next size. The animal is vulnerable during this phase and would seek a hiding place to protect itself. Many fossil remains of trilobites are of molts and some can actually be identified as such by possessing only the cranidium (the fixed portion of the cephalon). The suture lines of the head have been used to classify trilobites into four groups: *Paradoxides* belongs to the opisthopygian group.

Lateral to the glabella and at the ends of the free cheeks (librigena) were the genal spines (see Fig. 5), which extended posteriorly about 2/3 of the body length. Many of these have been found in a pyritized state. They were probably used as stabilizers while the trilobite swam above the surface of the ocean bottom.

Numerous partial specimens have been found and the Boston Museum of Science has a fine complete specimen on display for public viewing. The sedimentary rocks, in which the fossils are found, are called the Braintree Slate formation. This formation, in which the fossils are found, is dark-gray in color upon initial collection, which, if left to weather, turns a purplish-red. According to

Emerson, this is a rock called a lydite. It is very hard and a four-pound crack hammer is needed to break apart the blocks of rock. If you see an indication that some part of the trilobite is under some matrix, use a one-inch chisel to remove the unwanted matrix. If you are lucky a small specimen can be found, but more likely you will find partials. Familiarize yourself with the pictures seen here to be able to ascertain which part of the trilobite you were able to collect. Good Luck in your collecting.

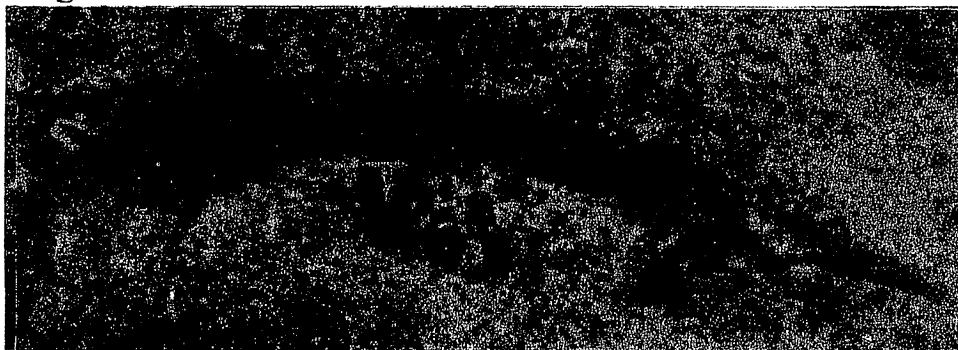


Fig. 5 Genal Spine (RFMtr-102b)

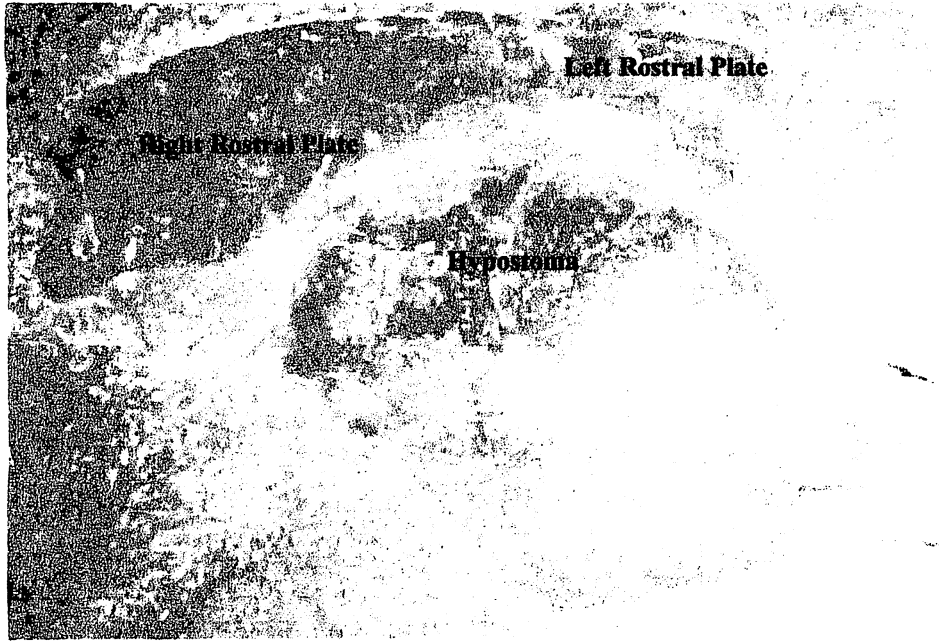


Fig. 6 Hypostoma with rostral plate (Russell's Fossil Museum RFMtr-102c)



Fig 6A Hypostoma (Russell's Fossil Museum RFMtr-102d)

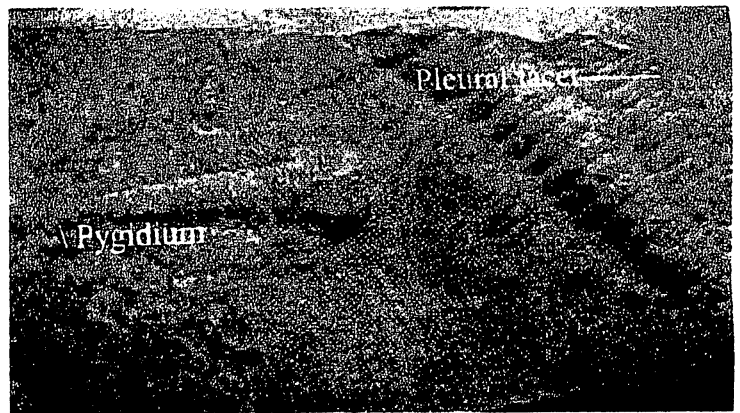


Fig. 7 (From the collection of Mr. & Mrs. William Kelly)

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THE PHILATELIC TRILOBITE

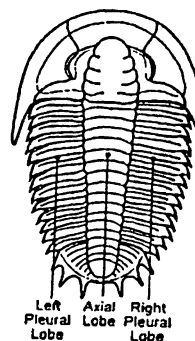
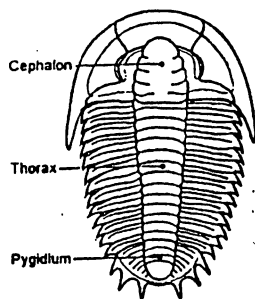
As much as trilobites are popular with fossil collectors -- they are also popular with stamp collectors.

What are trilobites?

The trilobites were a class in the phylum arthropoda. The arthropods are invertebrate animals which also include crustaceans, insects, arachnids, and myriapods. Trilobites lived during the Paleozoic Era from 570-245 million years ago. They became extinct just as dinosaurs appeared on earth. The trilobite is considered by many to be the signature creature of the Paleozoic Era.

The trilobite body plan consists of three main body parts. They are the cephalon (head), the thorax, and the pygidium (tail).

The name trilobite means three lobed. They have a long central axis flanked on each side by a right and left pleural lobe. These three lobes run from the cephalon to the pygidium.



Three states have a trilobites as their state fossil:
Ohio -- *Isotelus*
Pennsylvania -- *Phacops rana*
Wisconsin -- *Calymene celebra*

More than thirteen countries have pictured a trilobite on postage stamps. The earliest stamp was issued in 1958 by China. In the 1990's, seven countries issued stamps picturing trilobites.

In the year 2000, Czechoslovakia issued four stamps honoring Joachim Barrande. There is a trilobite on each of the stamps plus other fossils..

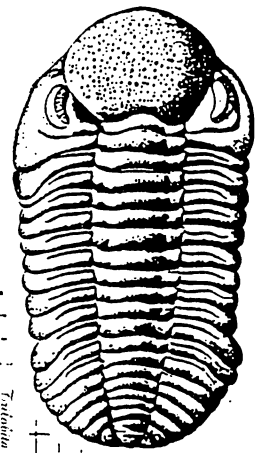
Barrande was born in Saugues, France in 1799. He was an engineer and a paleontologist, who devoted 44 years of his life to the study of paleontology and geology in central Bohemia. Barrande donated his collection of 1,200 crates of fossils to the Czech National Museum.

The last stamp in my collection, which pictures a trilobite, is from Slovenia -- issued in mid 2000.

FOSSILS

THE TRILOBITE

An Introduction to Prehistoric Life



<p>CHINA</p> <p>1958</p>	<p>CZECHOSLOVAKIA</p> <p>ČESKOSLOVENSKO</p> <p>1968</p>	<p>TUNISIA</p> <p>1982</p>	<p>ÅLAND</p> <p>1996</p>
<p>CANADA</p> <p>1990</p>	<p>BRITISH ANT. TERR.</p> <p>1990</p>		<p>GERMANY</p> <p>1973</p>
<p>CZECHOSLOVAKIA</p> <p>ČESKÁ REPUBLIKA</p> <p>2000</p>		<p>SLOVENIA</p> <p>2000</p>	

Trilobite Fragment Identifier

Dry Dredgers
Department of Geology
University of Cincinnati
Cincinnati OH 45221-0013

Introduction

Trilobites are commonly found throughout the Cincinnati Area. Yet some people seem to find all the trilobites while others have spent countless hours in fields and road cuts without a single trilobite to show for it. What's the secret to finding trilobites? There are several. This guide has been written to help give you what it takes to find and identify fragments and complete specimens of *Flexicalymene meeki* and *Isotelus maximus* trilobites.

The first and foremost secret is persistence. People who have spent the most time looking for trilobites are usually the ones who have found the best specimens. Never give up.

The second secret is knowing where to look. Even though nice specimens can be found anywhere in Cincinnati, trilobite fossils are easily found in "zones" within the rock strata. In these zones, there are spots where you will find large populations of trilobite parts that are the result of molting. This is where trilobites have shed their old exoskeletons as they grew. You can increase the chance of finding a whole trilobite by finding a trilobite zone and looking carefully for trilobite parts.

The next secret is knowing what to look for. Use this document to help you identify trilobite parts and whole specimens that are partially below ground. Another secret is the skill of careful examination. Once you've found a place that shows evidence of trilobites, get on your hands and knees and look for the whole trilobites. Often they are no bigger than a pebble. Close scrutiny of the ground will eventually pay off.

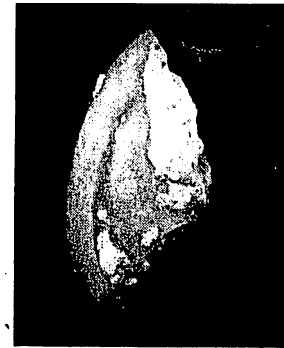
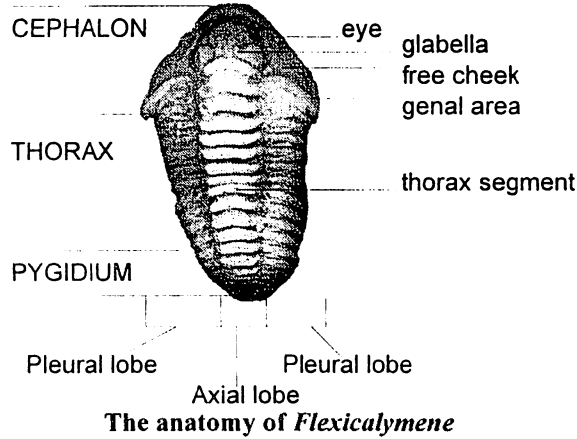
This article describes the exoskeleton parts of the two most common trilobites in Cincinnati, *Flexicalymene meeki* and *Isotelus maximus*. Prepared by Bill Heimbrock and the Dry Dredgers. The Dry Dredgers are an association of amateur geologists and fossil collectors

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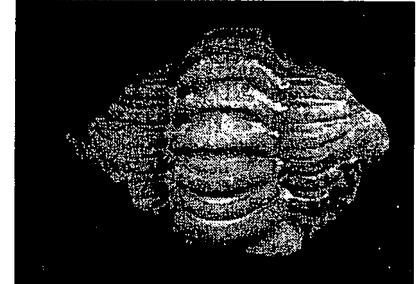
Trilobite Fragments Identifier

Flexicalymene meeki

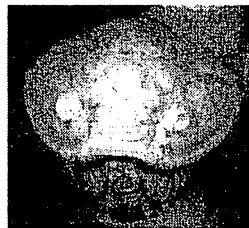
Flexicalymene meeki range in size from less than a millimeter to more than an inch across and several inches long. This is the most common trilobite species to be found whole in Cincinnati. They are most often found enrolled (in a ball) but are sometimes found fully or partially stretched out.



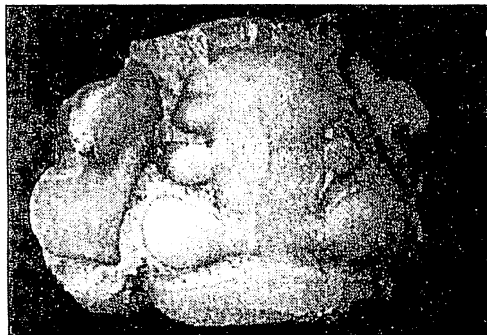
Flexicalymene meeki free cheek from a molt. 1.9x Colerain Township, OH Waynesville Formation



Flexicalymene meeki. An enrolled thorax. 3x Colerain Township, OH Waynesville Formation



An Enrolled *Flexicalymene meeki*



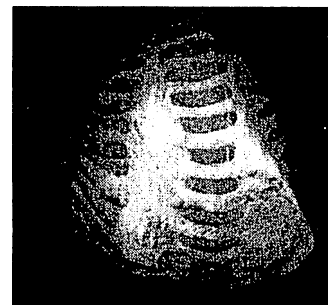
Flexicalymene meeki. Glabella exterior. 3.5x Crestview Hills, KY. McMillan Formation.



Flexicalymene meeki. Glabella interior. 2.3x Crestview Hills, KY. McMillan Formation



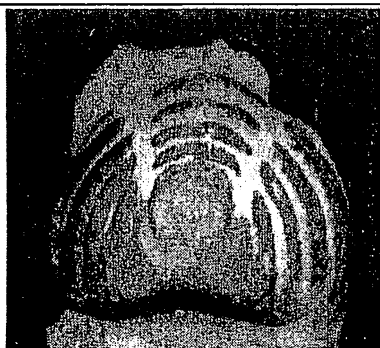
Flexicalymene meeki. Many cheek molts in matrix. 1.5x Crestview Hills, KY McMillan Formation.



Flexicalymene meeki. A partially enrolled thorax in matrix. 1.5x Colerain Township, OH Waynesville Formation

Flexicalymene meeki

Trilobite Fragments Identifier



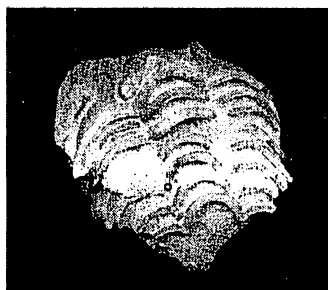
Flexicalymene meeki. Pygidium exterior. 3.25x
Crestview Hills, KY. McMillan Formation.



Flexicalymene meeki. Pygidium interior. 4.67x
Crestview Hills, KY. McMillan Formation.



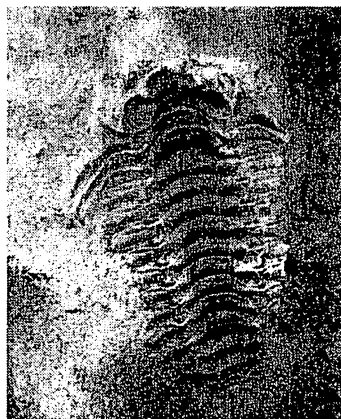
Flexicalymene meeki. A thorax segment in rock matrix. 2.5x
Crestview Hills, KY McMillan Formation.



Flexicalymene meeki. The thorax from a molt. 2.25x
Crestview Hills, KY McMillan Formation



The pleural lobe thorax of an enrolled *Flexicalymene meeki*. 2.5x
Colerain Township, OH Waynesville Formation



Flexicalymene meeki. An inverted thorax in rock matrix showing interior. 1.2x
Cincinnatian series, Courtesy of Dry Dredgers

Flexicalymene meeki

A set of thorax segment ends held together by matrix (left). An end fragment of a thorax segment seen free from matrix and trilobite (right). 1.37x (left) 1.62x (right) Courtesy of Dry Dredgers

Trilobite Fragments Identifier

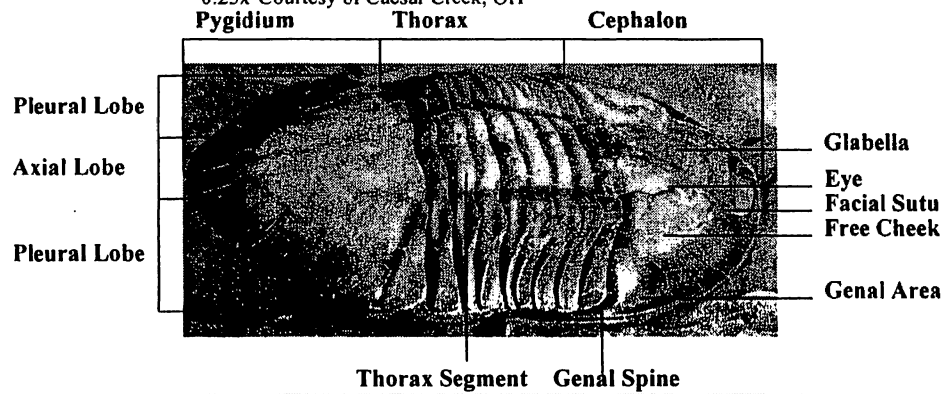


Isotelus maximus

Isotelus maximus range in size from less than a millimeter to as long as 14 inches. The exoskeleton of this giant of trilobites is usually found in fragments. For this reason, most people only find parts of Isotelus trilobite. Isotelus maximus has been found whole, but this is quite unusual and a great treasure. Usually, complete specimens of Isotelus are found in hundreds of pieces that must be meticulously reassembled. You will probably be satisfied finding parts of Isotelus often several inches long. You may get lucky and find a complete specimen of enrolled Isotelus as small as a pebble. The pictures below will help you find and identify evidence to what these fascinating giant trilobites looked like.

The anatomy of *Isotelus maximus*.

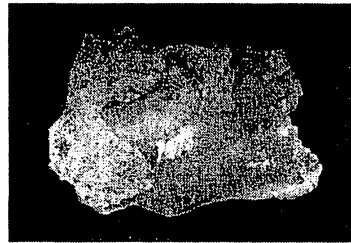
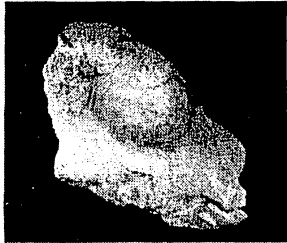
0.25x Courtesy of Caesar Creek, OH



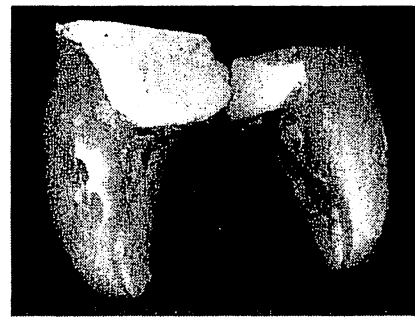
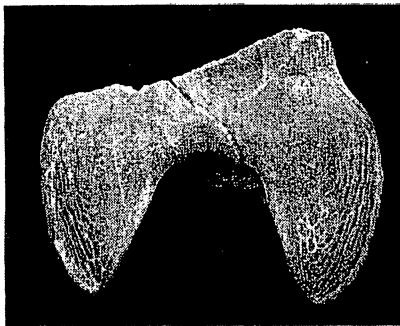
Isotelus maximus. An entire cephalon showing facial suture. 0.36x Courtesy of Caesar Creek, OH

Isotelus maximus

Trilobite Fragments Identifier

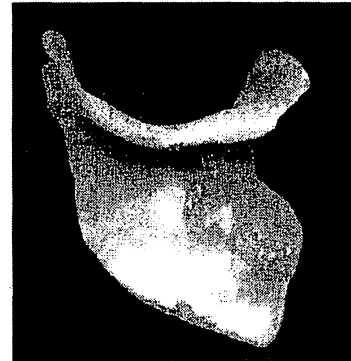
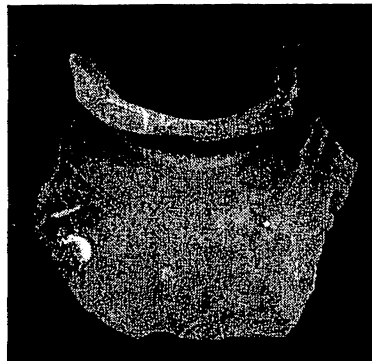


Isotelus maximus. Two separate eyes in matrix.
2x & 1x Crestview Hills, KY McMillan Formation



On the underside of the *Isotelus* mouth is a hard part called the hypostoma. The two nodes of the hypostoma are often of unequal size and frequently separated. Each have three unique surfaces. The outward facing side (left) is distinguished by squiggly contour lines with two round indentations near the top of each node. The inward facing side (right) has two surfaces, the outer surface is smooth while the inner is corrugated with fine ribs that are remarkably preserved. .

1x Harsha Dam, East Fork Lake, OH. McMillan Formation

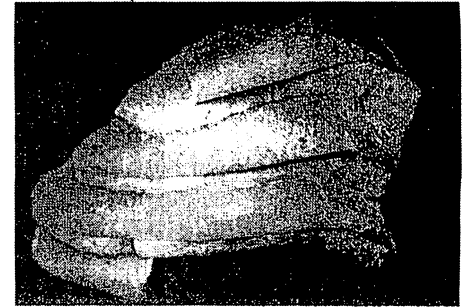
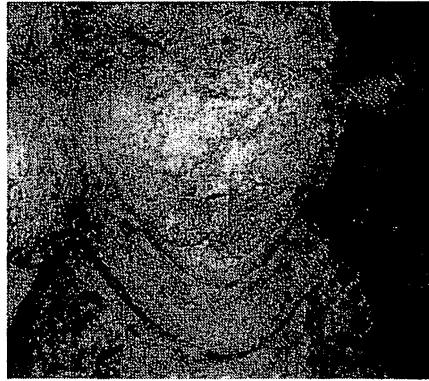
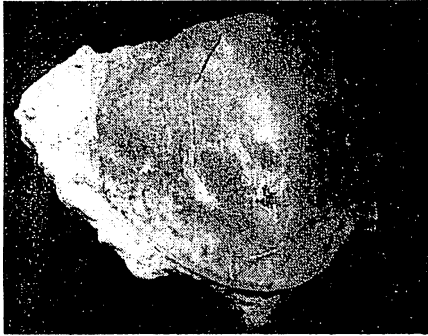


These two *Isotelus* fragments are from the center section of a hypostoma. Where the two nodes meet, a concave lip shape is often found when no rock matrix fills the hypostoma.

2x Crestview Hills, KY McMillan Formation

Isotelus maximus

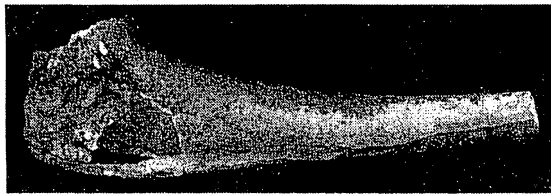
Trilobite Fragments Identifier



Complete pygidium are often found either attached to rocks (left) or encased in rock matrix (right).

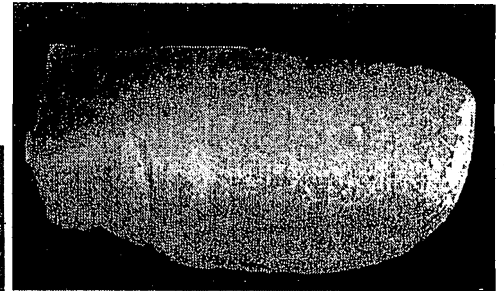
1.4x *Isotelus maximus*. Crestview Hills, KY McMillan Formation

A thorax segment ends held together by matrix (1.37x)



Isotelus maximus. The genal area including genal spine (left). A more complete genal spine (right).

1x (left) 2x (right) Caesar Creek, OH Waynesville Formation Courtesy of Dry Dregders



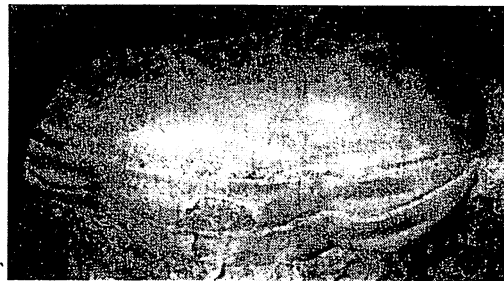
An end fragment of a thorax seen free from matrix and trilobite (1.62x)

Isotelus maximus. The genal area in matrix. *Isotelus maximus*. The free cheek and eye in matrix.

0.8x Richmondian Stage

1.5x State Rt. 17, KY Kope/Latonia Formation

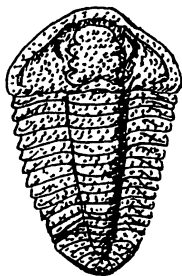
Isotelus maximus



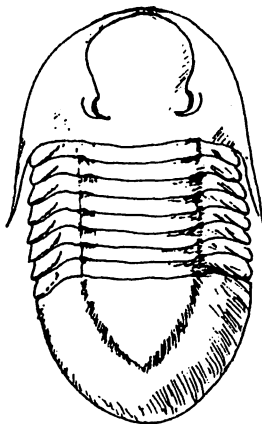
Portions of *Isotelus maximus* thorax can be found still attached to the pygidium (left) or isolated as a brown stripe on the surface of a rock.

2.85x & 1.15x Harsha Dam, OH McMillan Formation

Flexicalymene granulosa: a smaller version of *F. meeki*, found in the Kope. The skeleton is covered with little bumps. Hence, the species name.

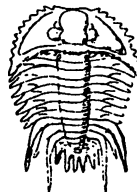


Isotelus maximus: the largest trilobite of the area. Complete specimens up to 40 cm. in length have been found. Pieces collected indicate that some grew to as much as 60 cm (24 inches) or more. This is the official Ohio state fossil.

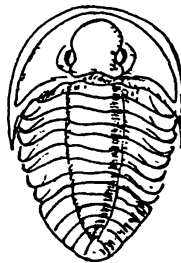


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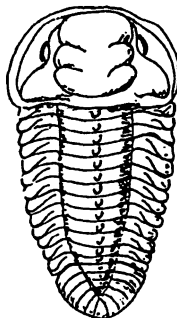
Primaspis crossota: another small, rare trilobite, similar to *Acidaspis*, but without the occipital spine. Pieces are found in some rocks. Limited to the lower portions of the Kope Formation.



Proetus spurlocki: very rare. Fragments are not common. Only known specimens are not very complete because of the fragile nature of the exoskeleton.



Triarthrus eatoni: generally limited to the base of the Kope formation. Although complete specimens have been found, they are extremely rare.



Some
TRILOBITES
of the
CINCINNATIAN



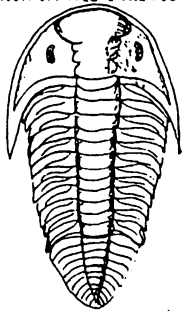
Courtesy of the
DRY DREDGERS

An Association of Amateur
Geologists and Fossil Collectors

Trilobites are extinct members of the Arthropod family which were quite common in the Paleozoic sea waters that covered what is now the area in and around Cincinnati, Ohio. Fossils of these creatures, although plentiful, are sometimes hard to find. But, persistent looking can lead to great "treasures" and, once in a while, pockets of these long-gone creatures.

Although only a couple of species are very common in the area, about 18 species of trilobites have been found in the limestones and shales of the region. This brochure is designed to acquaint you with some of the more common, and a few of the less common, members of the trilobite family of the Ordovician Period of Cincinnati history.

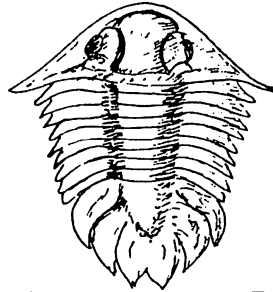
Achatella carleyi: a rare trilobite. The exoskeleton is somewhat flattened with very prominent compound eyes. Usually found in the Fairview Formation.



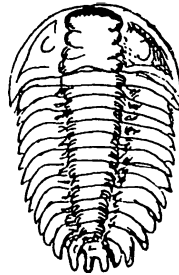
Acidaspis cincinnatiensis: a spiny trilobite. Rarely found complete, pieces can be found in many rocks from the Kope up into the Maysville. Cephalon contains a characteristic occipital spine extending over the thorax. Generally of very small size, but, some specimens measuring several centimeters have been found.



Amphilichas shideleri: although cephalons and pygidiums have been found, less than half a dozen complete specimens have been collected. Characterized by a beautiful pygidium (or tail).



Ceraurinus icarus: very rare. Even pieces of this trilobite are difficult to find. Located in the Liberty and Whitewater Formations.



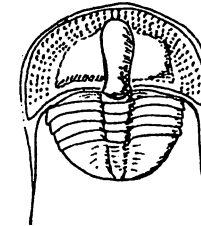
Ceraurus milleranus: complete specimens are rare, but parts can be found, abundantly in some locations. Characterized by a pair of curved spines on the pygidium. Known from the Fairview Formation.



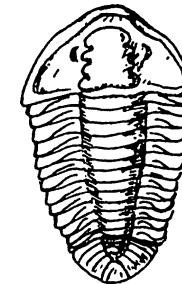
Chasmops breviceps: similar in some respects to *Phacops* of the Devonian, this trilobite have been found in only one Whitewater Formation site.



Cryptolithus bellulus: the "lace-collared" trilobite of the Kope Formation. Cephalons and parts of cephalons are readily found. However, complete skeletons are difficult to find because the thoracic segments are very thin and fragile.



Flexicalymene meeki: the most common trilobite of the Cincinnati. Pieces, as well as complete specimens, can be found in nearly all rock formations above the Kope.



TRIARTHURUS SPINOSUS BILLINGS

By Jean-Guy Pellerin and Thérèse Séguin
Montréal, Québec, Canada

The following article and drawing are of a specimen found in the Ottawa area.

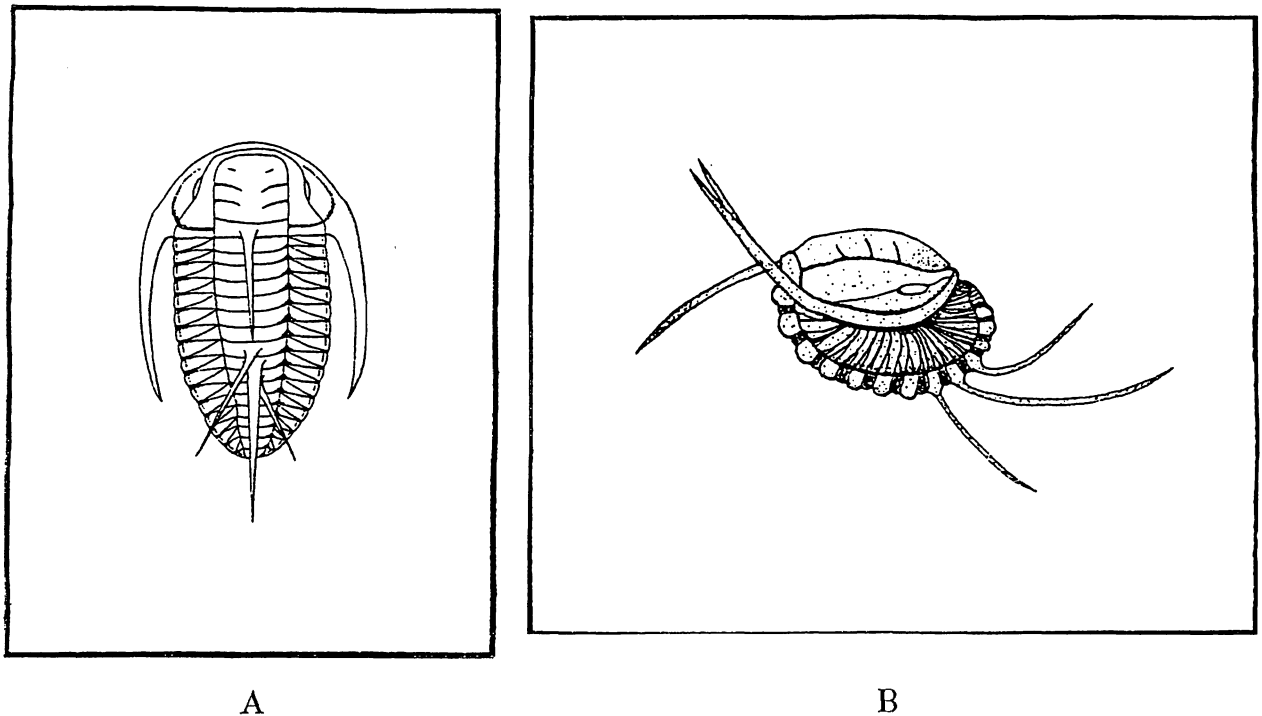


Figure 1 *Triarthrus spinosus* Billings

A) dorsal view of spiny trilobite (X 4).

B) reconstruction of an enrolled specimen (X 4).

Black shale are found in the Ottawa area. These sediments, deposited 440 million years ago, are of upper Ordovician. They from the Utica Group which was divided locally in two formations.

The Eastview formation belongs to lower Utica and the Billings formation belongs to upper Utica.

The bottom of this sea was extremely poor in oxygen as shown by the pyrite in these sediments. Fossils are sometimes literally replaced by pyrite.

Locally the fauna was principally pelagic. This show, that these animals had succeed to adapt to better living conditions in the upper level of sea water.

Trilobites have also succeed in this adaption as demonstrated by their presence. Among them is *Triarthrus spinosus*, well known by collectors in the Ottawa area. So here are some information on this species.

The genus *Triarthrus* was described in 1832 by Green and the species *spinosus* in 1857 by Billings.

Here are the major characters of this species:

- Cephalon:** Semicircular, genal point long and curved towards the back. Long median spine on occipital ring.
- Thorax:** 12 thoracic segments on adult specimen. On the 8th, 9th and 10th thoracic segment is a median spine. The spine located on the 9th segment is much longer than the two others.
- Pygidium:** Trapezoidal in shape, with 4 axial rings.
- Geological distribution:** Period : Upper Ordovician
Group : Ulica
Formation: Billings

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Fossils of Ohio, Bulletin 70, Ohio Division of Geological Survey, Columbus, 577 p.

Trilobites of Wisconsin's Upper Cambrian

by

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Middleton, WI 53562

Ronald C. Meyer
920 Miami Way
Boulder, CO 80303

Trilobites became an early passion of ours. We grew up in the Fox River valley in the northeastern corner of Wisconsin, where the allure of a Middle Ordovician *Isotelus*, *Flexicalymene*, or *Ceraurus* drew us to the many quarries in the region before we were fifteen years old. Later, we would collect near Milwaukee in a quarry famous for the many *Calymene celebra* found there. But always in the back of our minds were the ancient Cambrian trilobites in the western part of the state. We knew of them from musty old monographs and the nineteenth-century book, *Geology of Wisconsin, Volume IV, 1873-1879*. Many of the trilobite heads and tails illustrated in these sources were seen and studied by the famous Charles Doolittle Walcott probably while he was in search of new taxa near the end of nineteenth century. It was fun to fantasize about the old master tromping through the dark wooded hills of Wisconsin's driftless area, searching for trilobites in strata with such mysterious-sounding names (to our young ears!) as the Potsdam, the Franconia, and the Dresbach.

As soon as we got our driver's licenses we headed into this region. But instead of the easily located large quarries we were used to, the Cambrian sites were often located in tiny, overgrown quarries or on huge bluffs that were difficult to traverse. When we did find a site, we had to dig and split large quantities of siltstone and sandstone that produced precious little in the way of fossils – to say nothing of complete trilobites. At the time we had no idea that

one had to actually *work* a location, often mining only a narrow fossil-bearing strata within a larger exposure.

We were about to give up on late Cambrian trilobites when our paleontological mentor, Dr. William Read of Lawrence University, Appleton, revealed his secret site to us. It was a farmer's small quarry located on a knoll near the town of North Freedom, Wisconsin. The site was later named "Trilobite Hill." This previously secret location was later revealed to the world during a field trip of the 1960s USGS meeting, hosted by the University of Wisconsin-Madison. As result of that meeting, a second quarry was opened across the road from the original small pit. Up until then, we had had exclusive collecting "dibs" on the site where we found many spectacular very large heads and tails of the Upper Cambrian trilobite *Dikelocephalus*, along with our first complete trilobite. (Unfortunately, that specimen, a small, spiny creature, ended up in the collection of a friend, Dan Fredrickson.)

Throughout the 1960s and 1970s we would visit Trilobite Hill at least a couple times a year. The siltstones found here belong to the Lodi shale, a member of the St. Lawrence Formation. The Lodi has a rich assemblage of fossils. Some of the animals represented in this stratum are a variety of trilobites, gastropods, brachiopods, graptolites, and a phosphatic, soft-body-like arthropod group, Aglaspida. In some ways these aglaspidid arthropods look like horseshoe crabs and probably share a common ancestor with trilobites. More of the articulated specimens of this enigmatic group of animals have been found at Trilobite Hill than at any other single locality.

While we continually collected at Trilobite Hill, we also ventured north to explore an older formation, the Eau Claire. Here we found many wonderful slabs containing the heads and tails of *Cedaria* and *Crepicephalus*, but it wasn't until later that Jerry found our first complete trilobite in this formation--one with at least 30 body segments. It was much like the genus *Menomonina*. Soon after this find, we found a one-millimeter-long juvenile trilobite (Fig. 2a), which we

discovered while cleaning a phosphatic inarticulate brachiopod with the aid of a compound microscope. However, due to its small size, we have been unable to identify this trilobite.

We would have thought finding more complete trilobites in these Cambrian rocks was unlikely if we hadn't, in the early 1980s, discovered the Silurian soft-bodied fauna in the Brandon Bridge near Waukesha, Wisconsin. This discovery brought us in contact with Dr. Derek Briggs, a British paleontologist famous for his work on the Burgess Shale.

Dr. Briggs brought two very bright young Ph.D. candidates to the U.S. to work on the Upper Cambrian of Wisconsin. Their arrival re-energized our interest in the Lodi shale. Steve Hesselbo, who would study the Aglaspidida, arrived first. A few years later, Nigel Hughes followed, to study *Dikelocephalus* (Fig. 2 c). In order to help them with their work, we had to locate and recollect many of the sites O. G. Raasch had used in his earlier studies of Upper Cambrian fauna. In the process of searching for Raasch's localities, we found a number of new places where Lodi shale was exposed. Three of these new sites would produce complete specimens. Eventually, during this intense collecting period, we found seventeen complete trilobites, including three complete Saukiids (Fig. 1 b), four *Tellerina* (Fig. 2 b), and the second complete *Dikelocephalus*. But, by far the most commonly found complete trilobite was *Iliaenurus quadratus* (Fig. 1 a), represented by eight specimens. Most of these *I. quadratus* specimens had ten thorax segments. Two of these specimens had eleven thorax segments, but we believe it is reasonable to conclude that they all belong to one species. Such variability in a species has been found in trilobites from the Lower and Middle Cambrian as well, while species from the rest of the Paleozoic do not seem to show this morphological variability.

All in all, the few trilobites we found were paltry in number compared to the number of trilobites found in Utah and Nevada--especially considering it was over almost a lifetime of collecting by two people.

Sadly, even though so many collectors and geology groups have visited Trilobite Hill and found it a productive site, the farmer finally filled in both quarries in the mid-1990s. Still, the hope of finding just one more of these very special Cambrian trilobites remains.

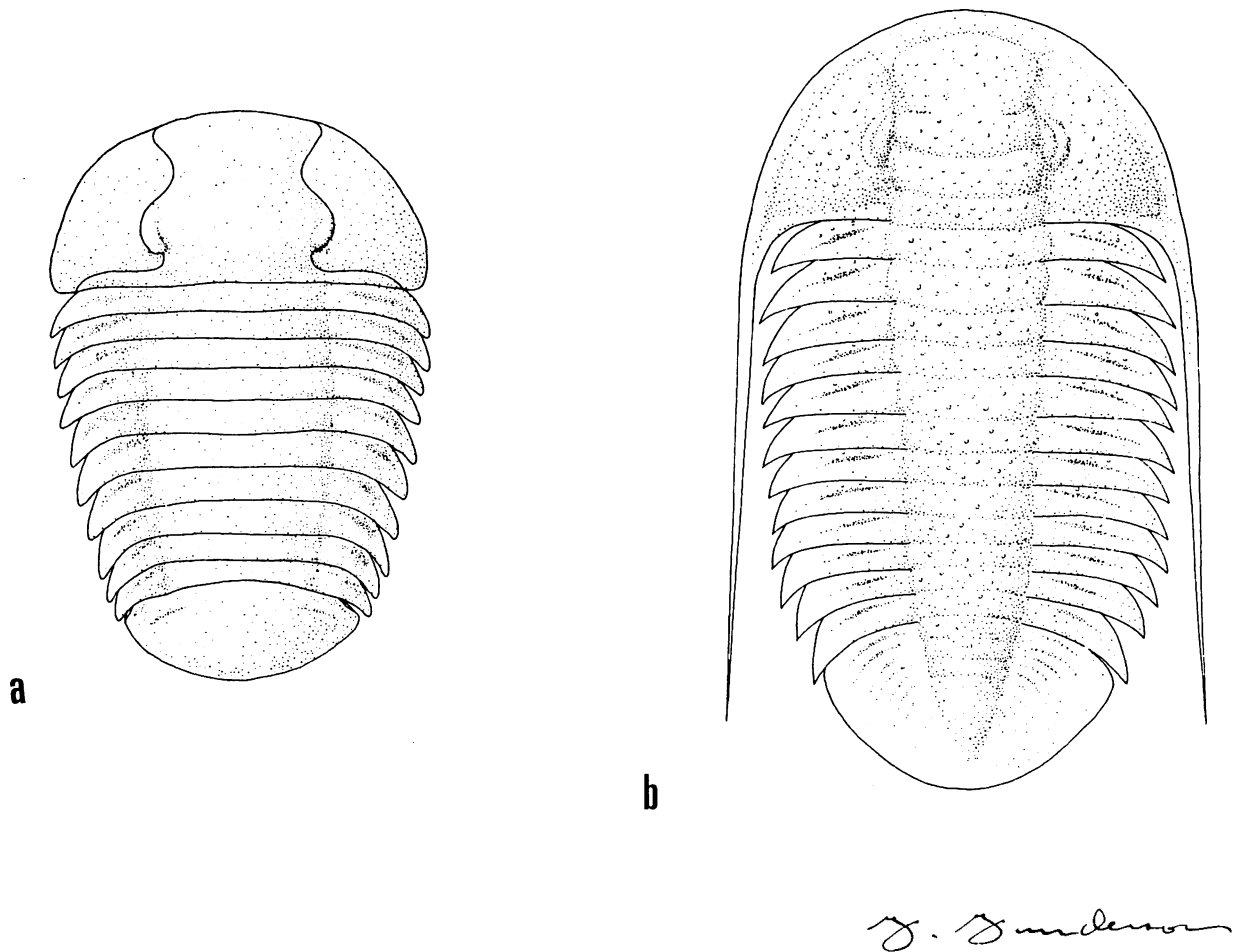


Figure 1. Found in the Saint Lawrence Formation, Lodi Member: a. *Illaenurus quadratus*, 2x; b. *Saukia acuta*, 1.7x.

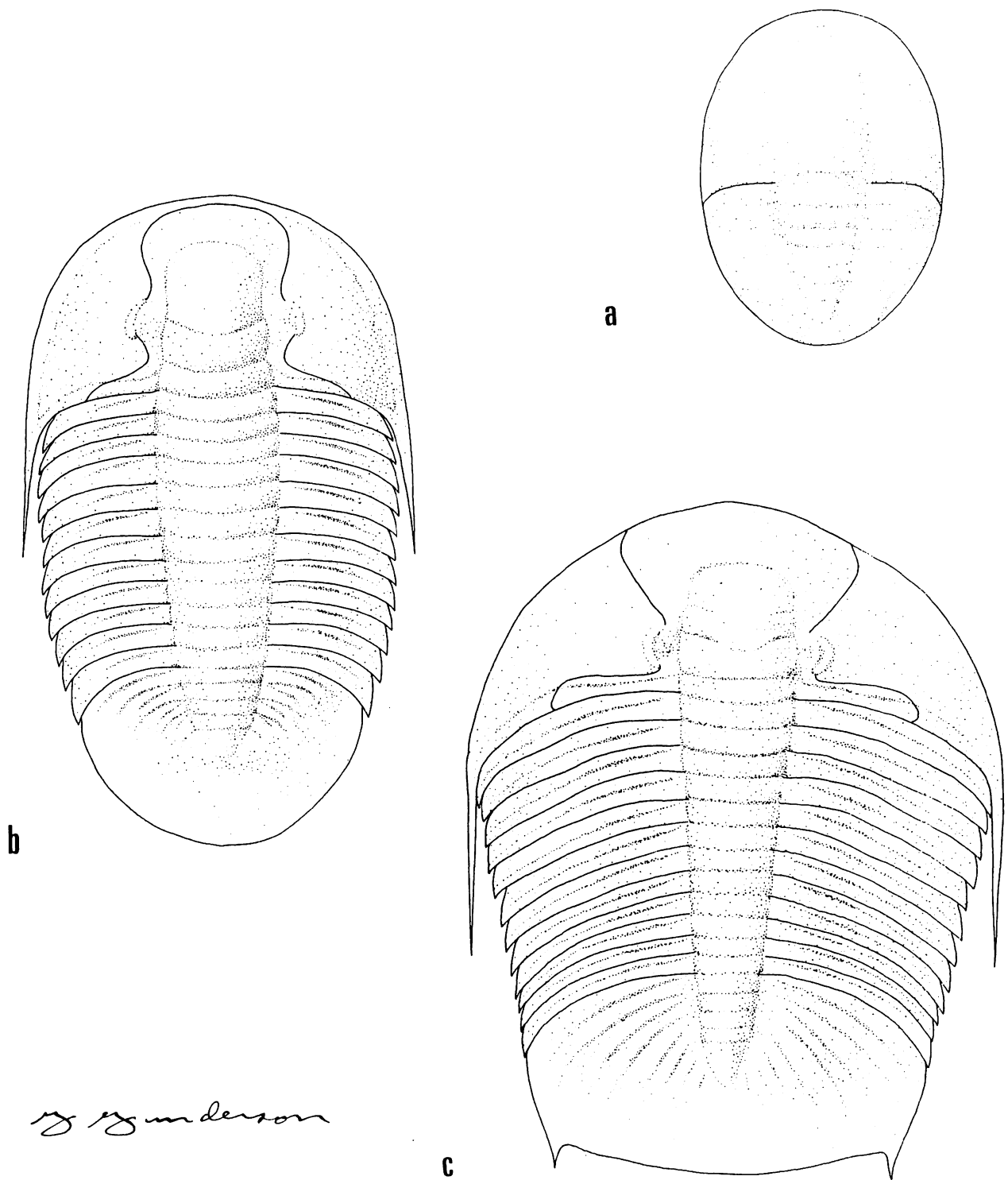


Figure 2. Found in the Eau Claire Formation: a. juvenile trilobite of unknown taxa, 55x. Saint Lawrence Formation, Lodi Member: b. *Tellerina crassimarginata*, 1x; c. *Dikelocephalus minnesotensis*, 1x.

Late Cambrian Nearshore Conditions

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When David Dale Owen sailed up the Mississippi River and then onto the St. Croix in the 1840s, he probably did not know what lay ahead. The lure of trilobites was sufficiently strong that he was prepared to risk his neck for the chance to find the perfect cranidium of trilobite species new to science.

So began the history of research on the Cambrian paleontology of the Upper Mississippi Valley. When Owen returned to his laboratory in New Harmony, Indiana (the site of an early Communist settlement founded by his father Richard Owen), he described these fossils in one of his monographs on the geology of the Midwest. These classic works are now every bit as collectable as the fossils he described.

Owen's pioneering efforts enticed many geologists to study the Cambrian of Wisconsin, Minnesota, and Iowa, and many aspects of the paleontology of the region are now known, even though much research remains to be done. During Cambrian times, most of present-day North America formed a large, isolated continent called Laurentia that straddled the equator and was rotated at 90 degrees, such that the equator itself cut each of the Dakotas in half, passing right on through Texas. Although the central-most part of the continent, including much of Canada, was land, most of the present land surface of the United States was covered by a shallow sea, probably quite warm. In this warm body of water, a varied fauna of different invertebrate animals lived, some of which eventually became fossils. The Upper Mississippi Valley region

became flooded only in late Cambrian time, about 505 million years ago, with the result that sedimentary rocks of lower- and middle-Cambrian age are absent from this region.

Cambrian rocks found in the area often look as if they were formed yesterday--at least that was how it appeared to my European eyes, which were used to all Cambrian rocks being compressed black shales, usually found in tilted beds. The Cambrian beds of Wisconsin are flat-lying, still retaining almost the same angle to the Earth's surface they had when they were first deposited as sands on the Cambrian seafloor. The tracks and trails of the animals that left them are, in some places, spectacularly preserved, as are a variety of body fossils. These include numerous trilobites, strange aglaspiddid arthropods, phylocariids, inarticulate and articulate brachiopods, early mollusks including snails, dendroid graptolites, tubular fossils of various kinds, and scyphozoans (jellyfish) of various kinds, including the earliest true conulariids. Where fossils are most common, preservation is unfortunately at its poorest. This is because in the most abundant beds, accumulations of animal parts were concentrated by the action of storm waves that winnowed away the finer grained sediment, leaving the coarser skeletal hash behind. This area straddled the equator--the best spot for tropical hurricanes that regularly swept through the area.

Sedimentary rocks were deposited in the region intermittently from about 505 million years ago up to about 495 million years ago. Fluctuations in the relative height of the sea level means that some beds are coarse sand, devoid of fossils, which represent beach deposits. When relative sea level was higher, more fine-grained rocks, deposited in conditions of lower energy, were preserved, and it is in those that there is a chance of finding a complete trilobite. But even in these finer-grained muddy rocks the chances of there being a complete specimen are low, because the entire

area was relatively close to the shore and the water was never deep enough to completely mask the seafloor from the effects of the most violent hurricanes. Stir up the bottom muds a little, and the chances of a complete trilobite are at zilch. Only the true enthusiast, like Jerry or Ron, persists in these sorts of situations!

Due to the cyclic nature of the deposition, coupled with the rapid evolution of trilobites, a nice biostratigraphic succession of trilobites was established through these rocks in the middle part of the last century. Distinctive trilobites like *Cedaria woosteri* and *Crepicephalus* characterize the lower units, while the large *Dikelocephalus* and *Tellerina* were common towards the end of Cambrian time. The varied shapes among many of the trilobites found from this region suggests a variety of life modes – some probably feeding on the sediment itself, while other, larger trilobites were more probably scavengers or even predators. As many collectors will know, many middle and late Cambrian trilobites tend to be rather unspectacular compared to species that appeared in the Ordovician and thereafter. Interestingly, the Upper Mississippi Valley region probably harbored the primitive relatives of these more striking, later groups. There are a number of weird wonders among the trilobites from the Upper Mississippi Valley. For example, *Cedaria* had a unique suture around its eye, while *Menomonina* had a similarly weird suture, and a thorax with over 40 thoracic segments – perhaps the largest known in any trilobite.

My own work in the region concentrated on the huge trilobite *Dikelocephalus* and its unusual pattern of shape variation that has been confounding paleontologists ever since Owen first described it in 1852. Jerry and Ron taught me a great deal about collecting in these fascinating, though challenging rocks, and it's been a great pleasure working with them over the past 15 years. We've even published a couple

of scientific papers together on these fossils, in the Journal of Paleontology! I want to congratulate all those in the amateur community (whom I call "non-professional professionals") that are actively involved in undertaking or supporting paleontological research. You are so vital to the prosperity of the science of paleontology.

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<http://cnas.ucr.edu/~earth/faculty/nch/nch.htm>
<http://www.trilobyte.ucr.edu>

I found a Trilobite

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A number of years ago when I lived in New South Wales, Australia I used to spend time at my mother's place in Parkes. This was about 20 miles from Forbes where I used to collect Trilobites which I used to trade for other fossils to add to my collection. This is a far cheaper way of getting additions without having your hand in your pocket all the time.

The Fossil Club of New South Wales use to go to Cotton Hill quarry occasionally, to collect a few Trilobites and Graptolites. It was usual to just search the matrix piles and split the shale. I eventually realized that I needed to find the layer which contained the Trilobites. Through trial and error I found the layer I wanted and used to go over week ends. I had obtained permission from the local council being a Council Quarry so I never had any problem going there in fact I meet the guy who originally approved my access into the quarry one day and we had a long chat.

According to information obtained from Lawrence Sherwin there were two Trilobites found there: *Primaspis* species which is now known as *Sinespinaspis* species (this was the common one) and *Paraaulacopleura* species, which is now known as *Aulacopleura* species which was a lot rarer, and only found occasionally.

In 1995 while digging in the layer one week end I split some shale and found a new one which probably had not been seen before. I thought it a Trinucleidae but would have to leave it for the experts.

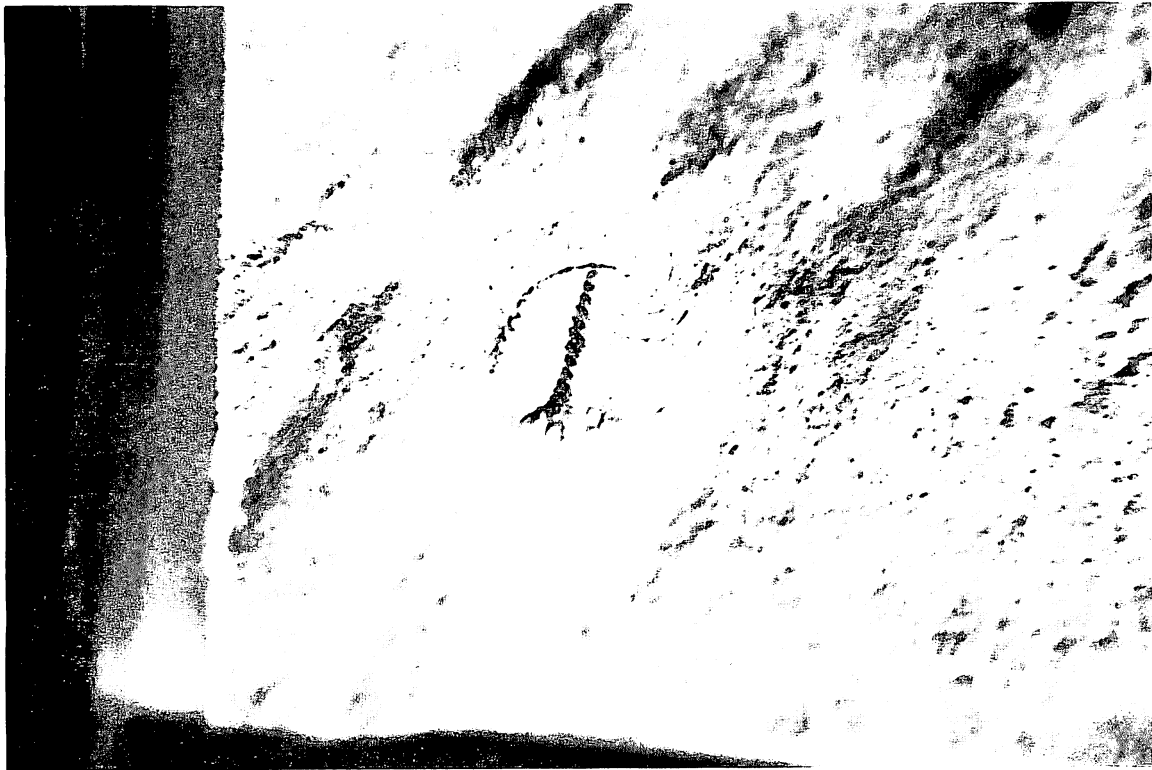
I happened to be travelling to Sydney on business in June so I made arrangements to show it to Greg Edgecombe, the Invertebrate Paleontologist, with the Australian Museum. Greg loves Trilobites and

was more than happy to identify it as a *Raphiophorus* species and offered to do a paper on it. As the original finder of the Trilobite I was more than happy to agree to this. The original type specimen (holotype) is currently on loan to the Museum.

Upon my return to Parks, I rang Mr. Sherwin who had done a paper on the Graptolites of the Forbes District and asked him how many different types of Trilobites were found at the Cotton Hill Quarry. He advised that there were only two, so I advised him I had found a *Raphiophorus*. I am advised that the paper is still being done. Greg was waiting for a paper to be printed on the Trilobites of the Melbourne Formation by Andrew Sandford which made reference to the *Raphiophorous jikaensis* (Holotype West Brunswick, Victoria). Andrew has advised me verbally that my Trilobite is different from the Victorian species.

Technical Information

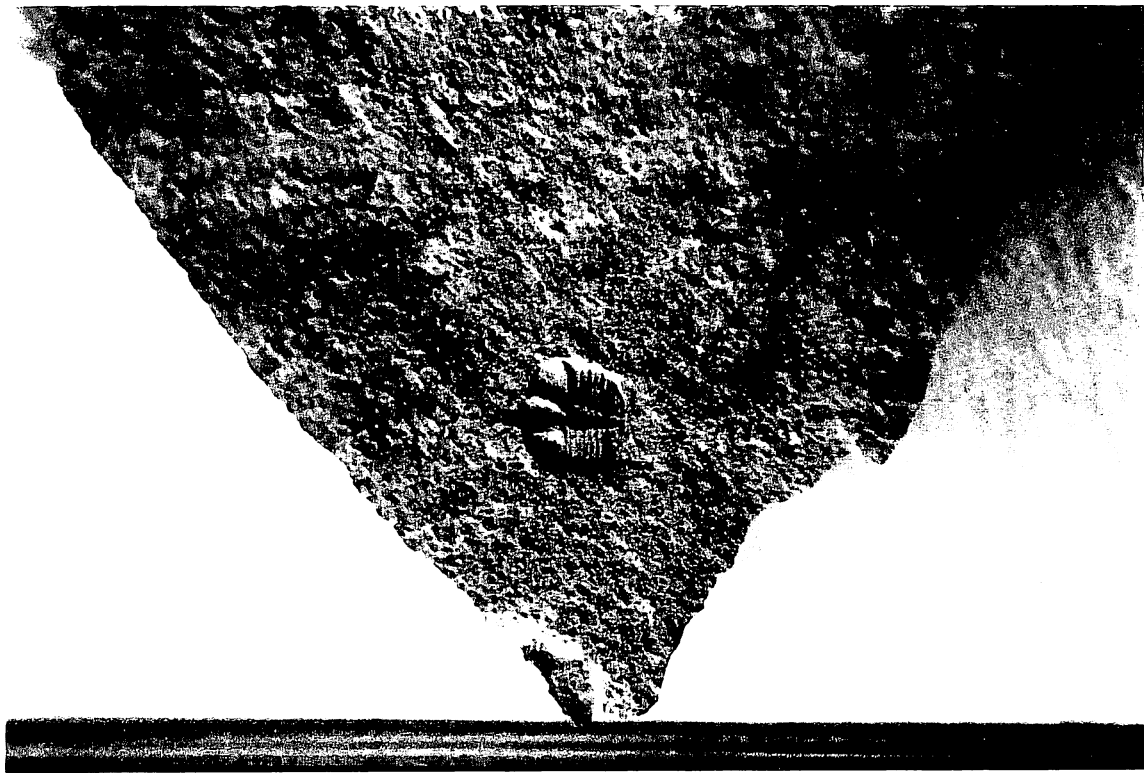
Raphiophorous species is found in the early Silurian (Llandovery) , Cotton Beds at Cotton Hill Quarry, about 10 km northwest of Forbes in central New South Wales. As well as the Trilobites, a large number of Graptolites are found including Monograptus, Orthograptus, Rastrites and Petalograptus. Other fossils found include : Nautiloids, Gastropods, Lamellibrachs, Ostracods, Sponges and Corals.



1. *Sinespinaspis* sp.



2. *Aulacopleura* sp.



3. Raphiophorous sp.



4. Cotton Hill Quarry, 1996



5. Cotton Hill Quarry, 1998
Trilobite layer in middle of photo



6. Trilobite layer close up

WHEN ARE WE OLD?

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Introduction to origin of life

During the celebration of my 92nd birthday someone asked me to what I attribute my long life, a question that is very often asked me when my age enters the conversation. I never admit the genes have any part to play in the length of life. It is always my diet over my entire life plenty of good exercise. All of it depends on clean living, and proper exercise all of my own choosing. But soon after that birthday it dawned on me that I should write an article on "The Origin of Life", thinking that I could look at the bottom of Pre-Cambrian and Cambrian seas and start from there and allow evolution to bring us to the present time but upon a little research I found that life goes back a long, long way from the Cambrian seas, in fact all of the earth scientists have not found any evidence as to how far back we must go to the origin of life. We just know it continues and we are proud to have it continue as it is.

The tree of life has many branches, Lichen, Lilly, Thistle and Thorn, all creatures great and small. The tree trunk, as nearly as anyone can tell, took roots when a dimmer sun in the warm water of a cooling earth, in the calm after its long and stormy infancy. Life began as micro-organisms with a single cell, the simplest of biochemical factories wrapped in porous membrane, but at first lacking so much as a nucleus, that occurred some time from four billion to three and one half billion years ago. More than half a billion years after the Earth came into being, but traces of early life are scant, leaving scientists at a loss to explain how life originated or when it began evolving into complex forms.

Recently molecular scientists have developed a "clock" showing when the major forms of life from bacteria and protozoa to plants, fungi and animals diverged from each other.

The most significant and controversial date derived by this technique is one for the first fundamental branching in the tree of life when certain cells that do have nuclei packaging their genes split off from cells without nuclei.

Among the estimated ten million species of today they thrive, constituting everything else including humans.

Doctor Russel F. Doolittle an evolutionary chemist of the University of California at San Diego, California concluded from a detailed analysis of proteins of 57 different enzymes that these two basic types of living things, last shared a common ancestor two billion years ago. Some scientists think this date is too too early and yet many think it is too recent. Anticipating some opposition, Dr. Doolittle defined his methods and the handling of the data. He and his team examined 531 protein sequences from 57 different enzymes encompassing 15 groups of organisms including 9 animal groups from fish and amphibians to birds and mammals. Plants, fungi, mold, bacteria and slime. This is by far the most exhaustive study to date. (pp 102).

John Noble Wilford wrote in 1996 that if the common ancestor of bacteria were proven correct as Dr. Doolittle suggest, it lies at the base of the Tree of Life, and questions must be asked, what kind of organisms gave rise to the present bacterial kingdom and what kind of organisms existed before that time, to which Dr. Doolittle replies, these studies may not be the last word in the Tree of Life. But it is a valuable first chapter.

The first vertebrate, the ancestral line of animals appeared on Earth at least was 40 million years earlier than previously believed according to British scientists who are studying fossil conodonts, animals that appeared in the shallow seas of the Cambrian period long before

animals began living on land. The bones identified by the British scientists in conodonts took the form of tooth-like grippers and there is bone in the rest of their bodies, and was adopted for use in external plates before developing hard bony skeletons. The positive identification of conodonts as vertebrates was the work of Dr. Ivan J. Sansom and Dr. Howard Armstrong both of the University of Durham, in Durham, North Carolina

The original tissue of all fossils is completely replaced by minerals, leaving only patterns rather than the substance of the flesh of the living animals. So we will continue to wrestle with the question of when and how life began.

TRILOBITES originated in the Cambrian, and continued through the Permian before becoming extinct.

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New York Times, Science Section - Fossils and Evolution, Nicholas Wade
Wonderful Life - Steven Jay Gould - The Burgess Shale
The First Branch of Life's Tree, John Noble Wilford (1996)

Trilobites! The Movie*

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Why don't they make a film of resurrected trilobites?
I don't know what they're waiting for. This tale should be in lights.
It never has been done before. Why can't they do it now?
It has great possibilities, and I could tell them how.

The film would have no dinosaurs. *T. rex* is getting old.
No aliens or hungry sharks – those stories have been told.
This movie would be different. Its villains are quite small.
They look as though they couldn't bother anything at all.

The first one was intriguing, which came as no surprise.
They watched it live and eat and grow before their very eyes.
Genetic engineering had brought the beast to life.
And when it was two inches long, they put it to the knife.

The first thing that they noticed was how hard it was to kill.
They couldn't understand just why, and maybe never will.
They dissected its cephalon, its thorax and its tail.
And when a liquid squirted out, their hearts began to fail.

This fluid was corrosive - much more so than the rest.
It ate right through a thick lab coat and burned the worker's chest.
The movie carries on with many ominous events.
The problems are peculiar, and they soon become intense.

For example, it is shown that their adaptability
Is developed far beyond what all past research could foresee.
They're amazingly prolific, storing eggs inside their cheeks.
A breeding pair can generate five million in nine weeks!

You probably have guessed by now, things soon get out of hand.
The trilobites are everywhere – in seas and lakes and sand.
They're immune to our diseases, but infect us with their own.
See! A movie based on trilobites could chill you to the bone!

* Reprinted from Gass, K.C. 2000. *Trilobite Poems*. Specialized Quality Publications, Wisconsin Rapids, WI. 21 p.

The *variolaris* Story –
The Quest For Its Identity and Stability

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It all started out in 1822,
When a Frenchman named Brongniart described something new.
His plate showed two specimens with the same name,
But, sadly, these trilobites were not the same.

Thus *Calymene variolaris* arose,
Causing controversy that took decades to close.
Its story might int'rest you if you're inclined
To let a few trilobites run through your mind.

It was Buckland who first showed that things were not right –
That two species shared one name in this trilobite.
The problem before him showed Buckland untorn.
Asaphus tuberculatus was thus born.

The next step occurred in 1839,
When the "King of Siluria" was in his prime.
Roderick Murchison showed us, in his classic book,
A *variolaris* with quite a new look.

But all of the authors from then on consent
That this is the species of Brongniart's intent.
The fact that it isn't what Brongniart had shown
Was of little concern to most authors, it's known.

That is, until recently, when came three men
Who were asked to submit to the ICZN.
They would make a proposal that none could deny.
They were R. P Tripp, J. T. Temple and I.

Our long-term goal, achieved when we were all done,
Was for Murchison's specimen to be the one
That would stand for the species that we'd come to know
As "*variolaris*," since so long ago.

We were not too concerned about Figure 3A.
As "*tuberculatus*," it's out of the way.
Although it is lost, it is true that 3B
Could be found. It's a remote possibility.

The *variolaris* Story ... (continued)

But in the event that 3B should appear,
We were certain that there would be nothing to fear.
If one studies its eyes, there is scant room for doubt
That it's of the Phacopina - so rule it out.

After five years of waiting, the voting was through.
The results were decisive at eighteen to two -
The vote for stability that we hold dear -
And *variolaris* was finally clear!

* Reprinted from Gass, K.C. 2000. *Trilobite Poems*. Specialized Quality Publications, Wisconsin Rapids, WI. 21 p.

JINGLE STORIES

By

Roadyard Coupling ,

-o00o--

The Friskey Trilobite

Contributed by : Wendell Ricketts

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Long ages ago, in the waters below,
 A Trilobite sat on the throne;
 "For I'm king, " he would say, "of the whole world today,
 'Tho' I haven't got any backbone."
 "My kingdom's as wide as the sweep of the tide,
 (And there's scarce any land worth the mention);
 At a glance of my eye all the Ostracods fly
 Lest I pay them some closer attention.

"And the spirifers bold feel their blood turning cold
 With their spiral arms all of a tremble,
 As I glide o'er the ooze, for they envied my shoes
 Though their purpose they tried to dissemble.

"It was footless, they said, to have me for their head
 When my legs would not stand petrification;
 But to make both ends meet I had no need of feet
 On account of my trilo-back-action.

" Oh Trilby, " they cried, 'you are tender inside
 Tho' you roll yourself up in your armor,
 When you get a swelled head your hard shell you must shed
 Alas for you, crusty old charmer!"

"By the fringe on my tail it made me turn pale
 To find that they thought I was a shell - fish.
 "We're on to your curves, take a pill for your nerves,'
 They yelled, - but then rose a devilfish.

"Keep a stiff upper lip,' he replied, with a skip,
 'Their heads are as weak as a scallops,
 And the're more slow than the crinolds, you know,
 Though they're both of them fast, like the polyps.'

With a shiek of dismay they shut up right away
 For Orthoceras gobbled the leader.
 Tra-la, I'm no slave!" and he plunged down the wave,
 Where we'll leave him, O honorable reader

George H. Chadwick

(Dr. Chadwick was a very close friend and a great teacher. After his death this fall I prepared a bibliography of his writings which totaled more than 150 titles)

OUTSTANDING NORTH AMERICAN TRILOBITES

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The good quality and wide variety of trilobites that have been found in the United States and Southern Canada is significant when compared the specimens found in the rest of the world. This is probably due to the fact that large portions of North America were covered by shallow seas throughout the Paleozoic Era, which coincides with the approximately 300 million years of existence of trilobites on the earth. Trilobites were especially common in the Cambrian, Ordovician, Silurian, and Devonian Periods, and strata from these ages are fairly widespread, particularly in the United States.

What one defines as an attractive, well-preserved trilobite may be subjective. For example, the trilobites preserved through carbonization found in the Burgess Shale of British Columbia in which the trilobite's legs have been preserved are very well-preserved fossils by any paleontologist's definition. The fossils from that locality, however, are very compressed and do not stand out well against matrix. Trilobite specimens that I and many other avid collectors find well-preserved and attractive, are trilobites that are three-dimensional, complete and have a good, contrasting color in relation to the surrounding matrix. Also, a well-preserved trilobite (my definition) will generally have its chitinous exoskeleton replaced or mineralized by calcite and/or partially replaced by pyrite.

There are abundant localities in the U.S. and Southern Canada where trilobites of outstanding quality can be found. Especially rich in Ordovician trilobites is the Cincinnati area of Ohio and the surrounding area of Southeastern Indiana and Northern Kentucky. The topography of this region consists of rolling hills, so fortunately, to the collector, there are numerous exposures of fossiliferous rock layers in area road-cuts and stream banks. Trilobite fragments can be found in most exposures of the area, but complete specimens are common only in a few formations, usually in a thin zone of a specific layer. The Waynesville and Arnheim Beds of the Brookville Formation appear to yield the best Ordovician trilobites of the area. Probably the two most common species found are *Flexicalymene meeki* (Foerste) and *Isotelus maximus* Locke, although because of its' large size and thin exoskeleton, complete specimens of *Isotelus* are quite uncommon. Specimens of these two trilobite species are often dark brown in color (with a tinge

of pink) against a gray shale matrix. Complete specimens of *Flexicalymene* are often found enrolled.

There are other regions of North America where Ordovician trilobites of exceptional quality have been found. They include Fayette County, Iowa where beautiful specimens of *Anataphrus (Vogdesia) vigilans* have been collected from the Maquoketa Formation. The *Anataphrus* here are beige-brown in color against a cream white limestone matrix. At another locality in Carter County, Oklahoma, fine specimens of *Homotelus bromidensis* have been found in the Bromide formation. Other good quality Ordovician trilobites of have been collected at various localities in New York and Southern Ontario.

Probably one of the best areas to find Cambrian Age trilobites that are common, complete, and contrast sharply against the rock matrix, are from the Wheeler Formation of Millard County, Utah. The most well known species found here is *Elrathia kingi* (Meek), which is usually black in color against the surrounding gray shale. Other Cambrian species found in this area include: *Asaphiscus wheeleri* Meek, and *Peronopsis interstricta* (White).

Fine quality Silurian Age trilobites are found in the Waldron Formation of South Central Indiana including: *Calymene breviceps* Raymond, *Harpidella christi* (Hall), and *Dalmanites verrucosus* Hall. Once they are cleaned, the trilobites from the Waldron Formation are dark brown color against a light gray shale. Complete *Dalmanites* specimens are rare. Another notable Silurian trilobite layer is the Henryhouse Formation of Pontotoc County, Oklahoma. In this formation are fine specimens of *Calymene clavacula*, *Dalmanites rutellum*, *Fragiscutum glebalis* and *Anasobella asper* Campbell.

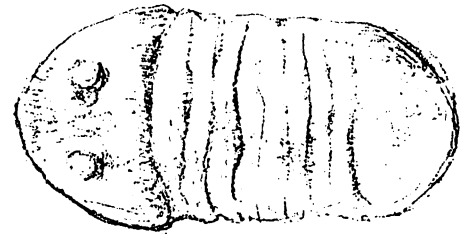
Although there are numerous good Devonian Age trilobite sites in North America, the beautiful *Phacops* found in the Silica Formation of Northwestern Ohio are probably the most well known. In the quarries of Lucas County, Ohio, large specimens of *Phacops* are black in color against a gray shale matrix. The two forms of *Phacops* found here are *Phacops rana milleri* Stewart, and *Phacops rana crassituberculata* Stumm.

Other significant Devonian trilobite localities of the general region are in Michigan, Western New York, and Southern Ontario. One of the best localities for fine specimens of *Greenops boothi* (Green) is in the Hamilton Formation near Arkona, Ontario. Cleaned specimens are usually black in color on a gray matrix.

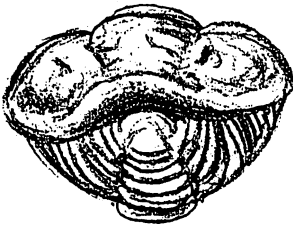
The most impressive Devonian trilobite locality in the Western United States is in Coal County, Oklahoma where a variety of beautiful dark brown trilobites are found in the



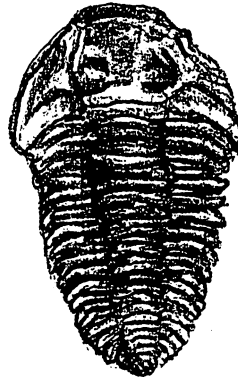
Anataphrus (Vogdesia) vigilans
(Meek & Worthen)
Trilobite- beige-brown, enrolled
Ordovician Age, Maquoketa Fm.
Fayette County, Iowa X2



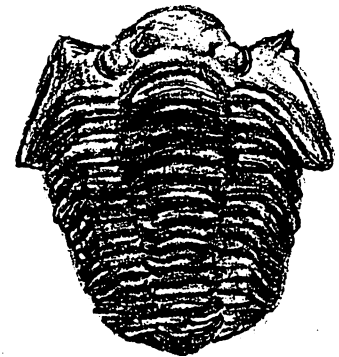
Anataphrus (Vogdesia) vigilans
(Meek & Worthen)
Trilobite- beige-brown specimen
Ordovician Age, Maquoketa Fm.
Fayette County, Iowa X2



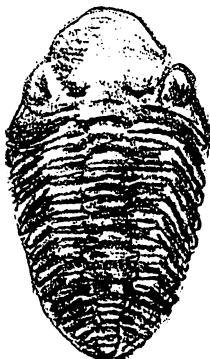
Flexicalymene meeki (Foerste)
Trilobite-dark brown, enrolled
Upper Ordovician Age
Brookville Fm., Waynesville Mbr.
Madison, Indiana X2



Flexicalymene meeki (Foerste)
Trilobite-dark brown specimen
Upper Ordovician Age
Brookville Fm., Waynesville Mbr.
Madison, Indiana X2



Calymene breviceps Raymond
Trilobite-dark brown specimen
Middle Silurian Age
Waldron Formation (shale)
Bartholomew Co., Indiana X2



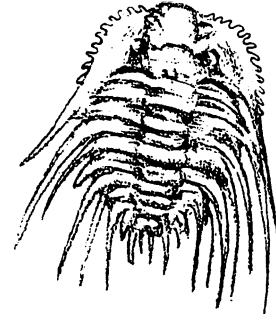
Kainops raymondi (Delo)
Trilobite-dark brown specimen
Lower Devonian Age
Haragan Formation
Coal County, Oklahoma X2



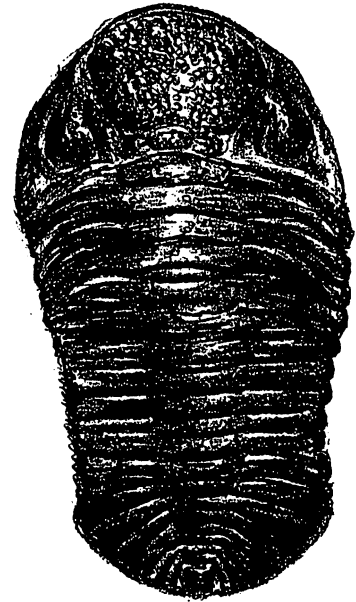
Paciphacops campbelli
Trilobite-dark brown specimen
Lower Devonian Age
Haragan Formation
Coal County, Oklahoma X2

Beena Henry 2001

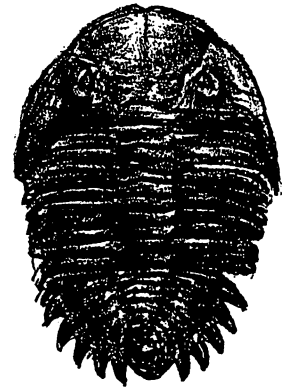
Kettneraspis williamsi
 Trilobite-dark brown specimen
 Lower Devonian Age
 Haragan Formation
 Coal County, Oklahoma X2



Phacops rana milleri Stewart
 Trilobite- black specimen
 Middle Devonian Age
 Silica Shale Formation
 Sylvania, Lucas Co., Ohio X1.5



Greenops boothi (Green)
 Trilobite- black specimen
 Middle Devonian Age
 Hamilton Fm, Hungry Hollow Mbr.
 Arkona, Ontario, Canada X2



Serena Henry
 2001

cream colored Haragan Formation. The trilobites found here include: *Kainops raymondi*, *Paciphacops campbelli*, *Reedops deckeri*, *Kettneraspis williamsi* and *Huntonia lingulifer*.

Although not common, good quality, complete specimens of Mississippian, Pennsylvanian, and Permian trilobites have been found at various localities in the United States including: Illinois, Indiana, Missouri, Nebraska, and Texas.

Most of my trilobite collecting has been in Indiana and Ohio, although I have also found specimens in Kentucky, Michigan, Minnesota, New York and Pennsylvania. Trilobite remains can be found in most of the United States and Southern Canada. North American trilobites are fairly good in quality, when compared to the trilobites found in Western Europe. In recent years, outstanding quality Ordovician trilobites have been coming out of Petersburg, Russia. In addition, the exceptional quality and variety of trilobites from Morocco, Africa is well known, however, the color contrast of the trilobite to the matrix is not always the best.

There are probably some areas in the world that are still unexplored, as far as trilobite collecting is concerned. All things considered, however, and at this point in time, North American trilobites are among the best in the world..

Acknowledgements:

I would like to especially thank my daughter, Serena, for her artistic drawings of my trilobite specimens.

I would also like to express my sincere appreciation to the following people who have either provided information to me in the past concerning trilobite identification, collecting, and/or the cleaning of specimens: Don Bissett, Doug DeRosear, Thomas T. Johnson, and Jeff Aubrey. I would also like to express my gratitude to the authors of the following references:

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***Flexicalymene* from the Ordovician of the Cincinnati Arch**

by Don Bissett and Dan Cooper
Hamilton and Fairfield, Ohio

Introduction

The upper Ordovician (~450 million years old) of the Cincinnati area encompasses a wide region. The Cincinnati Arch extends roughly from Richmond, Indiana and Dayton, Ohio in the north, to Wilmington, Ohio in the east, to Lexington, Kentucky in the south, and to Madison, Indiana in the west. With over 700 vertical feet of Ordovician deposits in the Arch, it also covers a sizeable span of geologic time. Due to the hilly terrain, the extensive erosion, and substantial commercial and residential development, there are many exposures of the region's typically soft Ordovician shales which contain an abundance of well-preserved fossils, such as brachiopods, bryozoa, corals, and trilobites, to name a few. This relatively easy access to quality material has led to considerable interest in fossils among both amateurs and professionals, dating from at least the early 1800's (1).

While there are many species of trilobites in the Ordovician of Cincinnati (2), by far the most abundant is *Flexicalymene*. It occurs at all levels in the Cincinnati Arch, although its abundance and preservation vary dramatically from horizon to horizon. Surface collecting at some localities will often yield many well-preserved enrolled specimens, but quality prone samples are primarily obtained only from fresh exposures. In our extensive excavations at several localities, we have unearthed thousands of complete *Flexicalymene*. In particular, in ~17 years at one site alone (near Mt. Orab, Ohio) we have collected over 25,000 of them.

While we are collectors at heart, we and other amateurs have also long supported the scientific study of the fossil record. From edrioasteroids to crinoids to cystoids to trilobites, we have worked with and/or provided specimens to professionals for study. This article will describe our observations on *Flexicalymene* from the Mt. Orab site and an ongoing university-sponsored research project we are involved with at this site.

Study Site

The site is the well-known Mt. Orab locality mentioned above. It originally was a series of natural exposures in a creek bank that was long visited by the locals who primarily surface collected there. One of these collectors, Ken Poehner, directed Dan Cooper to the site which he developed into a serious collecting area ~17 years ago. Dan paid the owner to permit a test dig to determine the density and exact horizon(s) at which the trilobites could be found. He purchased the property, brought in heavy equipment to clear overburden (up to 15 feet), and dug with hand tools through the trilobite horizon, which is ~2 feet thick. The property was later purchased from Dan in 1993 by Don Bissett and continues to be collected for the beautiful trilobites.

There are many life forms represented in the fossils at this locality, such as brachiopods, gastropods, cephalopods (often several feet in length), pelecypods, bryozoa, and occasional crinoids and starfish, but the primary fossils of interest to most are the trilobites. There are four genera found at the site: *Flexicalymene* (Figure 1), occasional *Isotelus* (Figure 2), very rarely *Amphilichas* (Figure 3), and fragmentary pieces of *Acidaspis* (Figure 4). *Flexicalymene* occur in relative abundance, typically one per cubic foot of layer. As with any site, there is variation from spot to spot within the layer, but typically a couple dozen *Flexicalymene* are found in a day of digging. There have been a few high-density areas resulting in a take of as many as 75-100 trilobites in a single day. While many of the specimens are not complete [often missing one or both pleural lobes ("free cheeks")], the abundance ensures that at least several complete ones are obtained with each trip to the site.

Flexicalymene

The quality of the *Flexicalymene* is the best found in the Cincinnati, although they tend to be on the small side, with the typical prone specimen being a little over one inch in length. They are inflated and fairly hard such that intact specimens are relatively easily extracted from the shale. The prone and enrolled forms occur in approximately equal abundance. However, our observations during collecting suggest differences in the distribution and specimen orientation depending on the layer within the trilobite-bearing zone.

The zone is about 2 feet thick. A description of the layers is in Table 1, progressing from the limestone cap down to the bottom of the trilobite-rich zone.

Figure 1. *Flexicalymene*

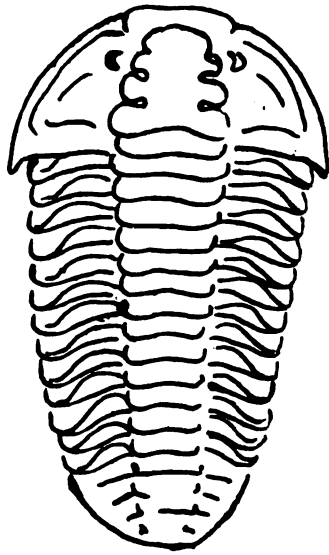


Figure 2. *Isotelus*

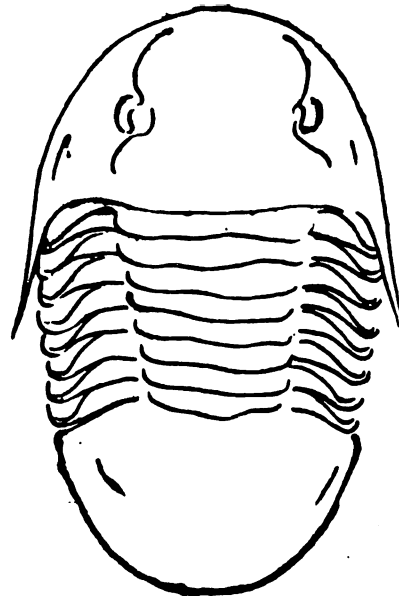


Figure 3. *Amphilichas*

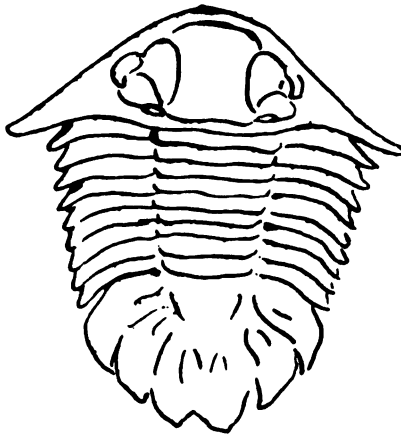


Figure 4. *Acidaspis*

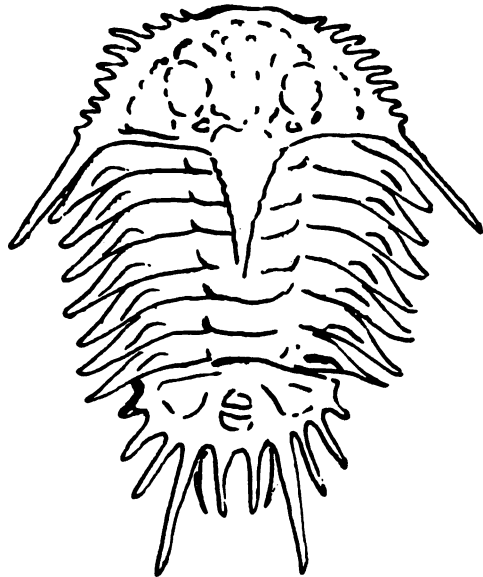


Table 1: Observations on layers in trilobite-rich zone of Mt. Orab, Ohio locality

Layer location (sequentially from top to bottom)	Layer characteristics	Density of <i>Flexicalymene</i>	Orientation* of <i>Flexicalymene</i>
brachiopod-rich limestone cap	~2-3 inches thick	none	-
shale; immediately below limestone cap and above <i>Rafinesquina</i> brachiopod layer	~1-3 inches thick; soft shale; no apparent bedding planes within this layer	sparse; ~ equal numbers of prone and enrolled specimens	apparent random orientation
shale capped by thin <i>Rafinesquina</i> brachiopod layer**	~8-10 inches thick; harder shale; abundant hard nodules; no apparent bedding planes within this layer	high; higher abundance of enrolled specimens	apparent random orientation
shale below nodule layer	~6-8 inches thick; soft shale; horizontal bedding planes spaced 1-2 inches; occasional nodules and intrusions of limestone up to 4 inches thick	moderate; higher abundance of prone specimens	prone specimens primarily face up
bottom of shale zone and above thin brachiopod limestone layer (<i>Rafinesquina</i> , <i>Hebertella</i>)	~2-4 inches thick; harder shale; no apparent bedding planes within this layer; often contains large bryozoan colonies; occasional nodules, gastropods (<i>Cyclonema</i>), and crinoids (<i>Glyptocrinus</i>)	low; ~ equal numbers of prone and enrolled specimens	apparent random orientation
thin brachiopod-rich limestone layer	~1 inch thick	none	-

* Orientation refers to direction in which the trilobites are "facing" (face up or face down) and compass direction (facing toward any specific compass point). There is no apparent dominant compass direction in any of the layers.

** While literally millions of *Rafinesquina* (a favored substrate for edrioasteroids in many other Cincinnati Ordovician sites) have been exposed during our excavations, not a single edrioasteroid has been found.

As mentioned above, many of the specimens are not complete since they are often missing one or both pleural lobes ("free cheeks"). There are also frequent specimens that are further disarticulated, such as the cephalon ("head") and/or pygidium ("tail") being separated from the thorax ("body"). Yet these disarticulated parts are often all present within a small area within the matrix. This suggests the burial was not violent, otherwise one would expect the parts to be widely dispersed.

Throughout the shale layers, the inarticulate brachiopod *Lingula* occurs. Other brachiopods (e.g., *Hebertella*, *Platystrophia*, *Rafinesquina*, *Zygospira*, and *Leptaena*) also occur occasionally.

While we have not documented these observations, the trends described above have consistently occurred during our experience in excavating the locality. Clearly there was a need for a thorough scientific investigation to not only document such observations, but also to interpret their implications, e.g., regarding the environment in which the *Flexicalymene* lived and died.

The Study

Dr. Nigel Hughes (formerly University of Cincinnati, now University of California at Riverside) became interested in the Mt. Orab site through discussions with Dan Cooper. Dr. Hughes recruited a graduate student, Brenda Hunda (a trilobite enthusiast from Canada), to participate in study of the site. Their aims are to study the trilobites, the layers, and the associated fossils to understand the environment that existed in the area 450 million years ago. For example, some of the questions follow:

- * What is the specific horizon within the Ordovician? It is the Arnheim but where within the 60+ feet of Arnheim is it located?
- * How many burial events are represented in the trilobite zone at Mt. Orab? A previous cursory thesis study (3) suggested it was a single burial event. But that seemed inconsistent with our experience in digging the layers (see table above). We felt there were at least 3-4 events represented.
- * Are the *Flexicalymene* at all levels in the zone the same species? From our experience in collecting many localities in the Cincinnati area, there are variations among *Flexicalymene* from site to site, so variation might exist even within the Arnheim. If there are variations within the Mt. Orab site, is there a connection to the environment?
- * Is there any dominant orientation of the specimens to suggest currents or to suggest rapid vs. gradual burial?

The study (started in the summer of 2000) focused on the trilobite layers between the *Rafinesquina* layer near the top and the thin brachiopod limestone layer at the bottom (Table 1). A 1-foot square vertical column of the entire trilobite zone was collected intact for study (e.g., of sedimentation patterns such as grain size, bedding planes, etc.). Preliminary results from that analysis suggest there are 7 burial events represented at the Mt. Orab site.

Then there was the painfully slow process of excavating and mapping every life form throughout a defined area. A 1-meter square area was marked off, and Brenda dug through it a few vertical millimeters at a time. She mapped the horizontal and vertical locations of every fossil and all the nodules. This mapping also included the tilt relative to the horizontal plane and their orientation (e.g., for the trilobites, are they face up or face down and what is their compass orientation?). All the trilobites were saved for cleaning and study in the lab. A second 1-meter square area was also dug, but only mapping of the trilobites was done to get a larger sampling of specimens for study. This tedious fieldwork took two months of daily effort to complete with over 70 trilobites collected.

Additional fieldwork at the site is planned for summer 2001. Brenda plans to collect at least 100 trilobites total to get a sufficient sample size for analysis. Other objectives may also emerge as she continues her study of the layer and specimens already collected.

Brenda has been successful in obtaining financial support for the project. She received two grants. One is the Paul Sanders Award from the Dry Dredgers (fossil organization affiliated with the University of Cincinnati). This financial award is provided to support paleontological research intended for publication, especially projects involving fossils of the late Ordovician period, in particular fossils in the Cincinnati Arch. The second award was the MAPS Award, presented by the Paleontological Society.

Other Study Opportunities

There are other sites with sufficient density of *Flexicalymene* to permit serious study, and the specimens from these sites have distinct differences in appearance from those at the Mt. Orab site. For example, specimens from Oldenburg, Indiana (specific formation not clear) are larger in size (up to 2 inches in length) and have much taller eyes. And specimens from Monroe, Ohio (Corryville) are also large, have short genal spines, and an enlarged axial lobe ("lip"). Are these species variations induced by the environment or are they truly distinct species of *Flexicalymene*? An in-depth study of many specimens from each site can determine if the variations occur consistently within a site to warrant designation of multiple *Flexicalymene* species. Other possible horizons that might be studied are Whitewater (e.g., St. Leon, Indiana), Fort Ancient, Miamitown Shale, and the Cope formation (specific localities to be determined).

At the Mt. Orab site, there is also interest in studying the distribution, orientation, etc. in regards to *Isotelus* trilobites. However, the sparse density of this genus complicates such an effort. In our experience, though, we have observed that complete prone specimens of *Isotelus* are upside down in the matrix. This suggests something related to lifestyle (e.g., feeding or mating behaviors) but the specifics are not clear at this point. Enrolled specimens of *Isotelus* are more abundant but still sparse enough to make serious study very difficult.

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THE POTOSI MINI-LAGERSTATTEN

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Strata that have preserved fossils with such a completeness that the fossil fauna serves as a sort of paleontological "window" on the part of geological time being represented is referred to as a conservat-lagerstatten. Such "windows" are represented by such well known fossil occurrences as the Mazon Creek (Braidwood Essex) ironstone fauna, the Solenhofen Plattenkalk, the Byrgess Shale, etc. These are well known fossil localities which do act as a sort of window on the geologic past. A "window" without the usual bias toward organisms with hard parts!

Fine grained, tripolitic chert of latest Cambrian age found near the town of Potosi, Washington County, Missouri were known early in the 20th century to yield a variety of well preserved fossils, Walcott 1912. Sometime around 1906, E. O. Ulrich, a prolific paleontologist-stratigrapher collected from hill tops around the town an assemblage of small fossils which were more or less unique. Later in the 1920's, these fossils would be recognized as representative of the Eminence Formation, a cherty sequence of massive dolomite beds of latest Cambrian age. Additional collecting in the same area at this time would add to the fauna which was first described and illustrated by J. Bridge in 1930. Most of the fossils of the Potosi area occur in chert boulders which occur at or near the tops of hills. these boulders come from a horizon (strata) characterized by masses of fossil algae (stromatolites), the fine grained tripolitic chert having been deposited between the stromatolites. The Potosi fossils present a window on marine life which lived at the very end of the Cambrian Period. In most conservat-lagerstatten like the Burgess Shale, organisms with their soft parts are preserved so that the bias for hard parts, typical of most fossil occurrences is missing. In view of this requirement for a conservat-lagerstatten, the Potosi cherts fall somewhat short as soft part preservation, while present, is rare. What is found is preservation of multi component organisms, in a complete and non-disarticulated manner. Considering this rarity of soft part preservation the Potosi fossil occurrence might better be called a mini-conservat-lagerstatten or a mini-lagerstatten.

Composition of the Potosi mini-lagerstatten

What makes up the Potosi fauna? Lots of marine invertebrates such as trilobites, brachiopods, various problematic fossils, annelids? And particularly mollusks. It's the mollusks which form the greatest and scientifically most interesting parts of the fauna. The arthropods (trilobites) might run a close second as many different genera, some quite rare and unusual are present. Many classes of mollusks are represented, including gastropods (snails), left handed snail-like forms called onychochilids, monoplacophorans of various types and plated mollusks which are well represented in the lagerstatten. Chitons or amphinurans are living multiplated mollusks, however the term plated mollusks as used here is restricted to early Paleozoic forms and these

may or may not have been Chitons. These plated mollusks include a diversity of variously shaped plates (or Valves) which presumably fit together to form an armor coated or plated animal. Plated mollusks include cap shaped paleoloricates, arrow shaped hemithecellids, matthevids, saddle shaped robustids as well as other forms. Controversy exists as to what class (or classes) of mollusks these plates represents. This controversy can be summerized under the following two premises.

Premise one (1). Potosi plated mollusks represent primitive polyplacophorans (Chitons). As chitons, the animal bearing the plates would have been made up of eight articulating plates with such plates overlapping and with a distinctive head and tail plate occuring at the front and rear of the animal.

Premise two (II). Potosi plated mollusks represent an extinct molluscan class (or classes) which unlike chitons, were not made up of eight plates and which also lacked differentiated head and tail valves

Advocates of premise one (the chiton premise) note the similarity of valve shape of some plated mollusks to those of chitons. They also note the presence of distinctive chiton-like ornamentation on many forms and compare to the overall similarity of valve shapes (morphology) to the valve chitons. This similarity can be quantified and statistically related in a computer program called morphometric analysis done by advocates of the chiton premise confirm the affinity of these plated mollusks to chitons.

Advocates of premise II (extinct class or classes) note that eight valved specimens are unknown and also note the grouping of similar valves in valve clusters where there are no head or tail valves evident. What is probably the strongest argument against a chiton affinity for these fossils is the presence of monoplacophoran-type muscle scars (musculature) on some plated mollusks there is also a convergence of shape (morphology) between some plated mollusks (paleoloricates) and the cone shaped monoplacophorans.

This paleontological controversy is an ongoing one and might be exemplified with a peculiar plated mollusk called Matthevia. Matthevia, like many plated mollusks, occurs in the Potosi mini-lagerstatten. It's considered by an advocate of premise two, Ellis Yochelson, as representative of an extinct molluscan class which he established as class Matthevia. Advocates of premise one, John Pojeta, Bruce Runnigar and Michael Vendrasco, consider Matthevia as an extinct ancestor of the chitons. As is the case with other plated mollusks, articulated specimens of Matthevia have not been found. This is significant as a chiton has eight valves, if Matthevia was a chiton, it should also have eight valves or plates. The Potosi mini-lagerstatten, preserving multicomponent organisms viz. trilobites, in a more or less complete condition seemingly should have preserved a complete eight valved (or sixteen valved) plated mollusk.

Complete trilobites in Cambrian rocks of the Ozarks are very rare fossils. High energy environments and the relatively fragile nature of Upper Cambrian trilobites resulted in the disarticulation of most specimens so that normally heads (cephalon) and tails (pygidia) are what's found. In the Potosi mini-lagerstatten complete specimens, while not common do occur with some frequency. An environment existed here which allowed entire specimens to be preserved, presumably as a consequence

of the lower energy, protected environment between stromatolites. Trilobites represented are the same genera as found in the Eminence Formation elsewhere but here they are complete. Species of the genera *Plethometopus*, *Stenopolis* are represented. These are genera which are associated with stromatolite reefs and which, because of their living in a normally high energy environment, are rare as complete specimens (Stitt, 1976). If trilobites are found complete in the Potosi mini-lagerstätten, why are not complete plated mollusks? Stinchcomb and Darrough (1995), on the bases of valve assemblages of numerous valves of the same type of plated mollusk valves but different sizes, proposed a sixteen valved "monster". No such "monster" has been found in the Potosi mini-lagerstätten, but a five valved articulated specimen has been found. If the chiton model (eight valved form) for plated mollusks is valid, eight valved complete specimens should be expected? An environment which preserves articulated trilobites should also preserve some articulated plated mollusks.

Occurrence of plated mollusks and the lack of an eight valved form might be explained by a third model. This model suggests that the plated mollusks reproduced asexually by forming "buds". Such "buds" would separate from a string of asexually produced animals and continue to grow as individual animals which were now protected by a single plate. Two, three or even five valved articulated specimens which have been found represent situations where such "buds" failed to separate. A (rather nasty) analogy to this method of reproduction can be found in the tapeworm. Here "buds" of this intestinal parasite separate on maturity from one another, and are then ejected with the feces of the host animal. This tapeworm model is totally unmolluscan, however plated mollusks are extinct organisms and reproduction in early mollusks, like their body plans, may have been more varied during the formative stages of the phylum than today. such evidence from the Potosi mini-lagerstätten, is negative evidence but evidence non- the- less in the interesting but frustrating matter of just what were the plated mollusks.

One might wonder why these two different premises discussed above are paleontologically important? The importance is because these plated mollusks are extinct life forms and the way extinct life forms are interpreted and classified reflects a fundamental pattern which evolution took during the early development of animal life. Stated another way, one might ask, do plated mollusks represent a "body plan" (Class) which existed in the Cambrian Period and is now gone (extinct) or do they represent early variations in a "body plan" (the chitons) which is still around (extinct) today.

There is an interesting recent hypothesis suggesting that during the formative stages of animal life, evolution worked more rapidly and differently than it has during later geologic time. Evolutionary development during the early Paleozoic, according to this hypothesis, produced many different body plans. (Ellis Yochelson hypothesizes that early animal prototypes threw off new body plans like "sparks from a St. Catherine's wheel"). Only a few of these body plans survived after the Ordovician Period, these becoming the classes which have diversified and exist today. Plated mollusks, under this hypothesis represents one of these non-surviving, extinct body plans. eight valved chitons on the other hand represent a successful body plan which, by chance, happened to avoid extinction and proliferated to become the modern chitons. This hypothesis also suggests had evolutionary success been different, the eight valved chitons might have been the organisms to have become extinct and the plated mollusks could have survived and would be living and dominant today.

This hypothesis looks at the earth's modern flora and fauna as a product of evolutionary chance. As in the Town of Bedford Falls (in Franks Capra's 1946 Cinematic classic. It's a wonderful life) where George Bailey has not been born, body

plans existing today could have been quite different if the evolution of life could be "played out again" (Gould, 1989).

Occurrence and present status of the lagerstätten

The exceptional fossils of the Potosi mini-lagerstätten came from a cherty zone found sporadically near or at the top of hills around Potosi, Missouri. Its occurrence is not limited to small, localized areas as is the case with some exceptional fossil horizons but the horizons seem to come and go depending upon availability of the particular silty fossiliferous chert zone. This fossil bearing zone (or zones) seems to locally come and go, possibly depending upon the presence of and accessibility of this silty layer. The fossil bearing zone seems to come and go, possibly dependent also upon its association with large stromatolites. The fine siliceous sediment which preserves the fossils, appears to have been deposited in water of medium depth between stromatolite domes in a relatively low energy environment.

Like most quality fossils, considerable effort must be invested to obtain specimens. Persistence over many years has taken advantage of both excavations and erosion which has exposed the fossil bearing cherts. A very important factor as with many other fossil sites, is the ability in the field to be able to recognize the proper rock which yields the fossils. This takes a "trained eye" which is cultivated, at least in part, through a strong desire to find fossils and which is exemplified in M.A.P.S. creed "A love of fossils brings us together". Part of the area around Potosi since the 1920's has until recently, been the site of extensive barite mining and sometimes such activity has exposed the fossiliferous chert on the surface. Recent Urbanization has also exposed for a time, some of these fossiliferous cherts, although this is ultimately going to make this unique material less accessible.

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Plate 1. Miscellaneous fossils from the Potosi
Mini-lagerstätten

1. *Microdictyon* sp.? Portion of this problematic fossil, x 8 2, Golf tee, problematic organism or part thereof. 3,4, *Preacanthochiton cooperi*. Articulated specimen of a plated mollusk with five valves. If this form were a chiton, eight valves should be present. 5-8, 14-16, Monoplacophorans. 5, *Protoconus eminense* a small monoplacophoran genus. 6-8,15, *Shelbyoceras robustum* 14, *Orthoconus striatus*. 16, *Proplina* sp. with muscle scars. 13, Group of *Dirhachopea* sp., an early undoubted gastropod. 9-12, *Hemithecella* sp. Plated mollusks, X 2 except for No. 10. All x1 unless noted. All specimens from the Potosi Missouri area, Washington County, Missouri

Plate 2. Trilobites

1-3, *Plethopeltis buehleri* 1, distorted specimen. 2, Cephalon of this common Emiennece trilobite. 3, Complete specimen with damaged thoraxial segments, note free cheek with eye directly above letter 'three", x1.3. 4, *Entomaspis radiatus* glabella of this small cryptolithid trilobite, x 2. 5,8, *Stenopolis latus*.5, Specimen lacking cephalon, x 2. 8, Complete specimen showing wide axial lobe of the genus, x 1.5. 6,7, *Calvinella ozarkensis*. This saukid trilobite is the largest trilobite found near Potosi. 6, Cephalon and pygidia, x 1.2. 7, Free cheek exhibiting granular diverticles, presumed nerve fiber impressions emanating from the glabella. 9, *Plethometopus convexus* specimen showing large, bowl shaped glabella characteristic of this genus, x 2. All specimens from the Potosi Mo area, Washington Co, Missouri.



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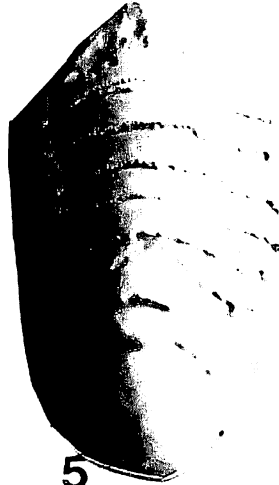
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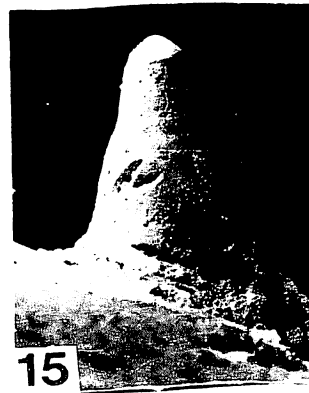
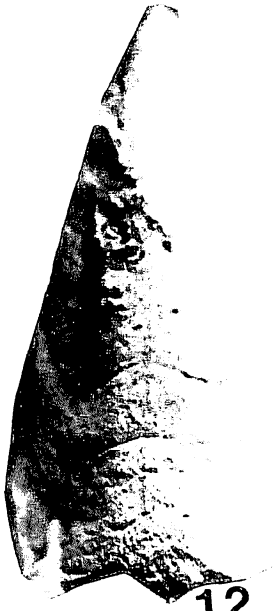
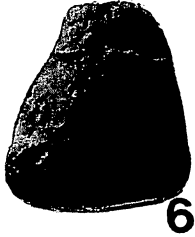
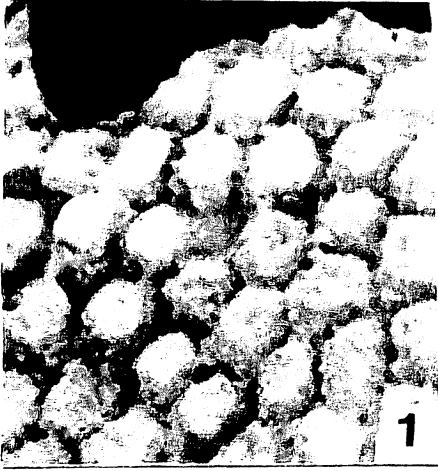
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Faking Trilobites in the Sahara Desert

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If you were at a gem and mineral show selling diamonds that were really made of cut quartz, you would be arrested and probably not allowed to come back. If you were selling bars of gold plated silver as solid gold, you would also go to jail. The making of a counterfeit commodity for the purposes of defrauding a customer, is going to put you behind bars just about anywhere.

Well maybe, except for the making and selling of counterfeit trilobites. For many years, we have been seeing trilobites that were prepared in Morocco having everything from just a little bit of restoration to finally seeing the bugs that were completely restored from nothing. Somewhere in that graduated series is the fine line between restoration and a complete fake, the latter being clearly across that line.

What I have finally learned in these last few years is that, ironically, the fake trilobites originate from exactly the same place as the very good trilobite material.

The Environs of Issoumour Mountain

By now, most people know that Issoumour Mountain is where all of the incredible Devonian trilobites are coming from. The Moroccan locality information ranges all the way from Erfoud (actually many miles to the east) to other odd locations and formations, but this is where the marvelously preserved trilobites actually originate. The entire stratigraphic sequence of this mountain is rich in trilobites, so specific localities over this very large area are best noted using lat-lon information from your GPS unit.

I've included a topo map of Issoumour and the surrounding mountains (Fig 1), so that all of the trilobite collectors can finally have a copy of this map and better understand the area and the villages located around this mountain. For those who want a feeling of where this large crescent shaped mountain is located, simply go south from Glasgow, Scotland and due east from Austin, Texas. The resulting cross hairs will converge directly on top of the mountain.

It is in the small villages on the northeastern corner of Issoumour where the village mayor has set up factories where trilobites are molded from a mixture of epoxy and ground up Issoumour rock. In their favor, they make no attempt to sell these objects as real trilobites, and the inexpensive price would seem to indicate what they are. As many of us spend the night in Tabourikt, it is these same villages that you drive through as you head directly east looking for a way past the enormous cliff to the south. These villages are where the road is able to go around the high wall, turn to the right, and head south toward the village of Fezzou.

For historical perspective, the long linear mountain directly to the west of Issoumour is Tiskaouine Mountain, a very large Ordovician locality. It was from this mountain that hundreds of thousands of poorly preserved Diacalymene trilobite nodules were mined during the 70's and 80's. These came over from Morocco, again with the incorrect Erfoud locality information.



Figure 1 - Issoumour Mountain, where the trilobites come from.

Counterfeit Trilobites

The sad thing is that trilobites sold as replicas have no markings to indicate what they are. After they are sold through a couple of middle-men, there is no reason why they cannot be sold to the unwary as real. By 2000, it was difficult to find any trilobites for sale in large coastal cities except for these fakes being offered at high prices. I now have one of the molds used to make replicas and will be bringing it to MAPS for people to examine.

At this last Tucson, I still find some dealers selling these same fakes and other highly restored trilobites. These dealers now stay away from the main fossil hotel on Oracle and fit in nicely among people who are selling jewelry, minerals, and objects made from rock.

It is important to note that a large number of American rock shops and even some museum rock shops have bought a great deal of trilobites in the past, and they are still trying to resell them at a profit.

The Museum of Trilobite Fakes

Horst Burkard, a German dealer in both fossils and minerals, purchased a number of these different fakes and castings and set up a museum to trilobite fakery in his room at the Executive Inn a few years back. Horst took a number of these "fossils" as well as a couple of actual (real) Moroccan trilobites that were badly prepared by the locals, and he sawed them into two or three pieces. In some cases, he was able to separate the actual rock material from the resin-glue-rock-dust material where trilobites (and matrix) seemed to have been cast as they were poured on to specially made saucers of actual rock matrix from the fossil outcrops. The poor quality of the casts was certainly equal to the poor quality of the actual Moroccan prepared trilobites, but the paint job used on the fakes was top notch!

As good as these fakes were, it is impossible to fool the cross-section. As thin as the skin (shell) is on a real trilobite, it is still much thicker than the paint on a fake one. An interesting feature is how good the resin-glue-rock-dust fake-rock matrix is on the cast portion of the counterfeit piece. In cross-section you can easily see the line of demarcation between the two areas. Then when you allow your eyes to follow that line to the edge of the rock, and then look at the surface again, you are able to convince yourself that you can see that same line along the surface of the matrix. With some practice you can, but the paint jobs were quite impressive, and it is difficult.

I'm thinking that maybe we should get about 10 people together and buy some of these rocks, for the saw, from selected dealers. This way, we can expose some of these problems without getting too much money involved. Horst was very unhappy at how much money he had spent on his 40 or so fake trilobites.

Brian Eberharde, a dealer from England, suggests asking the vendor for a guarantee of authenticity and the right to a full refund if the piece turns out to be a fake. Also he suggests that some of the resin used will fluoresce, and that a U. V. unit would be helpful. A heated needle can be applied to some casts and the resin will produce a definite scent.

The Real Trilobites from Issoumour

The good news is that no fake trilobite is going to get past any serious fossil collector.

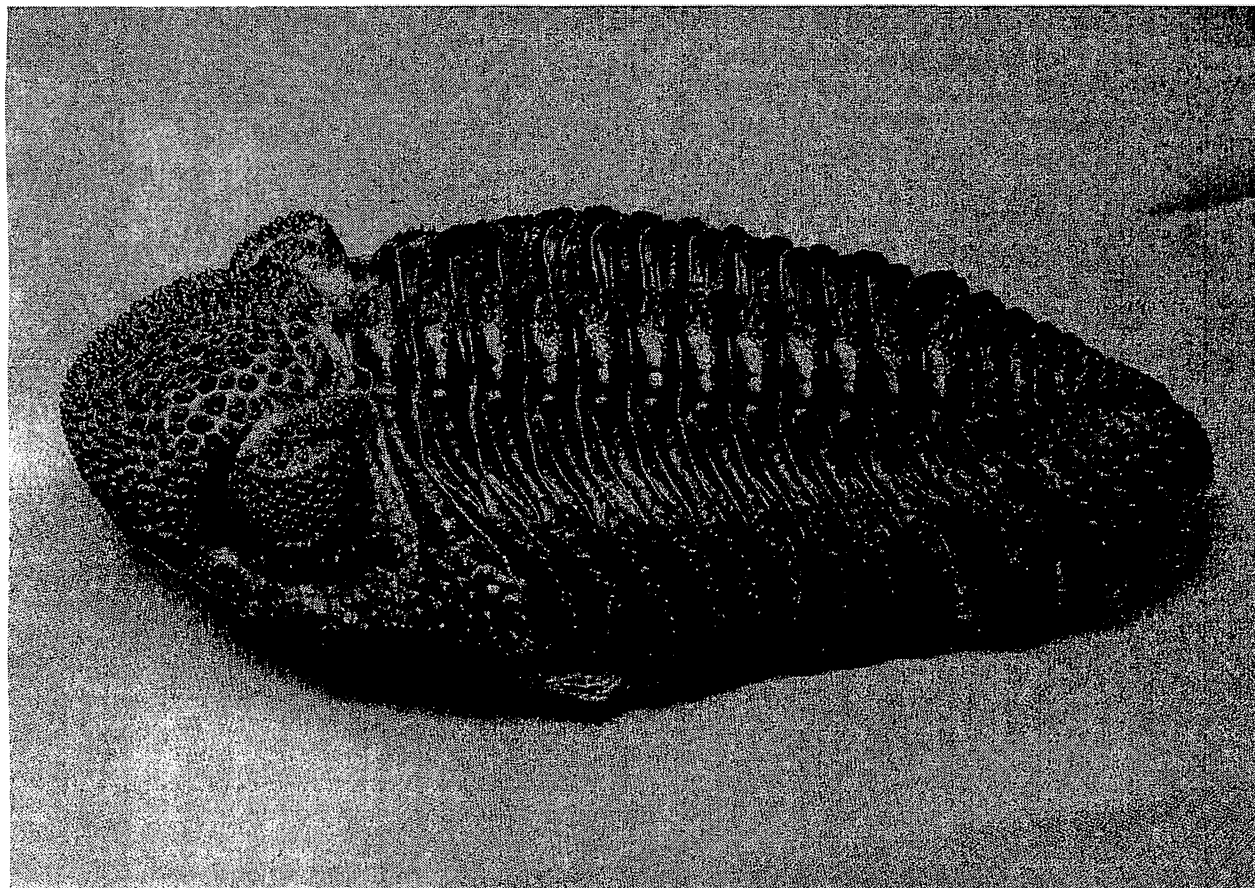


Figure 2 – The Phacopid Genus of large trilobites from Issoumour's lower zone

The trilobite pictured in Figure 2, is the trilobite that really opened up Issoumour. First discovered in a zone very near the top of the mountain, this Phacopid trilobite comes from what I like to call the lower zone of that region near the top. This quarry now completely circles each peak. Fossils found nearby seem to indicate that this zone is very close to the same age as the Harrigan Formation in Oklahoma (White Mound). It should not be a surprise that this was the first trilobite to be counterfeited. I'm quite pleased to have a number of these sculptures in my trilobite art collection.

As a result of this early trilobite discovery (about 1986), literally hundreds of other trilobite quarries were opened up at all levels of the mountain. Replicas of these other trilobites continue to be produced, faking out only those who are not familiar with fossils in general.

Finally, another important discovery of very large trilobites was made. The Phacopid trilobite pictured in Figure 3 was found almost exactly 200 meters above the first zone (Figure 2). This higher zone is within only a few feet of the very top of Issoumour and therefore has less total area than is in the lower zone. These two zones are now quite visible anywhere around the top of the mountain as a series of parallel rings around every peak and down both

sides of each valley still high enough to have these two formations. These two rings allow stratigraphic navigation around Issoumour, even by those possessing little geological experience.

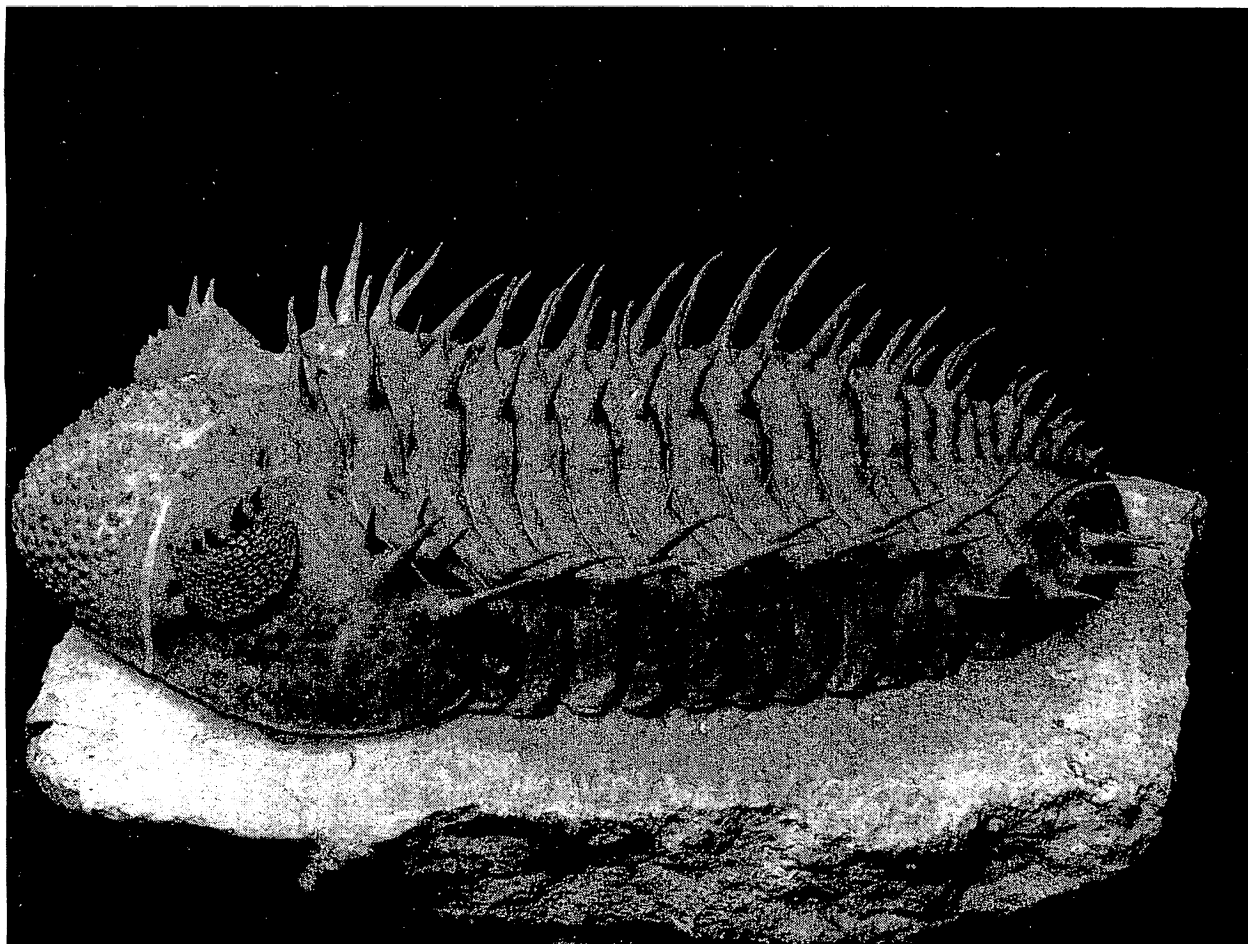


Figure 3 – The spiny Genus of large Phacopid trilobites from Issoumour

As far as I know, the Moroccans have made no attempt to make replicas of this spiny trilobite, but it is common for their preparation of this bug to have a lot of completely faked spines.

In addition to these two spectacular trilobites, there are now literally hundreds of other completely valid species coming out of Issoumour. Listing those (and a discussion of the names used) would be the subject of another article.

The Tahiri Brothers from Tabourikt

New to Tucson about 4 years ago (sponsored and partnered with Bill Barker of the Sahara Sea Collection) was Ali Tahiri who actually lived in a house at the foot of Issoumour Mountain. Brahim Tahiri has been representing the Tahiri clan since his brother had a fatal accident just before the year 2000 Tucson. Ali was a very dear friend and a trilobite digger that I've known since he was about 21. Whenever I travel to this part of the world, I still stay in Tabourikt, in the shadow of Issoumour.

Bill has now partnered with the family that most directly controls the trilobites at the source. Of course nobody is directly in charge of nearly anybody over there, but you can think of the hundreds of fossil quarries as a kind of mafia. Brahim now stands at the head of the organization controlling roughly 80% of the trilobite material from Issoumour, as well as extensive Cambrian and Ordovician localities in southern Morocco.

What We Can Do About the Fakes

One of the things that you can do is to know who you are dealing with. Most of the European dealers such as Brian Eberharde are certainly very good people to know. Dealing with the Tahiri brothers, now led by Brahim Tahiri and in partnership with Bill Barker, will put you closest to the actual diggers and an increasingly more reliable supply of prepared trilobites.

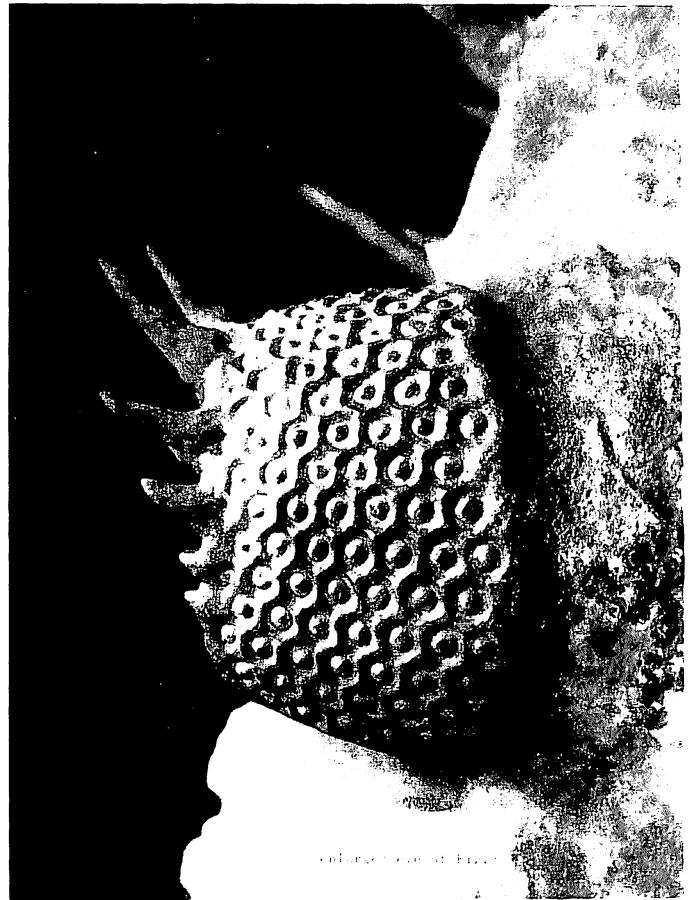
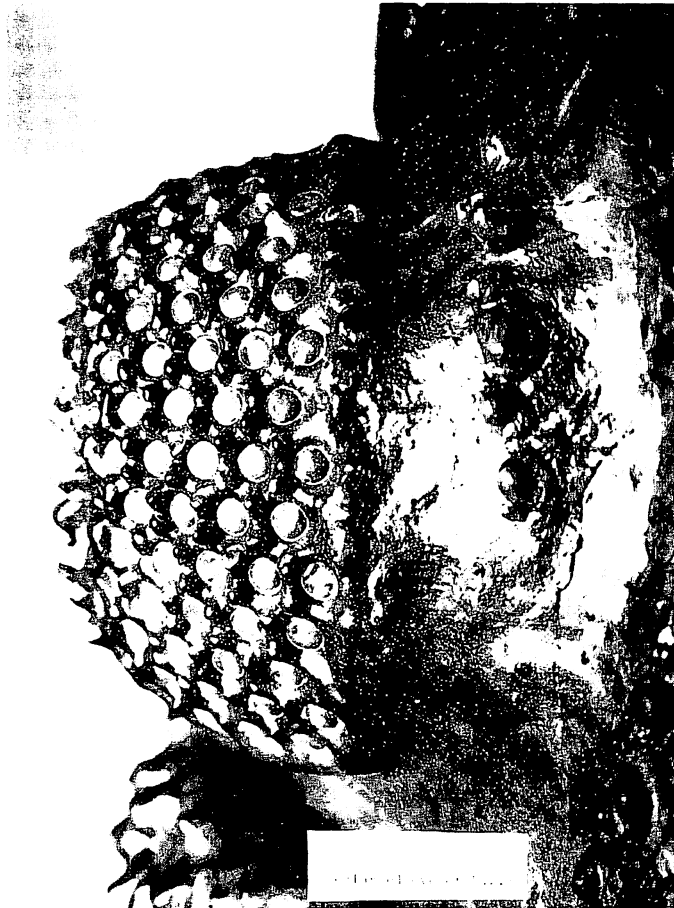
Rachid and Aziz Adnane, from Midelt, have been dealing worldwide the longest. I have found that Rachid and Brian are probably two of the best sources of completely unprepared trilobites, your best method of obtaining accurate material.

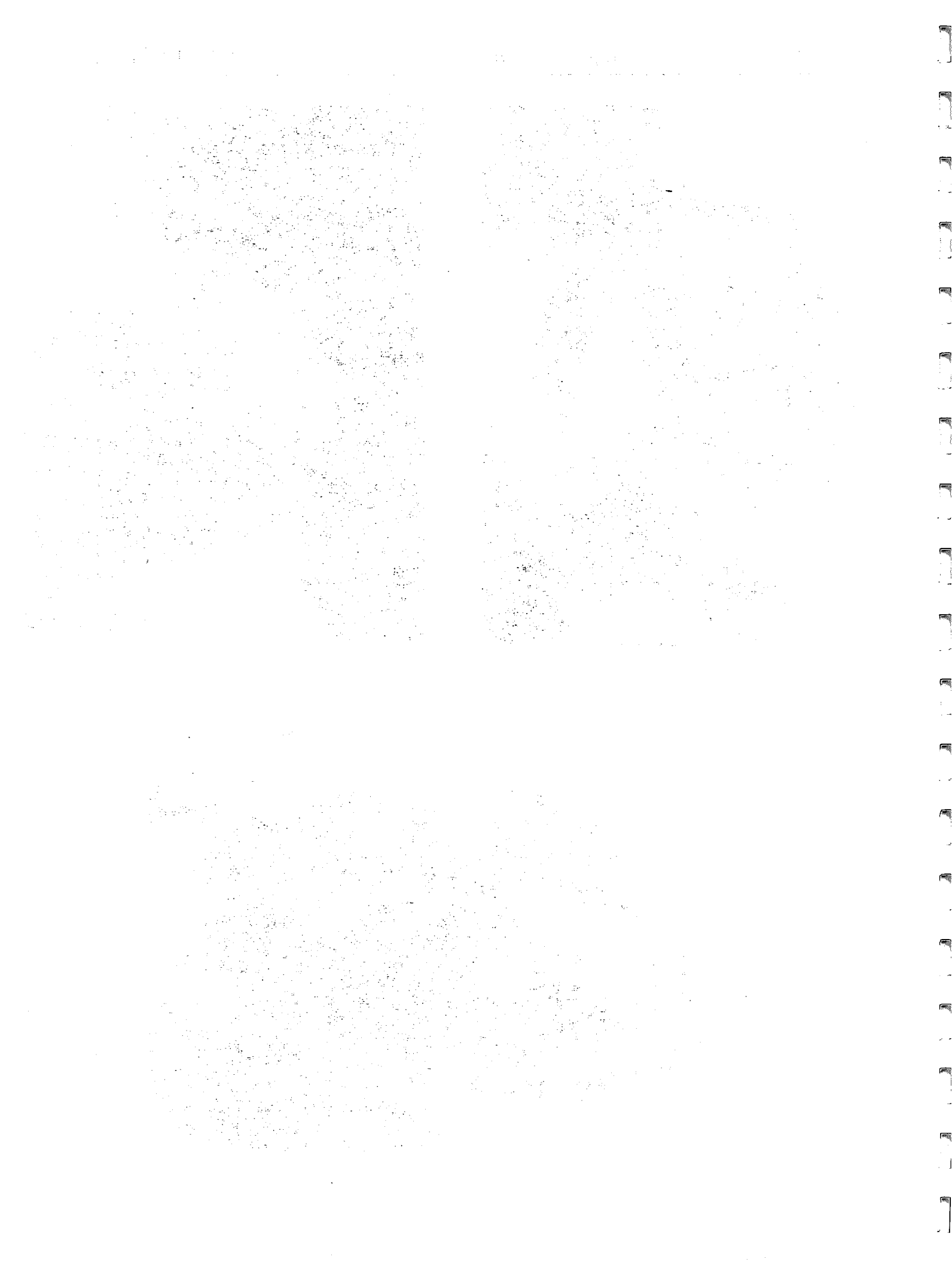
On an unrelated note, it is Rachid Adnane that worked with the Moroccan interior minister to solve the recent problems where the "government" was making it difficult to export trilobites and other fossils. If you are heading to Morocco to dig trilobites, you should find the going much easier now. You can thank Rachid when you run into him at Denver or Tucson.

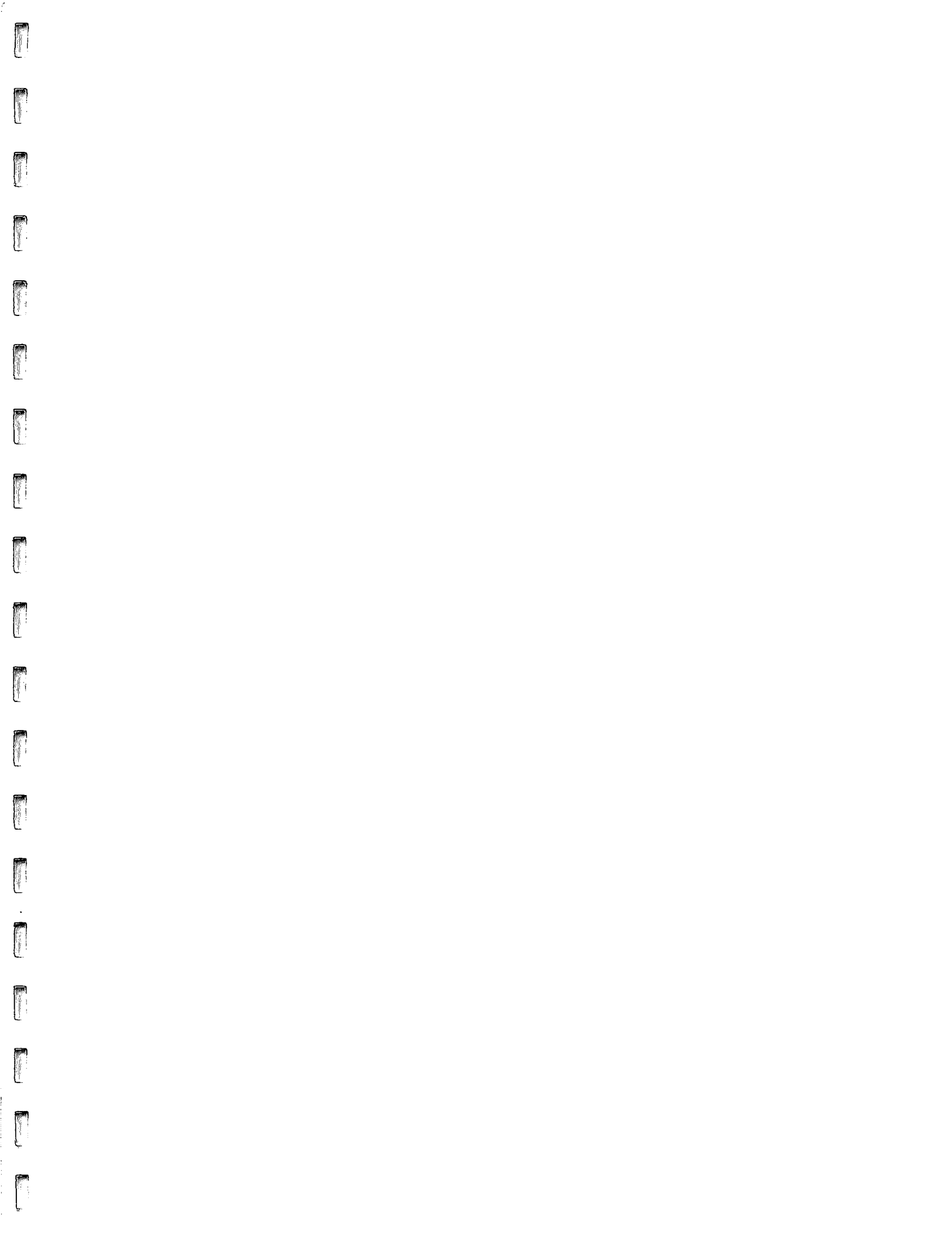
I would encourage everyone who buys what can be shown to be a counterfeit trilobite, to notify both the dealer and the show chairman of wherever this product was purchased. In this way, even those who might be unknowingly purchasing this material for resale, can be shown that it will not be economical.

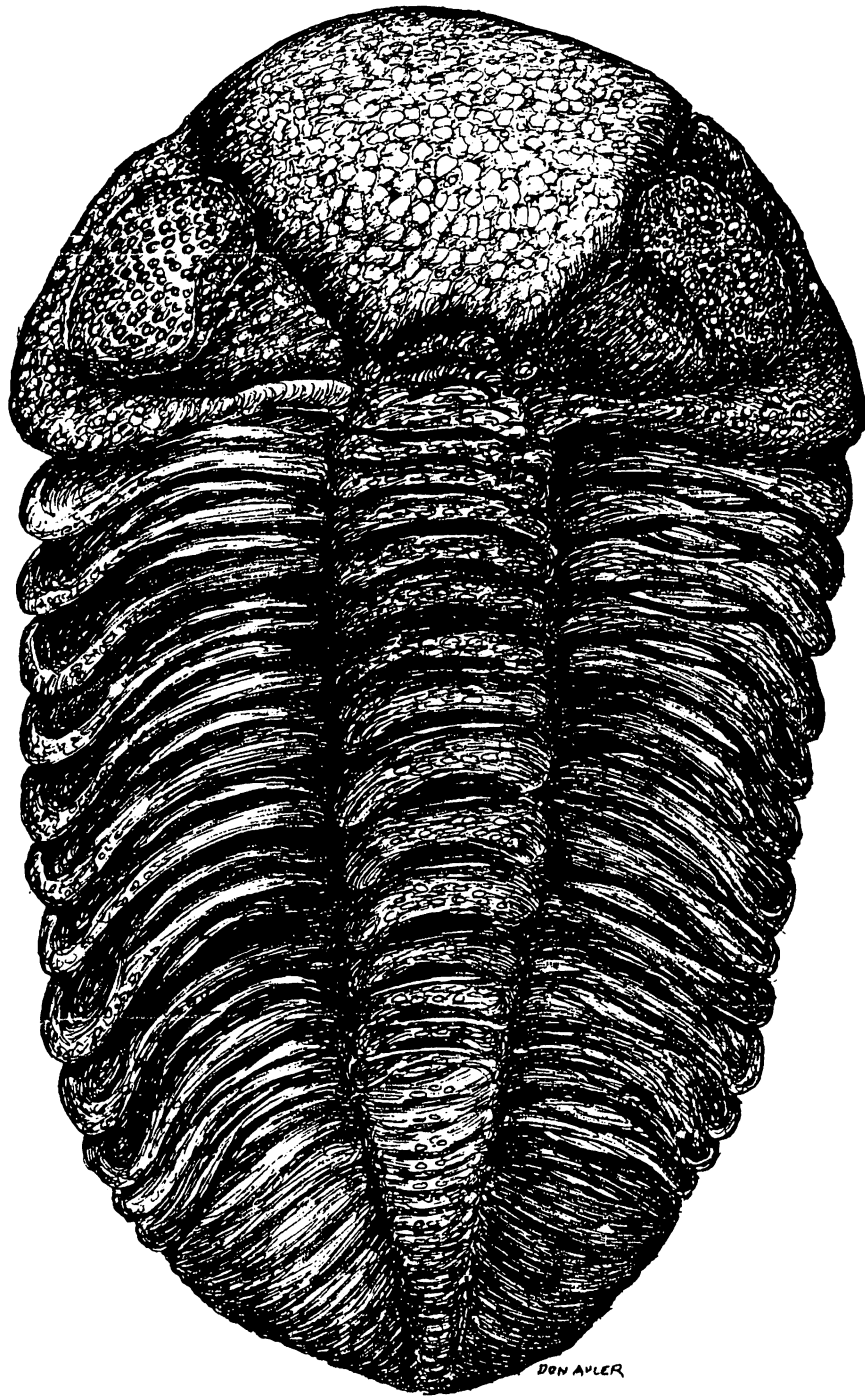
Otherwise the old rule of "buyer beware" should always be in force wherever you are and whatever you might be looking to buy. If the price is ridiculously low, you might take an even harder look. Putting it another way. It takes roughly 250 to 500 dollars just to prepare a *Dicranurus monstrosus*. If you buy the two or three pieces of split rock that are thought to contain such a beast (from a Moroccan), you will pay from 50 to 200 dollars. A European dealer will charge even more. That means a prepared specimen will result (sometimes) for between 300 to 700 dollars. With the bad bugs and other problems, you can expect to spend about 1200 dollars on the average for every perfectly prepared and complete *Dicranurus monstrosus*. You will then have a nice rare bug worth between 1500 and 3500 dollars. And that's only because you often do not need to completely clean a bug to see its problems and you can sometimes just throw a rock in the trash, with only 250 dollars invested in it. Compare that price with a table full of complete prepared *Dicranurus* trilobites for \$30 each. I once saw about 50 of these on a single table at the Roadway Inn in a display set up by Ali Khenafou. I was tempted to buy one for the saw, but I had better places to spend my money.

And I still like Brian's advice about asking the vendor for a guarantee of authenticity and the right to a full refund if the piece turns out to be a fake. You can tell a lot by how the vendor reacts to this request.









DON AYLER