SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 148, NUMBER 3

Charles D. and Mary Vaux Walcott
Research Fund

UPPER CAMBRIAN TRILOBITE FAUNAS OF NORTHEASTERN TENNESSEE

(With 21 Plates)

By
FRANCO RASETTI

The Johns Hopkins University
Baltimore, Md.

(Publication 4598)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
June 10, 1965

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 148, NUMBER 3

Charles D. and Mary Vaux Walcott Research Fund

UPPER CAMBRIAN TRILOBITE FAUNAS OF NORTHEASTERN TENNESSEE

(With 21 Plates)

By
FRANCO RASETTI

The Johns Hopkins University
Baltimore, Md.

(Publication 4598)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
June 10, 1965

CONNECTICUT PRINTERS, INC.
HARTFORD, CONN., U.S.A.

CONTENTS

PART I. Stratigraphy and Faunas

PART II. Systematic Paleontology

Charles D. and Mary Vaux Walcott Research Fund

UPPER CAMBRIAN TRILOBITE FAUNAS OF NORTHEASTERN TENNESSEE

By
FRANCO RASETTI
The Johns Hopkins University

PART I. STRATIGRAPHY AND FAUNAS

The purpose of this paper is both to describe the fossils and to present them in their proper stratigraphic setting. In the study of the Cambrian of the southern Appalachians, there has been in the past little collaboration between geologists and paleontologists. Stratigraphic work was done by geologists who had only a secondary interest in fossil collecting; on the other hand, almost all the species described by Walcott and by Resser were derived from old collections that bear more or less precise locality labels but no accurate indication of the stratigraphic position. In his paper on the Cambrian of the southern Appalachians, Resser (1938a) tried to refer the Upper Cambrian fossils to several zones. This assignment was essentially based on the occurrence of the genera in question in better-understood areas of the United States, chiefly the Upper Mississippi valley, and in a broad sense succeeded in providing an approximately correct time order for the fossils of the southern Appalachians. However, none of the finer details of the time succession could be determined.

The obvious procedure was therefore to locate well-exposed, relatively undisturbed, fossiliferous sections, to collect fossils from carefully measured horizons, and to rely on these alone, and not on the old collections, in establishing the faunal succession. Many of the previously known Upper Cambrian trilobites from Tennessee were thus collected again from known strata; those that could not be found seldom represent more than slightly variant forms related to the ones of ascertained age. A number of new forms were discovered. In general, the collections are much larger than the ones previously in existence, and provide indications on intraspecific variability in populations from a single bed and similar questions that cannot be discussed on the basis of a few scattered specimens from different localities.

On the basis of published records, first a brief reconnaissance was made of various areas of Cambrian outcrop in northeastern Tennessee and some adjacent areas of Virginia in search for sections that might yield the desired biostratigraphic information. Several belts of Cambrian outcrop did not appear promising for either one of two reasons. For example, those north of Clinch Mountain yield a few well-exposed sections, such as the ones at Thorn Hill, described by Hall and Amick (1934), and at Lee Valley, described by Rodgers and Kent (1948). However, most of these sections, with the notable exception of the one near Washburn, hold few fossiliferous beds of the *Crepicephalus* and *Aphelaspis* zones, and the preservation leaves much to be desired. On the other hand, other Cambrian belts, such as those in the vicinity of Greeneville and Morristown, yielded good fossils to the early collectors, but the sections are fragmentary and poorly exposed. Several localities were found that offered undisturbed, well-exposed, and highly fossiliferous sections.

Upper Cambrian fossils occur in northeastern Tennessee chiefly in the upper portion of the Maryville limestone and in the Nolichucky formation (including the Maynardville limestone). The overlying Copper Ridge dolomite, which seems to represent most of the Franconian and Trempealeauian stages, is almost totally barren. The few trilobites collected from this formation are mentioned by Rodgers (1953) and Bridge (1956). No search was made in the Copper Ridge dolomite.

Since the purpose of this paper is essentially paleontologic, no attempt was made to discuss the stratigraphy and nomenclature of the formations in question. This problem has been dealt with by Hall and Amick (1934), Rodgers and Kent (1948), Rodgers (1953), and Bridge (1956). The main points under discussion are whether the Maynardville limestone should be recognized as a separate formation or considered as the uppermost portion of the Nolichucky shale, and where the Maynardville–Copper Ridge contact should be placed. Several sections were measured and are described herein only in order to precisely locate the fossiliferous beds and establish the succession of the faunules. Questions of stratigraphic nomenclature are of secondary importance for these purposes.

Rodgers' geologic map of northeast Tennessee at the scale of 1:125,000 and the geologic map of the Mascot–Jefferson City zinc district by Bridge were found exceedingly useful in searching for possible sections and fossil localities. Dr. Charles R. L. Oder, Chief Geologist of the American Zinc Company of Tennessee, who has been studying the Maynardville limestone for years, showed the writer several interesting sections.

The area under consideration is covered by recent U.S. Geological

Survey 7½-minute quadrangles at the scale of 1:24,000. Localities are always indicated herein by coordinates (x = abscissa, y = ordinate) in millimeters, measured from the southeast corner of the map.

The present study has been limited to trilobites. In the Dresbachian formations of Tennessee the brachiopods are, as usual, the next invertebrate group in order of abundance. The phylum is represented mostly by inarticulates. Recent studies, such as those by Palmer (1954) and Bell and Ellinwood (1962) in Texas, have shown that adequate investigation of these fossils requires extensive etching of limestone with acetic or formic acid, since mechanical preparation generally yields only the exterior of the shell, of scarce taxonomic significance. It is possible that etching of large amounts of limestone of the *Aphelaspis* zone—the only portion of the Upper Cambrian in the area where brachiopods are relatively abundant—might yield interesting results. For a number of reasons such a program was not undertaken.

The other invertebrates observed are indeterminable echinoderm plates, fairly common in certain beds but poorly preserved; a small gastropod of the *"Helcionella"* type, and a few dendroid graptolites in shale beds. The description of these groups of fossils would not bring any significant contribution to paleontology.

ACKNOWLEDGMENTS

The present work was started as part of a research project under a grant from the Penrose Bequest of The Geological Society of America. This grant had already produced two papers (Rasetti, 1959, 1961) on the Cambrian of the central Appalachians. When funds from this source were no longer available, the work was continued and completed with grant No. 2829-P from the Penrose Fund of the American Philosophical Society. The author is greatly indebted to both institutions for their support.

Thanks are also due to Dr. Allison R. Palmer for valuable discussions on problems of taxonomy and biostratigraphy and for communicating unpublished results of his investigations in the Upper Cambrian of the western United States; to Dr. Robert B. Neuman for stratigraphic information; and to Dr. Charles R. L. Oder for communicating his unpublished measurements of sections and for accompanying the author in some field excursions.

DESCRIPTIONS OF LOCALITIES AND SECTIONS

GENERAL STATEMENT

This part of the paper presents the stratigraphic evidence that was used in arranging the Upper Cambrian faunules in their proper time

order. Sections were measured, and are described in some detail, whenever they yielded several faunules in unquestionable stratigraphic succession. Descriptions of lithology are generally limited to those indications that may be useful to a geologist in order to identify in the field the units from which the fossils were collected. In several cases, when the topography was not favorable to an accurate measurement of the thickness, the section was described qualitatively, by giving the succession of the various lithic units and an estimate of their thicknesses. Even in these cases the time order of the fossils collected is certain. Sections where any kind of structural complication might bring doubt about the sequence of the strata were never used.

The localities are indicated in the text only approximately with respect to towns, roads, etc., since a complete list of the fossil localities defined by coordinates on the U.S. Geological Survey topographic maps follows.

Faunal lists given in the descriptions of the sections usually assign to each species an indication of relative abundance (cc = very common, c = common, r = rare, rr = very rare). These indications are missing when the collection was too small to supply significant data. For brevity, author's names are omitted, since all the species listed are discussed elsewhere in this paper. An asterisk preceding the name indicates the type locality for the species.

Fossil collections are all labeled with the letters cn (for Cambrian, Nolichucky) followed by a third letter designating the horizon and a number indicating the locality. At least for the later collections, the same number is applied to all the collections from a given section. As far as possible it was attempted to designate by the same letters correlative beds in the different sections; a few discrepancies are inevitable since precise correlation was not always apparent at the time when the fossils were labeled. Collections designated by cna to cne belong to the *Cedaria* zone, cnk to cnn to the *Crepicephalus* zone, and cno to cnx to the *Aphelaspis* zone.

HAWKINS COUNTY

Big Creek section, near Rogersville.—The most complete and satisfactory section of the entire fossiliferous portion of the Upper Cambrian was found along Big Creek, just south of U.S. Route 11-W, a few miles east of Rogersville, Hawkins County (Burem quadrangle). The U.S. National Museum collections contain numerous fossils from unspecified horizons in this section; several species were described by Walcott (1916a, 1916b) and Resser (1938a).

A section of the upper portion of the Maryville formation and the entire Nolichucky formation were measured chiefly on the hill slopes on the east bank of Big Creek; the rest of the Maryville formation was added from complete sections exposed a short distance east along the

strike. This section with its numerous fossil-bearing beds represents a standard with which partial sections studied in other areas will be correlated. The upper boundary of the Nolichucky formation is here set at the first appearance of dolomite beds, which at Big Creek coincides with the disappearance of limestone. However, Rodgers (1953) assigned some of the lower, noncherty dolomite beds to the upper portion of the Nolichucky (Maynardville limestone member) rather than to the overlying Copper Ridge dolomite. The author, without questioning the reasons that prompted this assignment, has provisionally placed all the dolomite in the Copper Ridge formation because this boundary was more readily recognized in the field. In other sections there is an interval where limestone and dolomite beds alternate, making the definition of the formational boundary more uncertain than at Big Creek.

Big Creek section, measured 3 miles northeast of Rogersville, Hawkins County, Tenn.:

Nolichucky formation		Thickness Feet
8. Limestone and shale; aphanitic, dark-gray, gray-weathering limestone in thin, often nodular beds, ribboned with tan-weathering shale or dolomite. Some crystalline lenses are fossiliferous		67
Collection 66 feet above base (cnx/1):		
Cheilocephalus brachyops	r	
Dytremacephalus angulatus	c	
Dytremacephalus sulcifrons	rr	
Collection 42 feet above base (cnw/1):		
Aphelaspis tarda	r	
Dytremacephalus angulatus	c	
Collection 3–4 feet above base (cnv/1):		
Aphelaspis tarda	c	
7. Limestone and shale: similar to preceding unit, with lesser percentage of limestone in more distinctly nodular layers		6
Collection 0–1 feet above base (cnu/1):		
Aphelaspis tarda	c	
6. Shale, lacking limestone beds		16
5. Shale, with several limestone lenses and nodules		10
Collection 1 foot below top (cnt/1):		
Aphelaspis arsoides	r	
Aphelaspis tumifrons	c	
Pseudagnostus communis	r	
Collection 4 feet below top of interval (cns/1):		
Aphelaspis arsoides	c	
Aphelaspis tumifrons	c	
4. Limestone: one bed, massive, crystalline and conglomeratic, well exposed across stream bed		1
The above portion of the section was measured on the slopes SE of a dry creek bed at x = 182, y = 297 mm, Burem quadrangle.		
3. Shale: finely fissile, with a few siltstone beds near the top		40
2. Limestone: mostly very thick-bedded, light-gray, aphanitic, in part crystalline or oolitic, with some intervals of intraformational		

Thickness
Feet

pebble conglomerate. At the base some thin beds alternating with shale. Very sharp contact with overlying shale 156

Collection in top few inches (cnn/1) :

Blountia arcuosa	r
Blountia montanensis	r
Coosia alethes	c
Coosia robusta	r
Coosia, sp. undet.	r
Crepicephalus cf. *convergens*	r
Kingstonia inflata	c
Maryvillia arion	c
Meteoraspis mutica	r
Terranovella dorsalis	r
Tricrepicephalus thoosa	c

Collection from loose blocks in lower third of interval (cnk/3) :

Blountia alexas	r
Dresbachia amata	r
Kingstonia inflata	c

1. Shale: finely fissile, green or tan, with a few siltstone beds in uppermost portion. In the lower 15 feet a few lenses of silty or crystalline limestone 337

Collections in lower 15 feet both in shale and limestone lenses (cne/1, cne/2) :

Genevievella, sp. undet.	r
Kormagnostus simplex	c
Norwoodella saffordi	c

Total thickness of Nolichucky formation 633

Maryville formation

3. Dolomite and limestone: massive, gray, gray-weathering dolomite in lower part, grading upward to massive, gray, more coarsely crystalline or oolitic limestone. Fossile not rare in top 30 feet, more common in top 10 feet 185

Collections made at various places (cnc/2 to cnc/5) :

Hyolithes, sp. undet.	c
Bonneterrina appalachia	c
Coenaspis spectabilis	rr
Coosella andreas	r
Genevievella, sp. undet.	r
Holcacephalus praecursor	r
Kormagnostus simplex	c
Menomonia tuberculata	r
Menomonia, sp. undet.	r
Modocia crassimarginata	c
Modocia dubia	c
Modocia ? agatho	r
Norwoodia, sp. undet.	r
Tricrepicephalus, sp. undet.	c

2. Dolomite: very light gray, weathering almost white 67
1. Dolomite: gray, weathering tan or dark gray 740

Total thickness of Maryville formation 992

The following comments may be made about this section and the contained fossils:

The Maryville formation here consists mostly of dolomite, except in the uppermost portion which is rather pure, crystalline or oolitic limestone. The contact of the formation with the underlying Rogersville shale is very sharp. Presumably the Middle-Upper Cambrian boundary lies somewhere within the Maryville, since the uppermost portion holds a faunule of the *Cedaria* zone, of very early Dresbachian age. The author was unable to find fossils in the lower parts of the formation in the Rogersville area. However, a collection in the U.S. National Museum (loc. 107x, 11 miles NW. of Knoxville) mentioned by Walcott (1916b, p. 394) yielded the types of *Asaphiscus glaber* Walcott and a species of *Olenoides*. These are undoubted Middle Cambrian fossils and were certainly collected from limestone of the Maryville formation, or at least its equivalent in the Conasauga group.

The Nolichucky formation at Big Creek and in other sections studied in the Rogersville outcrop belt, as well as at many other localities, consists in ascending order of four members: a shale, a limestone, another shale, and the uppermost limestone. The lower limestone member, although very thick and conspicuous in the present section, is quite variable in thickness. It is essentially absent from some of the sections north of Clinch Mountain, such as the Thorn Hill and Purchase Ridge sections, and even from the section on Price School road which is not far from Rogersville and in the same outcrop belt. At several localities this limestone is in part of algal origin (Oder and Bumgarner, 1961). Geologists who discussed the stratigraphy of northeastern Tennessee generally recognized a Maynardville limestone, either as a member of the Nolichucky or as a separate formation. In the typical area, in the Maynardville quadrangle, there is essentially one limestone succession above the shale of the lower Nolichucky, and this was named the Maynardville limestone. It includes at least portions of *Crepicephalus* and *Aphelaspis* faunizones (see discussion of the Hurricane Hollow section). The question arises whether in areas where the upper Nolichucky consists of two limestone units separated by a shale, the name Maynardville should apply to this entire complex, or to the upper limestone alone, the characteristic thin-bedded limestone ribboned with shale and dolomite. Since the author's purpose is not to discuss stratigraphic nomenclature, the more noncommittal attitude of assigning all the strata in question to the Nolichucky is adopted, without implying any judgment on the validity and boundaries of the Maynardville limestone.

The faunules listed in the section show that the basal Nolichucky shale holds essentially the same fossils as the uppermost Maryville

limestone, indicating no considerable time interval between the deposition of the two units. In this section, younger faunules of the *Cedaria* zone such as those found at several localities north of Clinch Mountain seem to be absent, probably owing to the lack of limestone beds or nodules in the shale. The next higher faunules occur in the lower limestone unit, and these belong to the *Crepicephalus* zone. The upper, unfossiliferous 40-foot shale unit separates the uppermost *Crepicephalus* zone faunule from the lowest *Aphelaspis* zone faunule. As shown in the later discussion of other sections, the faunules of the lower portion of the *Aphelaspis* zone are here missing, while the faunules of the upper *Aphelaspis* zone are well represented.

Forgey Creek.—A partial section of the Maryville and Nolichucky formations is exposed along Forgey Creek, between Zion Hill and Carter Valley road, in the NE. corner of the Burem quadrangle. The uppermost beds of the Maryville hold the usual *Cedaria* zone fauna. This was the easternmost locality examined.

U.S. Route 11-W, 6½ miles NE. of Rogersville.—Although the section is poorly exposed here, the locality is important for the presence of unusual, highly fossiliferous red beds at the base of the Nolichucky shale. The best collecting locality (now deteriorated) was the road cut on the S. side of U.S. Route 11-W at the foot of the hill located at x = 326, y = 434, Burem quadrangle (U.S.N.M. locality 27d, author's locality cnd/1). Good collections were also made here in the underlying Maryville limestone, about 30 feet below the top of the formation (cnc/1).

Yellow and pink layers, absent in other areas, begin to appear here in the upper portion of the Maryville. The overlying Nolichucky formation consists, for the lower 50 feet, of alternating red shale and thick, irregular, partly lenticular beds of limestone. Each limestone bed often presents an irregular alternation of aphanitic, brick-red or pink limestone and coarse, yellow to light-brown calcarenite. Both types of limestone are highly fossiliferous in places. The calcarenite is sometimes a coquina of extremely fragmentary trilobite tests, among which only the strong, compact pygidia of *Ankoura triangularis* have escaped destruction. The red, aphanitic limestone supplies better-preserved fossils, including numerous larval stages of trilobites. A list of the species is given in the discussion of the faunas.

A search was made to ascertain how far along the strike these peculiar beds extend. The red beds can be traced eastward, north of the highway, to the south flank of the westernmost hill of Miller Ridge, about half a mile E. of locality cnd/1. On the next hill, where the Maryville–Nolichucky contact is well exposed, the red shale and limestone have disappeared. West of locality cnd/1, the first exposure

of the formational contact occurs at a distance of about half a mile, and no trace of red beds is present. In conclusion, the red beds probably extend for less than 1 mile along the strike. They were observed at no other locality.

The lower limestone member of the Nolichucky is sharply defined near this locality and has an approximate thickness of 180 feet.

One mile E. of Rogersville.—A good section of the lower limestone member of the Nolichucky was measured in a cut on the E. side of the road leading to Bell Cemetery. The limestone is 175 feet thick; however, the lower 50 feet here alternate with shale. Good fossils were collected about 40 feet above the lowest limestone bed (cnk/1).

Highly fossiliferous beds about 45 feet below the top of the lower limestone member of the Nolichucky occur about 0.2 miles SW. of the preceding locality, on the hill S. of a dirt road (loc. cnm/2). Loose blocks on the hill slope (cnm/3) were partly derived from these beds, partly seemingly from a higher horizon, as some hold a faunule more similar to that found in the uppermost beds of the lower limestone.

Guntown Road.—The lower limestone member of the Nolichucky is fairly well exposed on the E. side of the Guntown Road, about ½ mile S. of Rogersville. Good collections were made from the top beds of the lower limestone member of the Nolichucky (loc. cnn/2).

Crockett Creek.—Partial sections of the Nolichucky are exposed on the hills S. of Crockett Creek (Pressmen's Home quadrangle). A good section of the lower limestone member was found near the end of a dirt road branching off from U.S. Route 11-W near Bench Mark SN-113. The limestone is approximately 145 feet thick. Numerous fossils were collected from the top beds (loc. cnn/3).

Price School Road.—A partial section of the Nolichucky formation is exposed on the east side of Price School Road (x = 99–102 mm., y = 475–485 mm., Bulls Gap quadrangle). Shale beds a few feet above the top of the Maryville limestone yield *Kormagnostus simplex* and *Norwoodella saffordi* as do the strata at the same level in the Big Creek section. The lower limestone member of the Nolichucky, however, is here reduced to a small fraction of the thickness of 150 feet observed in all the sections near Rogersville. It consists of about 30 feet of limestone alternating with shale. This limestone is overlain by a thick succession of shale beds with a few, thin limestone lenses. A lens 90 feet above the top of the limestone yielded *Amiaspis?* sp.; one 140 feet above contained *Coosina* sp. and *Crepicephalus* sp.; and one 170 feet above, *Aphelaspis* sp. and *Glaphyraspis* sp. Even though the fossils are scarce and fragmentary, it is clear that the *Crepicephalus–Aphelaspis* zone boundary is somewhere between 140 and 170 feet above the top of the limestone. This is in contrast with the

relationships at Big Creek and Lost Creek, where the faunizone boundary approximately coincides with the limestone-shale contact, and on Shields Ridge (Piedmont Road, Russell Gap), where the boundary lies within the limestone unit. These observations indicate that, in accordance with its erratically varying thickness, the lower limestone member of the Nolichucky does not occupy the same time span in different sections. Limestone units in the Nolichucky shale are developed erratically at different levels, the only persistent one being the characteristic "ribbon rock" at the top.

HAMBLEN COUNTY

Three Springs.—A section of the upper Nolichucky formation is well exposed in a recent road cut on the E. shore of the Three Springs embayment of Cherokee Reservoir (Russellville quadrangle). This locality is in the same outcrop belt as the Big Creek section and is 14 miles distant along the strike. Unfortunately, some of the upper (Maynardville) limestone and its contact with the Copper Ridge dolomite are obscured by incomplete exposures and structural complications. The section was measured in descending order (northward), starting near an old stone bridge, where good exposures in the road cut on the E. side of the road begin. An undetermined portion of the upper limestone unit is therefore missing.

	Thickness Feet	Inches
32. Limestone, in thin beds ribboned with shale or dolomite, somewhat more shaly in lower portion	Not measured	
Collection cnv/15, 0–5 feet above base:		
Aphelaspis tarda c		
Dytremacephalus angulatus r		
31. Shale	3	6
30. Shale and limestone, the latter in nodular beds	4	
Collection cnu/15:		
Aphelaspis tarda c		
29. Shale, partly slumped and poorly exposed. A prominent lens of knobbly limestone 4 feet below top is exposed along road	10-30	
28. Shale, with nodular limestone beds	14	
Collection cnt/15 at top:		
Aphelaspis arsoides c		
Aphelaspis tumifrons c		
Pseudagnostus communis r		
Collection cnt'/15 at base:		
Aphelaspis arsoides r		
Aphelaspis tumifrons cc		
27. Shale	1	
26. Limestone: massive, granular, with tan-weathering stringers	2	

	Thickness Feet	Thickness Inches
25. Siltstone, with thin limestone beds and lenses	2	
Collection cnt''/15:		
Aphelaspis arsoides c		
Aphelaspis tumifrons cc		
Pseudagnostus communis r		
24. Shale	3	
23. Limestone: massive, one bed	1	
22. Shale	6	
21. Shale, with thin limestone beds	4	
Collection cns''/15, 2 feet above base:		
Aphelaspidella macropyge		
Aphelaspis rotundata		
Paraphelaspis vigilans		
20. Limestone: massive, one bed	2	
19. Shale, with thin-bedded limestone	5	
Collection cns'/15, from limestone lenses at middle and top of interval:		
Aphelaspis arses r		
Aphelaspis rotundata c		
Paraphelaspis vigilans c		
18. Limestone: granular, one bed	1	2
17. Siltstone	2	5
16. Limestone: massive, granular	1	
15. Shale, with some thin siltstone and limestone beds	9	
Collection cns/15, 5 feet below top:		
Aphelaspis camiro c		
Aphelaspis laxa r		
Aphelaspis quadrata c		
Aphelaspis washburnensis r		
Aphelaspis, sp. undet. r		
14. Limestone conglomerate: one bed		5
13. Shale, with a few thin limestone beds and lenses	10	
Collection cnr'/15, 2 feet below top:		
Aphelaspis laxa c		
12. Limestone: one bed, partly conglomerate		5
11. Shale, with a few, thin limestone beds	1	6
Collection cnr/15, 8 inches below top:		
Aphelaspis walcotti cc		
Glaphyraspis declivis c		
Glaphyraspis oderi c		
10. Limestone: one bed of irregular thickness		2–4
9. Shale	2	
8. Limestone: one bed of irregular thickness, partly conglomerate	1	
7. Shale, finely fissile	2	8
6. Limestone: silty, granular, one bed		6–7
5. Shale with thin siltstone and limestone beds, partly lenticular	4	8
Collection cnq/15, 6 inches below top:		
Aphelaspis minor cc		
Glaphyraspis ornata r		

	Thickness Feet	Inches
Collection cnp'/15, 1 foot below top:		
Aphelaspis lata c		
Aphelaspis walcotti c		
Collection cnp/15, 2 feet below top:		
Aphelaspis lata cc		
Collection cno/15, 3–4 feet below top:		
Aphelaspis buttsi cc		
Coosella perplexa r		
Glaphyraspis parva cc		
4. Limestone: 4 beds several inches thick, separated by shale and siltstone	3	4
3. Shale, siltstone, and limestone: one 3-inch limestone bed in middles of unit	5	4
Collection cnn/15 from loose pieces at foot of cliff, presumably derived from this or preceding unit:		
Amiaspis, sp. undet.		
Coosia alethes		
Crepicephalus, sp. undet.		
Terranovella dorsalis		
2. Limestone conglomerate: one bed, well exposed near road		5–7
1. Shale, siltstone, and limestone in part conglomerate, alternating as in preceding units, underlain by massive limestone. This part of the section was not measured as it yielded no fossils, and change in dip affects its lower portion.		

As it can be seen from the faunal lists, this section offers one of the most complete successions of *Aphelaspis* zone faunules observed anywhere. Noteworthy is the collection cno/14 at the base of the *Aphelaspis* zone, yielding *Coosella,* a genus more characteristic of the *Crepicephalus* zone, associated with *Aphelaspis buttsi,* so far known only from this locality in Tennessee, where it is believed to be the oldest species of the genus. Equivalent beds will be described from the Russell Gap section.

GRAINGER COUNTY

Smith Hollow.—A continuous section of the upper portion of the Nolichucky formation is exposed in a road cut at Smith Hollow, Luttrell quadrangle. The writer is indebted to Dr. Oder for leading him to this locality and supplying measurements of the section. Collections at various levels were made by Dr. Oder and the author. A brief description of the section in descending order follows.

The uppermost part of the Nolichucky is the usual limestone in thin beds, ribboned with shale or dolomite, alternating with minor shale intervals. This suit is approximately 150 feet thick.

Oder's collection No. 14A, about 80 feet below top of unit:
Aphelaspis tarda

Oder's collection No. 14, a short distance below the preceding:
Aphelaspis arsoides
Aphelaspis tumifrons

The above unit is underlain by a thick shale interval with minor siltstone, limestone, and limestone conglomerate layers. Some of the limestone beds are lenticular. The base of this shale rests on massive limestone as in the sections of the Rogersville area. The thickness of the limestone cannot be accurately measured but seems to be much less than in the vicinity of Rogersville.

The following collections were all made from thin limestone beds in the shale unit.

Collection cns/16 (= Oder's collection No. 13), about 100 feet below top of shale:
Aphelaspis camiro c
Aphelaspis laxa r
Aphelaspis quadrata c
Collection cnq/16, about 2 feet below the preceding:
Aphelaspis walcotti
Glaphyraspis ornata
Glaphyraspis declivis
Collection cnr/16, about 2 feet below the preceding:
Aphelaspis walcotti cc
Glaphyraspis ornata r
Collection cnn/16, about 145 feet below top of shale:
Amiaspis erratica
Amiaspis obsolescens
Coosia alethes
Crepicephalus buttsi

This section affords a good sequence of *Aphelaspis* faunules and confirms the order of the species of this genus observed in other sections. The lowest faunule belongs to the *Crepicephalus* zone. It is notable for the presence of the genus *Amiaspis*.

Thorn Hill.—The Nolichucky formation exposed in the Thorn Hill section, measured by Hall and Amick, is not particularly fossiliferous. The author collected from limestone beds interstratified with shale in the lower portion of the formation (*Cedaria* zone, loc. cnd/13) the following species:

Cedaria tennesseensis
Kormagnostus simplex
Menomonia, sp. undet.
Norwoodella walcotti

Washburn.—A richly fossiliferous and excellently exposed section of the beds of the *Aphelaspis* zone was measured in a cut of the Southern Railway about a mile north of Washburn. The locality is in

the Dutch Valley quadrangle, in the same outcrop belt as the Thorn Hill section studied by Hall and Amick, at a distance of 10 miles along the strike. The beds dip 42°–45° S. The Nolichucky–Copper Ridge contact is exposed in a ravine on the E. side of the railroad and seems to be rather gradational, the dolomite content increasing upward. Only the basal part of the upper (Maynardville) limestone member of the Nolichucky is exposed in the railroad cut, the best exposures being on the E. side. Below the limestone, every bed to the base of the *Aphelaspis* zone is visible.

	Thickness Feet
16. Limestone, ribboned with shale and dolomite, rather poorly exposed in ravine; only lowest 6 feet exposed in railroad cut	70
Collection cnx/20, 2–6 feet above base:	
Aphelaspis tarda cc	
15. Shale	5
14. Limestone, ribboned with shale and dolomite	21
Collection cnw/20, 4–7 feet below top:	
Aphelaspis punctata c	
**Aphelaspis tarda* cc	
Cheilocephalus brachyops r	
Dunderbergia tennesseensis r	
13. Shale, finely fissile	12
12. Shale, with thin limestone beds and lenses	16
Collection cnt'/20, 8 feet above base:	
Aphelaspis arsoides c	
Aphelaspis tumifrons cc	
Pseudagnostus communis c	
Collection cnt/20, 2 feet above base:	
Aphelaspis tumifrons c	
Pseudagnostus communis r	
11. Shale: finely fissile, lacking limestone beds	14
10. Shale, with thin limestone beds and lenses; one thick limestone bed at base	10
Collection cns/20, 0–4 feet below top:	
Aphelaspidella macropyge c	
Aphelaspis arses c	
**Aphelaspis rotundata* c	
**Paraphelaspis vigilans* c	
9. Shale: finely fissile, lacking limestone beds	9
8. Shale, with thin limestone lenses	2
Collection cnr'/20:	
Aphelaspis camiro c	
Aphelaspis laxa c	
Aphelaspis quadrata c	
Glaphyraspis oderi r	
7. Shale: finely fissile, lacking limestone beds	5
6. Shale, with thin limestone beds and lenses; a few limestone beds up to 4–5 inches thick, one at top	22

	Thickness Feet
Collection cnr/20 in thin lenses in top 1 foot:	
Aphelaspis camiro c	
Aphelaspis laxa r	
Aphelaspis quadrata c	
Collection cnq'/20 in thin bed 2½ feet below top:	
**Aphelaspis washburnensis*	
Aphelaspis, sp. undet.	
Aphelaspidella macropyge	
Glaphyraspis declivis	
Collection cnq/20 in thin beds and lenses, 10–14 feet above base:	
Aphelaspis walcotti cc	
Glaphyraspis oderi c	
Collection cnp'/20, in thin beds and lenses 6–8 feet above base:	
Aphelaspis minor c	
Glaphyraspis oderi r	
Collection cnp/20 in lenses and nodules 1–4 feet above base:	
Aphelaspis lata cc	
Cheilocephalus brevilobus r	
5. Limestone: in rather thick beds, with some shale intervals	7
4. Shale and thin-bedded limestone	5
Collection cnn/20, 1 foot above base:	
Crepicephalus, sp. undet.	
Terranovella dorsalis	
3. Limestone: in rather thick beds, with some shale intervals	6
2. Shale, siltstone, and thin-bedded limestone. Unit extends almost to northern end of railroad cut	27
Collection cnm'/20, 3½ feet below top:	
**Amiaspis obsolescens*	
Coosia alethes	
Collection cnm/20, 11 feet below top:	
Kingstonia inflata	

The Washburn section supplies one of the most complete successions of *Aphelaspis* faunules observed in Tennessee, and is probably unequaled in the number of fossils of the *Aphelaspis* zone. The trilobites are mostly well preserved, including the extremely numerous larval stages of *Aphelaspis* present in collection cnw/20 (pl. 20, fig. 1).

JEFFERSON COUNTY

The Nolichucky formation is partly exposed near the crest of Shields Ridge, in the New Market and Jefferson City quadrangles. Three localities yielded important fossils and information about the faunal succession.

New Market–Piedmont Road.—The Nolichucky formation is incompletely exposed along the road on the N. and S. slopes of Shields Ridge. The top of the lower limestone unit crops out where the road crosses the summit. This locality yielded numerous trilobites to early

collectors, and several of the fossils in the U.S. National Museum collections were used as types by Walcott and Resser (U.S.N.M. locality 120). In these early collections fossils from the *Crepicephalus* and *Aphelaspis* zones were indiscriminately mixed. Bridge (1956) gave a description of the section in which, however, many intervals were stated to be covered. His collection No. 2804, from which the new species *Aphelaspis bridgei* is described herein, was made at this locality.

The general lithology of the Nolichucky is very similar to that described for the Rogersville Big Creek section. Thicknesses were not measured because of the unfavorable topography and incomplete exposures. The lower Nolichucky shale is followed by a massive limestone unit that bears fossils at least in its upper portion. Fossils of the *Crepicephalus* zone occur (loc. cnn/5) 30–40 feet below the top of the limestone (*Tricrepicephalus thoosa, Meteoraspis* sp.). However, the top of the massive limestone belongs in the *Aphelaspis* zone. Crystalline lenses in aphanitic limestone in the uppermost 1 foot of the unit, as well as limestone lenses in the lower few feet of the overlying shale, yielded collection cns/2. The species observed are:

**Aphelaspis arsoides*	c
**Aphelaspis inermis*	r
Aphelaspis tumifrons	cc
Cheilocephalus, sp. undet.	r
Pseudagnostus communis	r

Comparison with the faunules of the Big Creek, Three Springs, and Washburn sections indicates that the above faunule is fairly high in the middle portion of the *Aphelaspis* zone. The U.S. National Museum collection 120 includes the types of *Aphelaspis camiro, A. laxa,* and *A. quadrata* which, as it appears from other evidence, are somewhat older than the species listed above. Collection 2804 of the U.S. Geological Survey yielded the types of *Aphelaspis bridgei,* unknown from other localities. Its association with *Blountia bristolensis* and *Glaphyraspis ornata,* species that were found only in the basal beds of the *Aphelaspis* zone at other localities, shows that this collection was made from beds still lower than those yielding *Aphelaspis camiro, A. laxa,* and *A. quadrata.* Unfortunately, the portion of the massive limestone with interbedded shale intervals, from which all these fossils are presumed to come, is now poorly exposed and shows only aphanitic, unfossiliferous beds.

The massive limestone is overlain by 40 to 50 feet of shale, the lower portion of which contains the rare limestone lenses mentioned above. The shale is in turn overlain by the usual limestone ribboned with

shale and dolomite. Its exposures are not extensive, and no fossils were observed. The contact with the Copper Ridge dolomite is exposed in a road cut on the S. slope of the ridge.

Russell Gap.—The lower limestone unit of the Nolichucky is more favorably exposed where a dirt road crosses Shields Ridge at Russell Gap, in the SW. corner of the New Market quadrangle. The overlying shale is poorly exposed in a dip slope in the woods E. of the road. The uppermost limestone is partly exposed only in a ravine E. of the road. The best exposures of the fossiliferous upper portion of the lower limestone unit are located near the crest of the ridge in the woods NE. of the gap. Fossils were collected from the following beds in descending order.

Collection cnw/14.—Crystalline beds in lower portion (probably lower 10 feet) of upper limestone unit of the Nolichucky. These lower beds are predominantly calcareous, with little shale or dolomite:

Aphelaspis tarda	r
**Dunderbergia tennesseensis*	r
**Dytremacephalus angulatus*	c
**Dytremacephalus sulcifrons*	rr
Cheilocephalus brachyops	r

Collection cnq/14.—Top 1–2 feet of lower limestone unit, underlying the upper shale unit, about 40–50 feet below the preceding collection. This and the underlying beds are massive, aphanitic limestone with crystalline lenses:

Aphelaspis minor	c
Blountia bristolensis	c
Cheilocephalus brevilobus	cc
Glaphyraspis ornata	r

Collection cnp/14.—Massive limestone, about 3 feet below the preceding, hence 4–5 feet below top of lower limestone unit:

**Aphelaspis lata*	c
Blountia bristolensis	cc
Cheilocephalus brevilobus	c
Glaphyraspis ornata	r

Collection cno/14.—Massive limestone, 11 feet below top:

Aphelaspis cf. *lata* (or *buttsi*)	r
Blountia bristolensis	c
Cheilocephalus brevilobus	c
Coosella perplexa	c
Glaphyraspis parva	r
Tricrepicephalus, sp. undet.	r

Collection cnn/14.—Massive limestone, 14 feet below top:

Blountia, sp. undet.	r
Blountiella, sp. undet.	r
Coosia alethes	r
Coosina, sp. undet.	r

Kingstonia inflata	r
Metearaspis, sp. undet.	r
Terranovella dorsalis	r
Tricrepicephalus thoosa	c

Collection cnw/14 belongs to the uppermost *Aphelaspis* zone of Tennessee, yielding an assemblage known from a number of sections. The middle portion of the faunizone may be represented in the poorly exposed shale unit. The underlying, massive limestone offers a remarkable transition from the *Crepicephalus* to the *Aphelaspis* zone within a few feet of beds. Collection cnn/14 contains a typical upper *Crepicephalus* zone assemblage. Collection cno/14, only 3 feet higher, still includes the typical *Crepicephalus* zone genera *Coosella* and *Tricrepicephalus*, associated with *Aphelaspis* and *Cheilocephalus*. The specimens of *Tricrepicephalus* are too fragmentary to be specifically identifiable, but the generic characters of the pygidium are unmistakable. An equivalent faunule was collected from the Three Springs section, where, however, *Tricrepicephalus* was not found.

Lost Creek.—A partial section of the upper Nolichucky was studied in a recent road cut near the headwaters of Lost Creek, 0.2 mile W. of Tennessee Route 92, about 2 miles S. of Jefferson City. The lower, massive limestone unit is partly exposed and is overlain by alternating beds of shale, limestone, and limestone conglomerate. The exposed section barely reaches the base of the uppermost limestone unit of the Nolichucky. Notwithstanding the limited exposure, this locality yielded a number of faunules in clear relative stratigraphic order. The section is described below.

	Thickness Feet	Inches
13. Limestone: massive, crystalline, banded with dolomite	2	4
12. Shale, with small scattered limestone lenses	12	0
Collection cnt/4, 0–2 feet above base:		
Aphelaspis arsoides c		
Aphelaspis tumifrons cc		
Dytremacephalus angulatus rr		
Pseudagnostus communis r		
11. Limestone: crystalline, one bed	1	0
10. Shale, with scattered limestone lenses	8	0
Collection cns/4, 3–4 feet above base:		
Aphelaspis inermis c		
Aphelaspis arses c		
Aphelaspis camiro r		
Aphelaspis laxa r		
Cheilocephalus, sp. undet. r		
Pseudagnostus communis r		
9. Limestone: coarsely granular, with insoluble stringers; one bed	1	0

	Thickness Feet	Inches
8. Shale	5	0
7. Limestone: massive, coarsely granular, with siliceous stringers	3	6
6. Shale, with thin limestone beds	2	6
Collection cnr′/4 in limestone bed at top:		
Aphelaspidella macropyge		
Collection cnr/4 in limestone bed at base:		
Aphelaspis arses r		
Aphelaspis cf. *lata* r		
**Aphelaspidella macropyge* c		
Cheilocephalus, sp. undet. r		
Paraphelaspis vigilans r		
5. Limestone: coarsely granular, one bed	2	0
4. Shale	2	0
3. Limestone pebble conglomerate: one bed		10
2. Shale, with limestone lenses and thin beds, especially in upper portion	18	0
Collection cnq″/4 at top:		
Aphelaspis cf. *rotundata*		
Collection cnq′/4, 13 feet above base:		
Aphelaspis cf. *laxa*		
Collection cnq/4 in a limestone bed 8 feet above base:		
Aphelaspis walcotti		
Collection cnn/4 in 1-inch limestone bed, 6 inches above base:		
Coosia alethes c		
Crepicephalus, sp. undet. No. 1 r		
Maryvillia arion c		
Tricrepicephalus thoosa c		
1. Limestone: massive, granular, aphanitic, or oolitic, poorly bedded, with tan-weathering siliceous stringers; incompletely exposed		60+

Although this section is in the same outcrop belt as the Piedmont Road and Russell Gap sections, it shows several differences. Here the *Crepicephalus* zone includes all the lower, massive limestone unit and extends a few feet above it. The overlying shale has much more interbedded limestone. The earliest *Aphelaspis* zone faunule with *Aphelaspis walcotti* is younger than the earliest faunules observed in the Russell Gap, Three Springs, Washburn, and Hurricane Hollow sections.

UNION COUNTY

Hurricane Hollow.—A section of the upper portion of the Nolichucky is exposed along the Hurricane Hollow embayment of Norris Reservoir (Maynardville quadrangle) and was measured by Dr. C. R. L. Oder, who showed it to the writer. The strata are exposed both in the road cut and along the shores on both sides of the embayment.

Dr. Oder measured his section in the road cut, whereas the more interesting fossils were found on the E. shore of the embayment, where the writer measured a partial section. Difficulty was experienced in correlating the road-cut section with the shore section, since the strata could not be accurately traced through the intervening area. However, all the fossils discussed herein were collected by Dr. Oder and the author from the shore beds in unquestionable stratigraphic order. The beds dip 25°–30° S. The section in descending order follows, beginning with the highest limestone beds below the dolomite.

	Thickness Feet	Inches
12. Limestone: weathering blue-gray, mostly very massive, at top and bottom thin-bedded, in part dolomitic	20	
11. Limestone: very massive, mottled with dolomite, weathering to rough surfaces	14	
10. Limestone: thin-bedded, aphanitic, with tan-weathering partings, weathering to smooth, blue-gray surfaces	6	
9. Limestone: crystalline, massive, with insoluble stringers weathering in relief	18	
8. Shale and thin-bedded limestone	2	
Collection cnr'/17 (= Oder's coll. No. 2):		
Aphelaspis walcotti		
Blountia mimula		
**Glaphyraspis declivis* c		
**Glaphyraspis oderi* c		
7. Limestone: crystalline, massive, weathering blue-gray; basal part weathering to spongy residue	2	6
6. Limestone: massive, mottled with dolomite, weathering to rough surfaces; in lower part with regular, insoluble stringers	10	
5. Shale, with limestone nodules	1	4
4. Limestone: massive, mottled with dolomite, weathering to rough surfaces	6	
3. Shale, with limestone lenses and nodules	8	
Collection cnr/17, 2 feet below top:		
Aphelaspis, sp. undet.		
2. Limestone and shale: limestone in thin, partly lenticular beds; interval grades eastward to almost pure limestone	7	
Collections cnq/17, 2½ feet above base:		
**Aphelaspis minor* c		
Glaphyraspis ornata r		
1. Limestone: mostly crystalline, massive, with a few thin-bedded intervals. Base of unit forms bottom of ravine on lake shore	18	
Collection cnp/17 in thin limestone bed at top:		
**Aphelaspis transversa* c		
Blountia bristolensis c		
Cheilocephalus brevilobus r		

Collection cnn/17, in massive limestone beds 5–8 feet below top:
Coosia, sp. undet.
Crepicephalus, sp. undet.
Tricrepicephalus, sp. undet.

The section extends into lower beds of similar lithology, with alternating massive and thin-bedded limestones and shale, the latter becoming more prevalent downward. Occasional very fragmentary fossils of the *Crepicephalus* zone were seen in this lower, unmeasured portion of the section.

This section, like the ones at Three Springs and Russell Gap, is interesting for offering an *Aphelaspis* faunule a few feet above a typical *Crepicephalus* zone faunule. The earliest *Aphelaspis* here is a new species, *A. transversa,* closely related to *A. buttsi* and *A. lata* which are the first to appear in the two above-mentioned sections.

CLAIBORNE COUNTY

Comby Ridge.—An interesting fossil locality occurs where U.S. Route 25-E crosses Comby Ridge (Howard Quarter quadrangle). On the E. side of the road and creek, the lower part of the Nolichucky formation consists of shale with numerous limestone beds and lenses. One such lens collected by Dr. Gunnar Henningsmoen and Dr. Robert B. Neuman yielded fossils of the *Cedaria* zone, some of which are illustrated herein. The author found further fossiliferous beds, in addition to collecting from the above-mentioned lens. Unfortunately, the exposures are poor and some of the fossiliferous lenses are weathered out of the shale, hence their stratigraphic order is not always certain. Lenses or beds believed to occur in ascending order were labeled cnb/10, cnd/10, and cne/10. There is a considerable thickness of shale underlying these fossiliferous beds but overlying the Maryville limestone.

The fossils are for the most part extremely fragmentary in a coarse-grained calcarenite. The following faunules were observed.

Collection cne/10:	
Cedaria tennesseensis	c
Kormagnostus simplex	r
Menomonia, sp. undet.	r
Norwoodella walcotti	cc
Collection cnd/10:	
Ankoura triangularis	r
Kormagnostus simplex	c
Norwoodella halli	c
Norwoodella walcotti	r

Collection cnb/10:

Ankoura triangularis	c
Kormagnostus simplex	r
Olenoides, sp. undet.	r

River Ridge.—A section of the uppermost part of the Nolichucky formation (Maynardville limestone member) was measured in a deep cut on the W. side of U.S. Route 25-E where it crosses River Ridge, a short distance N. of the bridge on the Clinch River (Howard Quarter quadrangle). At the top of the measured section are readily recognizable, massive beds of dolomite that may be considered the base of the Copper Ridge dolomite.

	Thickness Feet
14. Dolomite: mottled, weathering to rough surface. This bed is almost at top of exposures on west side of road; higher beds exposed on east side	3
13. Dolomite: thick-bedded, weathering to smooth surface. This and the overlying unit may be referred to the Copper Ridge dolomite	6
12. Shale	2
11. Dolomite, one bed	2
10. Shale: dark gray, hard, not fissile, with some interbedded dolomite but very little limestone	73
9. Shale: dark gray, fissile	5
8. Shale: as unit 10, but containing thin limestone beds and lenses	18
Collection cnv/21, 10 feet above base:	
Aphelaspis tarda c	
Collection cnu/21, 4 feet above base:	
Aphelaspis tarda c	
7. Shale: dark gray, fissile, with one limestone bed in middle of interval	3
6. Shale, alternating with thin-bedded limestone; more shaly in upper 5 feet	22
Collection cnu'/21, in limestone bed at top:	
Aphelaspis tarda	
5. Shale: finely fissile	3
4. Limestone, ribboned with shale or dolomite	5
3. Shale, finely fissile. Thickness approximate	20
2. Limestone, ribboned with shale or dolomite	3½
1. Shale: finely fissile, only the uppermost portion exposed. Thin limestone lenses present 20–25 feet below top	not measured
Collection cnt/21 in limestone lenses:	
Aphelaspis arsoides c	
Aphelaspis tumifrons c	
Pseudagnostus communis c	

KNOX COUNTY

Copper Ridge.—Numerous Upper Cambrian fossils in the U.S. National Museum collections were recovered from beds of the *Cedaria, Crepicephalus,* and *Aphelaspis* zones on the NW. slope of Copper Ridge near Bull Run, south of Heiskell (Powell quadrangle).

This area appears to offer now neither the opportunity for measuring good sections, nor plentiful fossils. A partial section of the Nolichucky is exposed in the cut of the Southern Railway, and some of the material of *Norwoodella walcotti* illustrated herein was collected at this locality (cnd/12). The fossils occurred in thin limestone beds in shale, and their stratigraphic position could not be referred to readily recognizable lithic units.

Mascot.—A partial section of the Nolichucky formation is exposed in a road cut on the E. side of the road leading N. from Mascot to U.S. Route 11-W. The lower limestone unit of the Nolichucky and some of the overlying shale with thin-bedded, partly conglomeratic limestone beds are exposed. Fossils of the *Crepicephalus* zone were collected from limestone beds in shale about 5 feet above the top of the massive limestone (loc. cnn/19).

MONROE COUNTY

Owing to flat topography, exposures are generally scarce in the southwestern portion of the area investigated. A partial section of the Nolichucky formation was studied by A. R. Palmer and R. H. Raymond in the bluffs on the E. bank of the Little Tennessee River, near the E. end of the bridge on U.S. Route 411. Two trilobite collections were made. Collection U.S.G.S. 2970 is from a single bed at the top of a 38-foot unit of thin-bedded, knobbly limestone; collection 2969 is from weathered siltstone about 45 feet higher. The author was able to find only fossils of the upper *Aphelaspis* zone in the higher beds.

The U.S. Geological Survey collections are interesting because they include 3 species not observed elsewhere. The list of species follows.

Collection 2969:
Dytremacephalus angulatus (complete specimens)
Collection 2970:
Aphelaspidella macropyge
Aphelaspis arses
**Aphelaspis palmeri*
Cheilocephalus, sp. undet.
**Dunderbergia longifrons*
**Dytremacephalus strictus*
Paraphelaspis vigilans

Collection 2970 may be correlated with collection cnr/4 from the Lost Creek section and collection cns/20 from the Washburn section, having in common with both *Aphelaspidella macropyge, Aphelaspis arses, Cheilocephalus* sp. undet., and *Paraphelaspis vigilans.* Thus the stratigraphic position of the three new species, *Aphelaspis palmeri, Dunderbergia longifrons,* and *Dytremacephalus strictus,* is at least approximately determined in the middle *Aphelaspis* zone.

PURCHASE RIDGE, SCOTT COUNTY, VIRGINIA

Although the section here discussed is outside of Tennessee, it was deemed worth mentioning because it is close to the State line, and occurs in the northernmost Cambrian outcrop belt in this portion of the Appalachians.

Most of the Maryville and Nolichucky formations are exposed in cuts on the road from Pattonsville to Clinchport, Scott County (Duffield quadrangle). The Nolichucky formation is mostly shale excepting the upper (Maynardville) limestone unit. The contact with the Copper Ridge dolomite is not well exposed. A partial section of the strata of the *Aphelaspis* zone in descending order follows.

	Thickness Feet	Inches
11. Limestone: in thin, often nodular beds, mostly aphanitic, ribboned with shale or dolomite	75+	
10. Limestone: similar to unit 11, but more readily weathering to separate layers	13	
Collection cnv'/7, one foot below top:		
Aphelaspis tarda c		
9. Shale, with some limestone lenses	3	
Collection cnv/7, 1 foot above base:		
Aphelaspis tarda c		
8. Limestone: thin-bedded, alternating with shale	10	
7. Shale	1	4
6. Limestone: crystalline, one bed filled with trilobite fragments		5
Collection cnu/7:		
Aphelaspis tarda cc		
Dunderbergia tennesseensis r		
5. Shale, with a few, thin limestone beds	6	
4. Limestone: thick-bedded	2	
3. Shale, with thin limestone beds	5	
2. Limestone: one bed	1	6
1. Shale, with some siltstone and limestone beds. Seemingly several hundred feet thick and extending to limestones of basal Nolichucky	not measured	
Collection cnt/7 from thin limestone lens 10 feet below top:		
Aphelaspis tumifrons cc		
Pseudagnostus communis c		

The upper (Maynardville) limestone unit of the Nolichucky shows the same lithology and faunal succession of the upper *Aphelaspis* zone as in the Big Creek section. Fossils of the lower *Aphelaspis* zone could not be found because of the unfavorable shaly lithology of the interval. The massive lower limestone of the Nolichucky present in many other sections is here lacking or greatly reduced. In most respects the lithology of the Nolichucky is very similar to that described by Hall and Amick (1934) for the Thorn Hill section.

INDEX OF LOCALITIES

CEDARIA ZONE

Collection	Quadrangle	x	y	County	Name of locality
cnc/1	Burem	325	435	Hawkins	U.S. Route 11-W
cnc/2	"	179	318	"	Big Creek
cnc/3	"	172	312	"	Big Creek
cnc/4	"	168	306	"	Big Creek
cnc/5	"	161	299	"	Big Creek
cnc/6	"	61	181	"	Rogersville
cnc/7	"	437	497	"	Forgey Creek
cnd/1	"	327	436	"	U.S. Route 11-W
cnd/2	"	343	442	"	Miller Ridge
cne/1	"	179	318	"	Big Creek
cne/2	"	168	306	"	Big Creek
cnb/10, cnd/10, cne/10	Howard Quarter	16	151	Claiborne	Comby Ridge
cne/12	Powell	249	248	Knox	Copper Ridge
cne/13	Avondale	227	560	Grainger	Thorn Hill
U.S.G.S. 2407	Howard Quarter	= cnd/10		Claiborne	Comby Ridge
U.S.G.S. 2406	" "	= cnb/10		"	Comby Ridge

CREPICEPHALUS ZONE

Collection	Quadrangle	x	y	County	Name of locality
cnk/1	Burem	68	171	Hawkins	Rogersville
cnk/3	"	172	295	"	Big Creek
cnm/2, cnm/3	"	58	165	"	Rogersville
cnn/1	"	68–73	171–174	"	Big Creek
cnn/2	"	13	127	"	Rogersville
cnn/3	Pressmens Home	367	52	"	Crockett Creek
cnn/4	Jefferson City	91	408	Jefferson	Lost Creek
cnn/5	New Market	295	237	"	Piedmont Road
cnn/14	" "	140	191	"	Russell Gap
cnm/15, cnn/15	Russellville	305	260	Hamblen	Three Springs
cnn/16	Luttrell	353	270	Grainger	Smith Hollow
cnn/17	Maynardville	50	129	Union	Hurricane Hollow
cnn/19	Mascot	14	403	Knox	Mascot
cnm/20, cnm'/20, cnn/20	Dutch Valley	98	266	Grainger	Washburn

APHELASPIS ZONE

Collection	Quadrangle	x	y	County	Name of locality
cns/1–cnx/1	Burem	180–183	290–296	Hawkins	Big Creek
cns/2	New Market	292	235	Jefferson	Piedmont Road
cnq/4–cnt/4	Jefferson City	91–94	411	"	Lost Creek
cnt/7–cnv/7	Duffield, Va.	194	277	Scott	Purchase Ridge

cno/14–cnq/14	New Market	138–141	190–193	Jefferson	Russell Gap
cnw/14	" "	142	188	"	Russell Gap
cno/15–cnv/15	Russellville	305–312	260–257	Hamblen	Three Springs
cnq/16–cns/16	Luttrell	354	271	Grainger	Smith Hollow
cnp/17–cnr/17	Maynardville	50	129	Union	Hurricane Hollow
cnp/20–cnx/20	Dutch Valley	98	266–263	Grainger	Washburn
cnt/21–cnv/21	Howard Quarter	137	141–139	Claiborne	River Ridge
U.S.G.S. 2969–70	Vonore	144	481	Monroe	Little Tennessee River

FAUNA OF THE *CEDARIA* ZONE

Fossils of the *Cedaria* zone occur in the uppermost portion of the Maryville limestone (only in the Rogersville area) and in the basal part of the Nolichucky formation. At all the localities studied, an unfossiliferous interval in the Nolichucky shale separates the uppermost beds carrying a *Cedaria* fauna from the lowermost beds holding a *Crepicephalus* zone fauna. Hence assemblages transitional between the two faunizones, as reported by Lochman and Duncan (1944) from Montana and Palmer (1954) from Texas, have not been observed.

The oldest Upper Cambrian faunule seems to be the one occurring in the uppermost 10–30 feet of the Maryville limestone in the Rogersville outcrop belt. The corresponding interval was examined at several other localities but yielded no fossils. Collections were made at several localities in the vicinity of Rogersville (author's collections cnc/1 to cnc/7; U.S.N.M. localities 102a, 123a). The species known from these beds are listed below. An asterisk preceding the name indicates that the types were collected from this area and horizon.

**Bonneterrina appalachia*
**Coenaspis spectabilis*
**Coosella andreas*
Genevievella, sp. undet.
**Hawkinsia minuta*
**Holcacephalus praecursor*
Ithycephalus typicalis
Kormagnostus simplex
**Menomonia tuberculata*
Menomonia, sp. undet.
**Modocia crassimarginata*
Modocia dubia
**Modocia ? agatho*
Norwoodella, sp. undet.
Norwoodia, sp. undet.
Tricrepicephalus, sp. undet.

The next higher faunule is especially well represented in the red limestone beds at the base of the Nolichucky, of very limited extent

in the Rogersville area as previously discussed (author's localities cnd/1, cnd/2; U.S.N.M. locality 27d). The faunule from these beds, excluding a few unrecognizable forms named by Resser, includes:

**Ankoura triangularis*
Bonneterrina appalachia
Cedarina, sp. undet.
**Coosella resseri*
Genevievella, sp. undet.
**Holcacephalus granulatus*
**Ithycephalus typicalis*
**Kormagnostus simplex*
**Loxoparia obliqua*
**Menomonia prominens*
**Modocia bidentata*
Modocia crassimarginata
**Modocia dubia*
Norwoodella saffordi
**Norwoodella rotundicollis*
**Norwoodia rogersvillensis*
Tricrepicephalus, sp. undet.

In the equivalent stratigraphic position in other parts of the Rogersville outcrop belt, the basal beds of the Nolichucky consist of the usual gray-green shale with rare lenses of crystalline limestone (author's localities cne/1, cne/2; U.S.N.M. localities 103, 124). The species collected from these beds include:

Genevievella, sp. undet.
Kormagnostus simplex
Menomonia prominens
**Norwoodella saffordi*

Outside of the immediate vicinity of Rogersville, fossils of the *Cedaria* zone occur in Tennessee chiefly in the northwestern portion of the Cambrian outcrop area, in the belts N. of Clinch Mountain from Forked Deer Creek (Thorn Hill section) to Heiskell W. of Knoxville. Trilobites occur at scattered localities, usually either in shale or in a coarse, glauconitic calcarenite where most of the tests have been ground to unrecognizable fragments. Very little information about the faunal succession can be determined from these occurrences. Species collected from several localities are listed below.

Seemingly the oldest Upper Cambrian fossils occur in U.S.G.S. collection 2406 (= author's collection cnb/10), where the following species were identified:

Ankoura triangularis
Kormagnostus simplex
Olenoides, sp. undet.

The most striking fossil is the *Olenoides,* unfortunately known only from fragmentary pygidia. Notwithstanding the presence of this predominantly Middle Cambrian genus, the abundance of *Ankoura* and *Kormagnostus* suggests about the same age as the red beds at the base of the Nolichucky in the Rogersville area.

Faunules collected from the Comby Ridge localities (cnd/10 = U.S.G.S. collection 2407, cne/10), Thorn Hill (cne/13), and Copper Ridge (cne/12) yielded:

Ankoura triangularis
Cedaria tennesseensis
Kormagnostus simplex
Menomonia, sp. undet.
Norwoodella halli
Norwoodella walcotti

This faunule is presumably somewhat younger than any of those of the *Cedaria* zone collected from the vicinity of Rogersville.

FAUNA OF THE *CREPICEPHALUS* ZONE

In all the sections studied, an unfossiliferous interval separates the youngest observed faunule of the *Cedaria* zone from the oldest fossils of the *Crepicephalus* zone. The lower and middle portions of the Nolichucky formation are in general sparingly fossiliferous, being represented either by shales with siltstone beds, or in part by the massive lower limestone member. Only when either the shales contain fairly pure, crystalline limestone layers, or the massive limestone is partly replaced by a thin-bedded limestone, may well-preserved fossils be expected. These conditions occur erratically at different localities, hence a single section seldom supplies a succession of several faunules, and it is difficult to place those collected in different areas in proper stratigraphic order. In general, the beds of the *Crepicephalus* zone become more fossiliferous upward, the richest in most sections being those that just underlie the *Aphelaspis* zone.

Probably the earliest fossils of the *Crepicephalus* zone collected in the area are those from near the base of the lower limestone member occurring in the vicinity of Rogersville (collections cnk/1, cnk/3). The species include:

**Blountia alexas*
Blountia montanensis
**Coosella planicauda*
Coosella, sp. undet.
**Crepicephalus convergens*
Dresbachia amata
**Kingstonia inflata*
Maryvillia arion

**Meteoraspis brevispinosa*
Tricrepicephalus thoosa
Undetermined cranidium No. 2

Most of these species are represented in higher beds except *Blountia alexas* and *Meteoraspis brevispinosa,* which were not found in the highly fossiliferous, higher portions of the same limestone unit. *Maryvillia arion* is very rare in the above faunule, whereas it becomes abundant in higher beds.

A rather large faunule was collected near Rogersville, a short distance from locality cnk/1, in beds approximately 45 feet below the top of the lower limestone unit of the Nolichucky, hence about 90 feet above the beds cnk/1. At other localities no fossils were observed at this horizon. The faunule (collection cnm/2) includes:

Blountia arcuosa
Blountia montanensis
Coosella planicauda
Coosia alethes
Coosina amage
Coosina ariston
Dresbachia amata
Kingstonia inflata
Llanoaspis walcotti
Madarocephalus laetus
Maryvillia arion
Meteoraspis mutica
Tricrepicephalus thoosa

Finally, the youngest faunule of the *Crepicephalus* zone is well represented at numerous localities. It occurs either near the top of the massive lower limestone unit of the Nolichucky, or in thin limestone beds near the base of the overlying shale. The transition between the *Crepicephalus* and *Aphelaspis* zones may occur either within the upper portion of the limestone unit, or within the lower part of the overlying shale. In some sections, such as at Big Creek, it is possible that the faunizone boundary coincides with the lithologic contact. The species observed at localities cnn/1, cnn/2, cnn/3, cnn/4, cnn/5, cnn/14, cnn/15, cnn/16, cnn/17, cnn/19, and cnm′/20 are listed below. These collections are lumped together, since age differences between them appear insignificant.

Amiaspis erratica
**Amiaspis obsolescens*
**Blountia arcuosa*
Blountia lata
Blountia montanensis
Blountiella, sp. undet.
Coosella, sp. undet.

Coosia alethes
Coosia robusta
Coosia, sp. undet.
Coosina ariston
Coosina, sp. undet.
Crepicephalus buttsi
Crepicephalus cf. *convergens*
Crepicephalus cf. *scissilis*
Crepicephalus, sp. undet. No. 1
Crepicephalus, sp. undet. No. 2
Kingstonia inflata
Llanoaspis walcotti
**Maryvillia arion*
Meteoraspis mutica
Meteoraspis, sp. undet.
Pemphigaspis, sp. undet.
Terranovella dorsalis
**Tricrepicephalus thoosa*
Undet. cranidium No. 1

Fossils from the U.S.N.M. localities 24m, 104, 121a, 123b, 125 and 125a were certainly all collected in the Rogersville area from the lower limestone member of the Nolichucky formation, hence from the horizons here designated cnk, cnm, and cnn.

FAUNA OF THE *APHELASPIS* ZONE

The faunal succession in the *Aphelaspis* zone is particularly well developed in Tennessee and was studied in great detail in several sections.

At some of the localities there is no gap in fossiliferous beds between the *Crepicephalus* and *Aphelaspis* zones, hence the change from one fauna to the other could be thoroughly investigated. It was shown in the preceding section that the latest *Crepicephalus* zone faunule is characterized by species of *Coosia, Crepicephalus, Tricrepicephalus, Blountia,* and *Kingstonia,* in addition to *Maryvillia arion* and *Terranovella dorsalis.* Other genera, such as *Amiaspis* and *Llanoaspis,* are occasionally present. At Russell Gap, a faunule that is considered to belong in the *Aphelaspis* zone appears about 3 feet above the typical *Crepicephalus* fauna, in a succession of massive limestone beds of uniform lithology. This basal *Aphelaspis* zone faunule (loc. cno/14) yielded several species of trilobites representing a holdover of *Crepicephalus* zone forms with the addition of new elements, which had certainly evolved elsewhere since no possible immediate ancestors occur in the local *Crepicephalus* fauna. The *Crepicephalus* zone genera *Tricrepicephalus,* represented by an undetermined species, and *Coosella,* represented by *Coosella perplexa,* are associated with the typical *Aphelaspis* zone forms *Aphelaspis* cf. *A. lata* and *Cheilocephalus*

brevilobus. Further members of the faunule are *Blountia bristolensis* and *Glaphyraspis parva. Blountia bristolensis* was not found in the *Crepicephalus* zone but is there represented by the very similar *Blountia montanensis. Glaphyraspis* was not found in Tennessee below the *Aphelaspis* zone. However, the author collected cranidia attributed to *G. parva* in a late *Crepicephalus* zone faunule from northeastern Virginia (Rasetti, 1961).

In the Hurricane Hollow section, also, an interval of a few feet separates the uppermost *Crepicephalus* zone faunule from the earliest *Aphelaspis* zone faunule in a uniform succession of massive limestone beds. Here, however, the only remnant of the *Crepicephalus* fauna is the genus *Blountia,* represented again by *B. bristolensis.* It is associated with *Aphelaspis transversa* and *Cheilocephalus brevilobus.*

The transition between the two faunizones is excellently shown in the Three Springs section. Here the rock at this level is mostly shale with thin fossiliferous limestone beds and lenses. The earliest *Aphelaspis* zone faunule (loc. cno/15) is essentially the same as at Russell Gap, holding in great abundance *Aphelaspis buttsi* and *Glaphyraspis parva,* with rare specimens of *Coosella perplexa.*

At all these localities, *Coosella* is absent from higher beds, while *Blountia* and *Glaphyraspis* continue in association with different species of *Aphelaspis.* In this portion of the section faunal changes may occur within a few feet of beds, and very accurate determinations of the relative positions of beds and lenses are required to avoid mixing forms that do not occur together. In the field every single lens was labeled separately and its stratigraphic position carefully recorded. In the Russell Gap and Three Springs sections, a characteristic faunule (locs. cnp/14, cnp/15) including innumerable remains of *Aphelaspis lata,* a close relative of *A. buttsi,* occurs a few feet above the faunule described above. Associated species are *Blountia bristolensis, Cheilocephalus brevilobus,* and *Glaphyraspis ornata.* This faunule is well represented also in the Washburn section (loc. cnp/20).

In the Three Springs section, in a thin bed 1 foot higher, *Aphelaspis walcotti* appears in association with *A. lata.* This is an unusually early occurrence of that species which is more common in higher strata. Still 6 inches higher, another species of *Aphelaspsis, A. minor,* makes its appearance in the Three Springs section and is also common in the equivalent position in the Russell Gap and Hurricane Hollow sections (locs. cnq/15, cnq/14, cnq/17). Associated forms, as in the underlying faunule, are *Blountia bristolensis, Cheilocephalus brevilobus,* and *Glaphyraspis ornata.*

The next higher faunule, known from a number of sections, is characterized by *Aphelaspis walcotti,* the type species of the genus. The

stratigraphic position of the type collection from Saltville, Va., is unknown, but in Tennessee the species was found to occur always in the same relative position to other forms of *Aphelaspis,* excepting the unusually early occurrence mentioned above. It was collected at Three Springs (cnr/15), Smith Hollow (cnq/16, cnr/16), Lost Creek (cnq/4), Hurricane Hollow (cnr/17 = Oder's coll. No. 2), and Washburn (cnq/20). Associated species are *Glaphyraspis declivis, G. oderi,* and *Blountia mimula,* the last found only at Hurricane Hollow.

This is the latest known occurrence of *Blountia* in Tennessee. In view of this fact and other faunal changes, it seems proper to designate the strata so far discussed as the lower portion of the *Aphelaspis* zone.

The overlying beds, here assigned to the middle *Aphelaspis* zone, hold various faunules characterized by several species of *Aphelaspis* and related genera. These assemblages do not appear exactly in the same order in the different sections, hence we may assume that they are essentially of the same age. In the Washburn section, the earliest of these faunules (collection cnq′/20) consists of *Aphelaspis washburnensis* and *Glaphyraspis declivis.* This is followed by an assemblage of *Aphelaspis camiro, A. laxa,* and *A. quadrata,* recognized at several localities (U.S.N.M. locality 120, Shields Ridge; cns/15, cns′/15, Three Springs; cns/16 (= Oder's collection No. 13), Smith Hollow; cnr/20, cnr′/20, Washburn). The Washburn section yields from somewhat higher beds (cns/20) a very characteristic assemblage of *Aphelaspidella macropyge, Aphelaspis arses, A. rotundata,* and *Paraphelaspis vigilans.*

However, at Lost Creek we encounter in ascending order a bed with rare *Aphelaspis* cf. *laxa* (cnq′/4), followed by one with *A. rotundata* (cnq″/4). Above the latter are limestone beds (cnr/4, cnr′/4) with an abundance of *Aphelaspidella macropyge,* accompanied by *Aphelaspis arses, Aphelaspis* cf. *lata, Cheilocephalus* sp., and *Paraphelaspis vigilans.* The still higher beds cns/4 yielded rare *Aphelaspis camiro* and *A. laxa,* in addition to other species to be mentioned later. In the Three Springs section, above a bed (cnr′/15) with *Aphelaspis laxa,* collection cns/15 yielded *Aphelaspis camiro, A. laxa, A. quadrata, A. washburnensis,* and *Aphelaspis,* sp. undet. (the last two not associated in the same stratum with the other three). The still higher beds cns′/15 and cns″/15 yielded *Aphelaspidella macropyge, Aphelaspis arses, A. rotundata,* and *Paraphelaspis vigilans.* These findings indicate that although the *Aphelaspis camiro–laxa–quadrata* and the *Aphelaspidella macropyge–Aphelaspis rotundata–Paraphelaspis vigilans* assemblages were never observed in the same bed, each may occur either below or above the other.

An approximate equivalent of the last-mentioned assemblage is the one collected from Monroe County (U.S.G.S. collection 2970) with *Aphelaspidella macropyge, Aphelaspis arses, A. palmeri, Cheilocephalus,* sp., *Dunderbergia longifrons, Dytremacephalus strictus,* and *Paraphelaspis vigilans.*

In Jefferson County, lenses at the previously mentioned locality cns/4 also yield *Aphelaspis arses* and *A. inermis,* both also present in collection cns/2, accompanied by *Cheilocephalus* sp. and *Pseudagnostus communis.*

Above these faunules appears a widespread assemblage characterized in all sections where it is known by innumerable examples of *Aphelaspis tumifrons.* It was collected from Big Creek (cns/1, cnt/1), Lost Creek (cnt/4), Shields Ridge (cns/2), Three Springs (cnt/15, cnt′/15), Smith Hollow (Oder's coll. No. 14), Washburn (cnt/20, cnt′/20), River Ridge (cnt/21), and Purchase Ridge, Va. (cnt/7). Here should be mentioned the exceptional occurrence at Lost Creek in the collection cnt/4 of very rare specimens of *Dytremacephalus angulatus,* a species that becomes common in strata of the upper *Aphelaspis* zone. Normal associates of *Aphelaspis tumifrons* are instead *Aphelaspis arsoides, Cheilocephalus* sp., and *Pseudagnostus communis.*

The beds above the *Aphelaspis tumifrons* faunule and up to the top of the fossiliferous sequence, i.e., to the top of the Nolichucky formation (or Maynardville limestone), shall be assigned to the upper *Aphelaspis* zone. One faunule seems to occupy this interval, covering in the Big Creek section about 70 feet of strata, and the characteristic species are *Aphelaspis tarda* and *Dytremacephalus angulatus.* Less frequent and widespread are *Aphelaspis punctata, Cheilocephalus brachyops, Dunderbergia tennesseensis,* and the rare *Dytremacephalus sulcifrons.* This *Aphelaspis tarda* faunule was collected at Big Creek (cnu/1, cnv/1, cnw/1, cnx/1), Purchase Ridge (cnu/7, cnv/7, cnv′/7), Russell Gap (cnw/14), Three Springs (cnu/15, cnv/15), Smith Hollow (Oder's coll. No. 14A), Washburn (cnw/20, cnx/20), and River Ridge (cnu/21, cnv/21).

In Tennessee all the higher fossiliferous beds of the Nolichucky, up to the top of the formation, have been assigned to the *Aphelaspis* zone, since the faunules are very homogeneous, being dominated by species of *Aphelaspis.* However, the younger of these faunules may be equivalent to faunules attributed by Palmer to post-*Aphelaspis* zones in the western sections (see later discussion).

It seems likely that the vertical distribution of genera and species described above does not mean that each species only lived for the short time span indicated by the thickness of beds through which it was

collected. Two examples, the presence of *Aphelaspis* cf. *lata* at an unusually high horizon in collection cnr/4, and the early occurrence of *Dytremacephalus angulatus* in collection cnt/4, probably indicate that while at a given locality each species was abundant for only a very limited time, it may have lived at different times at other places. The inversion of the order of the *Aphelaspis camiro* and *Aphelaspis rotundata* assemblages, observed in two sections, even though it does not involve a considerable thickness of strata, is another indication that the presence or absence of a species at a certain level may have little time significance, being determined rather by some ecologic factor, or simply a historical accident.

Even considering these restrictions to its validity, it is clear that the above-discussed succession of *Aphelaspis* faunules is the best documented in the entire Cambrian of the Appalachians and may allow the stratigrapher to correlate new sections with great precision. As it will be pointed out in the discussion of *Aphelaspis,* a species of that genus may not be identifiable from a single individual, even if perfectly preserved, much less from weathered or flattened material. Fortunately, however, the strata of the *Aphelaspis* zone, and especially thin, crystalline limestone lenses in shale, may be so fossiliferous that a small sample of rock in many cases supplies sufficient information for the clear recognition of one of the faunules described herein.

In view of the relatively meager knowledge of the biostratigraphy of the *Aphelaspis* zone in North America and of the observed transition between the *Crepicephalus* and *Aphelaspis* faunas, a comparison with recent findings in other areas is of interest. A detailed study of the distribution of genera and species of trilobites near and above the *Crepicephalus–Aphelaspis* zone boundary was made by Palmer (1954, 1962b) in Alabama, central Texas, and Nevada. His main conclusions, derived from the study of the faunal succession in the Conasauga formation at Woodstock and Cedar Bluff, Ala., and in the uppermost part of the Hamburg limestone and the overlying Dunderberg shale at several localities in Nevada, may be thus summarized: (1) There is a sudden change, often occurring in a few feet of strata, from a faunule containing trilobite genera of the *Crepicephalus* zone ("Crepicephalid biofacies") to a faunule with *Aphelaspis* and other trilobites of the *Aphelaspis* zone ("Pterocephaliid biofacies"). (2) This change in Nevada coincides with the contact between the relatively pure, massive Hamburg limestone and the interstratified siltstone and silty limestone beds of the overlying Dunderberg formation. (3) Notwithstanding the great faunal change, no appreciable hiatus is believed to be involved. (4) The replacement of the Crepicephalid biofacies with the Pterocephaliid biofacies is believed not to have been synchronous every-

where, but to have taken place earlier in the geosynclinal areas and to have spread later toward the interior of the continental shelf. Hence the use of the term "biofacies" rather than faunizones. (5) The uppermost faunule attributed to the Crepicephalid biofacies at McGill, Nev., and a similar faunule collected at Woodstock, Ala., include *Cedaria prolifica,* the type species, or related forms of *Cedaria.* If the interpretation is correct, the type species of *Cedaria* would be a trilobite of the *Crepicephalus* rather than the *Cedaria* zone.

In a second, more extensive paper on the Upper Cambrian faunas of Nevada, Palmer (1965)[1] recognizes in ascending order the *Aphelaspis, Dicanthopyge, Prehousia, Dunderbergia,* and *Elvinia* zones, all belonging to a Pterocephaliid "biomere." The validity of some of these zones may be limited to the Great Basin.

The observations in Tennessee show several features in common with the faunal development in Nevada. The change from the *Crepicephalus* to the *Aphelaspis* fauna is equally sudden, and the writer has already expressed agreement with Palmer's conclusion that most of the trilobites of the *Aphelaspis* fauna have no immediate ancestors in the *Crepicephalus* fauna; hence the change occurred by immigration of a new fauna that had been evolving elsewhere, presumably in geosynclinal areas. In Tennessee the faunal change may occur either within the lower, massive limestone member of the Nolichucky formation, or coincide with the contact between this limestone unit and the overlying shale with interbedded, thin limestone beds and lenses; or it may occur within the latter lithologic unit. In any case there is no evidence whatever that the faunal change is associated with a hiatus.

The earliest *Aphelaspis* faunule observed in Tennessee has species identical with or closely related to some of the earliest species of the Pterocephaliid biofacies found by Palmer in Nevada. In particular, *Aphelaspis buttsi* is the earliest species of the genus appearing both at McGill, Nev., and in the Three Springs section in Tennessee. Instead, no very close relationship appears between the youngest faunules of the Crepicephalid biofacies observed in Nevada and Tennessee; only the genus *Coosia* seems common to both. This fact might be indicative of the presence of a hiatus in the Nevada sections.

It becomes more difficult to correlate younger faunules from Tennessee with those of the Nevada sections. Several *Aphelaspis* species described from Nevada, *A. brachyphasis, haguei, subditus,* and *longispina,* all closely resemble species from Tennessee, but in view of the fact that in either region species of *Aphelaspis* of rather different ages

---

[1] The writer is indebted to Dr. Palmer for reading the manuscript before publication.

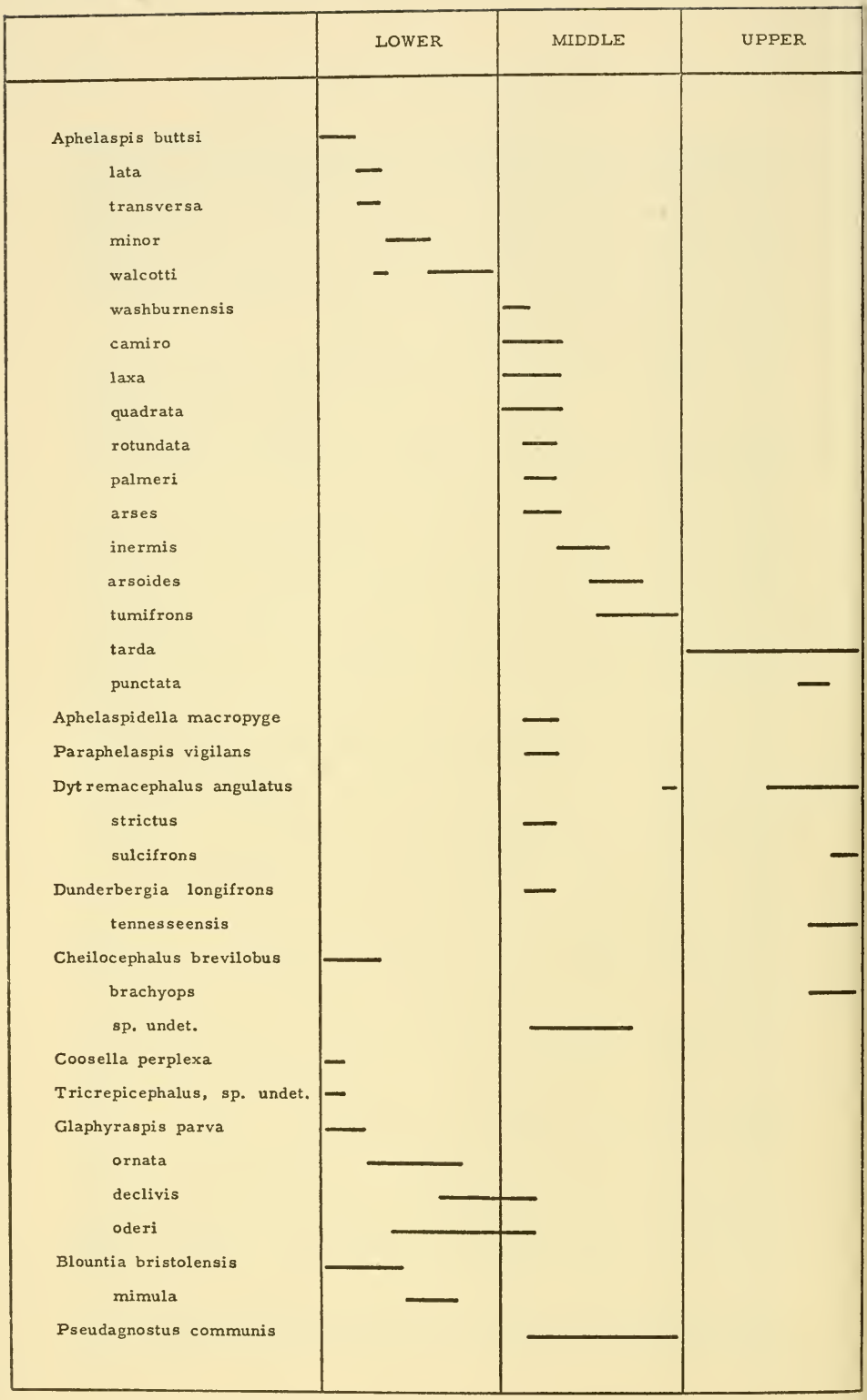


FIG. 1.—Range of trilobite species in the *Aphelaspis* zone of Tennessee.

may be extremely similar (e.g., in Tennessee the early species *A. walcotti* resembles the late species *A. tarda*), not much time significance can be attributed to such similarities. In Nevada, Palmer finds *Tumicephalus* (based on a species almost identical with *Aphelaspis tumifrons*) in the post-*Aphelaspis, Dicanthopyge* zone, species of *Dytremacephalus* in the still younger *Prehousia* and *Dunderbergia* zones, *Cheilocephalus brachyops* and various species of *Dunderbergia* in the *Dunderbergia* zone. These findings might be taken to indicate that part of the middle *Aphelaspis* zone and all of the upper *Aphelaspis* zone of this paper are equivalent to portions of Palmer's post-*Aphelaspis* zones in Nevada. On the other hand, these latter zones are characterized by a large number of genera of Pterocephaliid trilobites never observed in Tennessee. Hence it is difficult to decide what fauna in Nevada is the equivalent of the youngest *Aphelaspis* faunule from Tennessee, the *Aphelaspis tarda* faunule, which occurs in the uppermost beds of the Nolichucky formation. Perhaps the evidence favors equivalence to part of the *Prehousia* or *Dunderbergia* zones in Nevada.

Even in the lower part of the *Aphelaspis* zone several genera present in the early *Aphelaspis* fauna in Alabama and Nevada were not found in Tennessee. Conspicuous among these are *Glyptagnostus* and other agnostid genera, and the Pterocephaliid genus *Olenaspella,* indistinguishable from *Aphelaspis* in the cranidial features but characterized by the development of one or more pairs of marginal pygidial spines. Apparently these trilobites are more characteristic of the geosynclinal facies and never migrated far enough within the continental shelf to reach northeastern Tennessee. Absence of trilobites of the geosynclinal facies is a feature of both the *Crepicephalus* and *Aphelaspis* faunas.

The observations in Tennessee bear no evidence on the question whether the replacement of the *Crepicephalus* fauna with the *Aphelaspis* fauna was simultaneous or not in different areas, since the localities studied are all within a narrow belt parallel to the margin of the geosyncline.

In Tennessee no occurrence of *Cedaria* or other genera of the *Cedaria* zone close to the base of the *Aphelaspis* zone, or even a few hundred feet below this level, was ever observed. This fact may again be related to the "cratonic" rather than geosynclinal environment prevailing through the entire Upper Cambrian in Tennessee.

PART II. SYSTEMATIC PALEONTOLOGY

GENERAL STATEMENT

Not all the species of trilobites described from the Upper Cambrian of Tennessee are treated in this paper. With few exceptions, only those collected by the author from measured sections and hence contributing to the knowledge of the faunal succession are discussed herein.

Type catalog numbers and type localities for previously described species are given only when the types are from the southern Appalachians.

Unless otherwise stated, all the described and illustrated specimens are preserved in limestone, and show the outer surface of the test, on which the description is based.

The author's localities are often given only by their numbers in this descriptive part; their topographic position may be readily identified from the locality list, the stratigraphic position from the descriptions of the sections.

All the types and other figured specimens collected by the writer were deposited in the U.S. National Museum collections. All the Museum numbers beyond 144000 are listed in Paleozoic catalog No. 30.

DESCRIPTIONS OF TRILOBITE GENERA AND SPECIES

Order AGNOSTIDA

Family AGNOSTIDAE McCoy, 1849

Genus KORMAGNOSTUS Resser, 1938

Type species.—*Kormagnostus simplex* Resser.

KORMAGNOSTUS SIMPLEX Resser

Plate 1, figures 8, 9

Kormagnostus simplex Resser, 1938a, p. 49, pl. 9, figs. 11–13.
Kormagnostus harlanensis Resser, 1938a, p. 49, pl. 10, figs. 11, 12.
Kormagnostus simplex Resser, Palmer, 1954, p. 718, pl. 76, figs. 8–12 (includes complete synonymy).
Kormagnostus simplex Resser, Lochman and Hu, 1960, p. 822, pl. 99, figs. 5–31.

Common almost everywhere in the fossiliferous beds at the top of the Maryville limestone and the overlying basal Nolichucky shale (*Cedaria* zone).

Occurrence.—Type locality for *K. simplex* is U.S.N.M. 27d (= author's locality cnd/1); red beds at the base of the Nolichucky E. of Rogersville. Type locality for *K. harlanensis* is U.S.N.M. locality

124, presumably near the top of the Maryville limestone and identical with one of the author's localities, cnc/2 to cnc/5. Collected by the author at localities cnc/5, cnc/6, cnd/1, cnd/2, cne/1, cne/2, cnb/10, cnd/10, cne/10, cne/13.

Types.—Cotypes of *K. simplex:* U.S.N.M. 94842. Cotypes of *K. harlanensis:* U.S.N.M. 94863. Plesiotypes figured herein: U.S.N.M. 144546.

Genus PSEUDAGNOSTUS Jaekel, 1909

Type species.—*Agnostus cyclopyge* Tullberg.

PSEUDAGNOSTUS COMMUNIS (Hall & Whitfield)

Plate 10, figures 23–25

Agnostus communis Hall and Whitfield, 1877, p. 228, pl. 1, figs. 28, 29.
Agnostus neon Hall and Whitfield, 1877, p. 229, pl. 1, figs. 26, 27.
Pseudagnostus communis (Hall and Whitfield) Palmer, 1955, p. 94, pl. 19, figs. 16, 19–21; pl. 20, figs. 4–11, 14; 1960, p. 61, pl. 4, figs. 3, 4.
Pseudagnostus communis (Hall and Whitfield) Rasetti, 1961, p. 109, pl. 23, figs. 13–17.

A *Pseudagnostus* that occurs at several localities in beds of the *Aphelaspis* zone does not differ in any observable features from topotype material illustrated by Palmer. The latter is from the *Dunderbergia* zone of Nevada. The author (Rasetti, 1961) figured specimens from the *Dunderbergia* zone of Maryland.

Occurrence.—Collected at localities cnt/1, cns/2, cns/4, cnt/4, cnt/7, cns/15, cnt/15. All these collections are from the middle portion of the *Aphelaspis* zone.

Types.—Plesiotypes: U.S.N.M. 144547.

Order CORYNEXOCHIDA

Family DORYPYGIDAE Kobayashi, 1935

Genus OLENOIDES Meek, 1877

Type species.—*Paradoxides nevadensis* Meek.

OLENOIDES, species undetermined

Plate 5, figures 12, 13

Available material.—Two fragmentary pygidia.

Description.—Pygidium fully typical of the genus, of the four-spined group. Axis not preserved except for the terminal portion, almost reaching the posterior margin. Pleural regions of low convexity. Three pairs of pleural furrows and as many of interpleural grooves about equally impressed, regularly curved, all becoming somewhat deeper in the indefinite border furrow; each interpleural groove approximately parallel to the preceding furrow but diverging from the following fur-

row. Spines progressively closer to each other; those of the first two pairs strong, the last two progressively more slender. Spines of last pair directed straight backward, their distance greater than between the third and fourth pairs. Surface of test smooth.

Discussion.—This form, as far as can be ascertained from the fragmentary material, does not greatly differ from several Middle Cambrian species of the genus, such as *O. curticei* Walcott, and *O. convexus* Rasetti, but is readily distinguished by the course of the pleural furrows and the spacing of the marginal spines. The writer (Rasetti, 1946) described a Dresbachian species of the genus which, however, has only 3 pairs of marginal spines.

Occurrence.—U.S.G.S. collection 2406 (= author's collection cnb/10), Comby Ridge. The species occurs in the same piece of rock with abundant *Ankoura triangularis*.

Disposition of material.—Figured specimens: U.S.N.M. 144548.

Order PTYCHOPARIIDA

Family LONCHOCEPHALIDAE Hupé, 1953

Genus TERRANOVELLA Lochman, 1938

Type species.—*Terranovella obscura* Lochman.

TERRANOVELLA DORSALIS (Hall)

Plate 6, figure 7

Conocephalites? (Arionellus?) dorsalis Hall, 1863, p. 222.
Ptychoparia dorsalis (Hall) Vogdes, 1890, p. 141.
Lonchocephalus sospita Walcott, 1916a, p. 195, pl. 36, figs. 1, 1a.
Terranovella buttsi Resser, 1938a, p. 100, pl. 15, figs. 22–26.
Terranovella dorsalis (Hall) Raasch and Lochman, 1943, p. 234, pl. 35, figs. 3–10, 17.
Terranovella dorsalis (Hall) Rasetti, 1961, p. 118, pl. 22, figs. 7–13.

Occurrence.—Type locality for *T. buttsi* is U.S.N.M. 35s, near Abingdon, Va. Collected by the author in the uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at localities cnn/1, cnn/14, cnn/15, cnn/19, and cnn/20.

Types.—Holotype of *T. buttsi:* U.S.N.M. 94984. Plesiotype: U.S.N.M. 144549.

Genus GLAPHYRASPIS Resser, 1937

Type species.—*Liostracus parvus* Walcott.

GLAPHYRASPIS PARVA (Walcott)

Plate 10, figures 9–17

Liostracus parvus Walcott, 1899, p. 463, pl. 65, fig. 6.
Glaphyraspis parva (Walcott) Resser, 1937, p. 12.
Raaschella occidentalis Lochman, in Lochman and Duncan, 1944, pl. 43, pl. 4, figs. 1–5.

Glaphyraspis parva (Walcott) Rasetti, 1961, p. 112, pl. 22, figs. 14–17.
Glaphyraspis parva (Walcott) Lochman and Hu, 1962b, p. 438, pl. 68, figs. 7–52.

A form that occurs in the transition beds between the *Crepicephalus* and *Aphelaspis* zones is referred to the species. The cranidia are somewhat variable both in shape and ornamentation. The glabella is typically parallel-sided, but in some individuals it is slightly tapered and proportionately shorter and wider. The depth of the glabellar furrows is also variable. The ornamentation of the type material from Yellowstone National Park consists of a dense, extremely fine granulation plus scattered, larger granules. Some of the individuals from Tennessee match this type of ornamentation; others show granules of one size, while some are almost smooth. All these features may be found in specimens from a single piece of rock, hence they must be ascribed to intraspecific variability.

Occurrence.—The illustrated material is from locality cno/15, Three Springs. Also collected at locality cno/14, Russell Gap. At both localities it occurs below the beds yielding other species of *Glaphyraspis.*

Types.—Plesiotypes: U.S.N.M. 144550.

GLAPHYRASPIS ORNATA (Lochman)

Plate 10, figure 8; plate 11, figures 13, 14

Raaschella ornata Lochman, 1938, p. 82, pl. 18, figs. 6–10.
Raaschella ornata Lochman, Palmer, 1954, p. 767, pl. 98, figs. 7–9.
Glaphyraspis ornata (Lochman) Rasetti, 1961, p. 112.

The species is not rare in the basal beds of the *Aphelaspis* zone. Complete specimens in shale collected by Dr. Oder, one of which is illustrated herein, show that the thorax has 8 segments. The axial rings have no nodes or spines. The pleurae are flat, straight, and uniformly furrowed for most of their course. Near the distal end they bend backward and downward and possess the peculiar ridges previously observed in the pygidium.

Occurrence.—Author's localities cnp/14, cnq/14, cnq/15, cnq/16, cnr/16, cnq/17. Also in Oder's collection No. 3 at Hurricane Hollow and U.S.G.S. collection 2804 on Shields Ridge.

Types.—Plesiotypes: U.S.N.M. 144551–2.

GLAPHYRASPIS ODERI Rasetti, new species

Plate 10, figures 18–22

Available material.—Numerous cranidia, free cheeks, and pygidia well preserved in limestone.

Description.—Glabella of same shape as in *G. ornata;* glabellar furrows of usual pattern but exceedingly shallow on outer surface.

Occipital furrow well impressed; occipital ring expanded medially, rounded. Fixed cheeks convex, rising somewhat above axial furrow, then downsloping. Frontal area short, about one-fifth the glabellar length; border narrow and poorly defined by a shallow border furrow. Ocular ridges faint, transverse in direction; palpebral lobes narrow and short, in advance of glabellar midpoint. Posterior area as in type species, steeply downsloping, well furrowed. Free check with border well defined anteriorly, poorly marked posteriorly; genal angle rounded.

Pygidium with long axis, showing about 4 distinct rings, reaching the posterior margin. Pleural platforms flat; border downsloping. Pleural and interpleural furrows both well marked. Each segment has the characteristic distal ridge as in other species.

Surface of cranidium in most of the specimens from the type locality with scattered tubercles only in certain areas, more apparent on the posterior portion of the fixed cheeks, almost lacking on the glabella. Some of the cranidia appear entirely smooth, particularly among those from collection cnq/20, and especially from the higher collection cnr'/20. However, smooth and granulated cranidia occur on the same piece of rock, and there are all intermediate forms.

Length of largest cranidium 3.0 mm.; length of largest pygidium 1.8 mm.

Discussion.—This species resembles both *G. parva,* from which it differs in the somewhat wider and shorter glabella, and *G. ornata,* from which it can be separated by the much weaker ornamentation.

Occurrence.—The types are from Oder's collection No. 2 at Hurricane Hollow, in beds immediately overlying those with *G. ornata.* Also present in collections cnr/15, cnp'/20, cnq/20, and cnr'/20. The species ranges through an appreciable thickness of beds, appearing in the *Aphelaspis minor, A. walcotti,* and the *A. camiro, A. laxa,* and *A. quadrata* assemblages.

Types.—Holotype: U.S.N.M. 144553. Paratypes: U.S.N.M. 144554.

GLAPHYRASPIS DECLIVIS Rasetti, new species

Plate 14, figures 20–24

Available material.—Numerous cranidia and free cheeks well preserved in limestone.

Description.—Glabella subovate, slightly tapered, rounded in front, rising well above the cheeks. Posterior glabellar furrows of same shape as in *G. ornata,* very shallow; other pairs indistinct. Occipital furrow moderately impressed; occipital ring widely subtriangular, bearing an indistinct node. Cheeks sloping down steeply from axial furrow; frontal

area about one-fourth the glabellar length, slightly convex, barely divided by a trace of a border furrow; anterior outline somewhat pointed medially. Ocular ridges faint; palpebral area about one-fourth the glabellar width; palpebral lobes very small, at level of anterior third of glabella. Anterior section of facial suture convergent immediately in front of palpebral lobes; posterior section slightly convex outward, gradually curving backward and inward to produce broad, well-rounded posterior area. Furrow on posterior area broad and shallow. Free cheek rounded at genal angle; border narrow but fairly distinct anteriorly, becoming indistinct posteriorly. Surface of test smooth. Length of largest cranidium 2.4 mm.

Discussion.—The pygidium has not been identified. The cranidium of *G. declivis* differs from other species of the genus in the steeply downsloping palpebral area and the tendency to obsolescence of all the furrows; however, its close relationship to the more typical forms is unmistakable.

Occurrence.—The type is from Oder's collection No. 2, Hurricane Hollow. Also present in collections cnr/15, Three Springs, and cnr/16, Smith Hollow. In all these occurrences it is associated with *Aphelaspis walcotti*. Rare specimens were collected at locality cnq'/20, Washburn, in somewhat higher beds.

Types.—Holotype: U.S.N.M. 144556. Paratypes: U.S.N.M. 144557.

Genus AMIASPIS Lochman, 1944

Type species.—*Amiaspis erratica* Lochman.

AMIASPIS ERRATICA Lochman

Plate 5, figure 20

Amiaspis erratica Lochman, in LOCHMAN and DUNCAN, 1944, p. 68, pl. 8, figs. 41–46.

A few cranidia do not appear to differ appreciably from topotype material from Montana.

Occurrence.—Locality cnn/16, Smith Hollow.

Type.—Plesiotype: U.S.N.M. 144558.

AMIASPIS OBSOLESCENS Rasetti, new species

Plate 5, figures 21–24

Available material.—The holotype, a good cranidium, is the only specimen from the type locality. Several fragmentary cranidia from another locality are also available.

Description.—Glabella large, somewhat tapered, widely rounded in front, unfurrowed, barely defined on the outer surface by a very shallow

axial furrow, almost merging with the general convexity of the cephalon. Occipital furrow very shallow; occipital ring extended into a long, slender, almost horizontal spine. Fixed cheeks convex and downsloping; frontal area short (sag.), not differentiated into preglabellar field and border. Ocular ridges barely indicated; palpebral lobes almost indistinct, at level of the anterior fourth of glabella. Posterior area broad, strongly downsloping, rounded distally, deeply furrowed in contrast to the shallowness of all other furrows. Margin of posterior border showing a geniculation close to the axial furrow. Surface of test completely smooth. Length of largest cranidium, exclusive of spine, 2.2 mm.

Discussion.—The species differs from the type, with which it is associated, in the obsolescence of the axial furrow and the proportionately larger and unfurrowed glabella.

Occurrence.—The type locality is cnm′/20, Washburn. Also in collection cnn/16, Smith Hollow. The stratigraphic position is in the upper *Crepicephalus* zone.

Types.—Holotype: U.S.N.M. 144559. Paratypes: U.S.N.M. 144560.

Family CATILLICEPHALIDAE Raymond, 1938

Genus PEMPHIGASPIS Hall, 1863

Type species.—*Pemphigaspis bullata* Hall.

PEMPHIGASPIS, species undetermined

Plate 7, figures 23–25

A few cranidia and pygidia of *Pemphigaspis,* the latter fragmentary, may be identical with the type species but are not sufficient for a satisfactory identification.

Occurrence.—Uppermost beds of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnn/3.

Disposition of material.—Figured specimens: U.S.N.M. 144562.

Genus MADAROCEPHALUS Resser, 1938

Type species.—*Madarocephalus laetus* Resser.

MADAROCEPHALUS LAETUS Resser

Plate 8, figure 20

Madarocephalus laetus Resser, 1938a, p. 87, pl. 10, figs. 51–53.

A single cranidium agrees with the types, and proves that the species belongs to the *Crepicephalus* zone.

Occurrence.—Type locality is U.S.N.M. 56v, near McCalla, Ala. The author collected the specimen in the upper part of the lower lime-

stone member of the Nolichucky (*Crepicephalus* zone) at locality cnm/2.

Types.—Cotypes: U.S.N.M. 94885. Plesiotype: U.S.N.M. 144563.

Family CREPICEPHALIDAE Kobayashi, 1935

Genus CREPICEPHALUS Owen, 1852

Type species.—*Dikelocephalus ? iowensis* Owen.

CREPICEPHALUS cf. C. SCISSILIS Resser

Plate 8, figure 30

Crepicephalus scissilis Resser, 1938a, p. 72, pl. 11, figs. 34, 35.
Crepicephalus greendalensis Resser, 1938a, p. 73, pl. 11, figs. 46, 47.

A few, exfoliated pygidia resemble this species in the general shape, differing in the following minor features. The outline between the spines is slightly concave rather than straight; the median profile of the pleural region behind the axis is somewhat concave, instead of convex as it appears in Resser's specimens. Possibly these differences should be attributed specific value when better-preserved and more complete material can be found.

Occurrence.—Type locality for *C. scissilis* is U.S.N.M. 124a, 4 miles NE. of Rogersville. Type locality for *C. greendalensis* is U.S.N.M. 36u, near Greendale, Va. The author's material was collected from the uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnn/3.

Disposition of material.—Figured specimen: U.S.N.M. 144564.

CREPICEPHALUS BUTTSI Resser

Plate 6, figures 5, 6

Crepicephalus buttsi Resser, 1938a, p. 72, pl. 11, figs. 28, 29, 49, 50.
Crepicephalus expansus Resser, 1938a, p. 73, pl. 11, fig. 36.

Crepicephalus buttsi is represented by cranidia and pygidia poorly preserved and somewhat flattened in shale, while *C. expansus* is based on a limestone pygidium. No observable differences separate the pygidia bearing the two names. A form collected by the author and represented only by pygidia is identified with this species. The individual specimens vary to some extent in possessing straight or somewhat inward curved spines. Since both types occur in the same bed, these slight differences are not attributed specific significance.

Occurrence.—The type locality of *C. buttsi* is U.S.N.M. 26s, near Cleveland, Va. The type locality of *C. expansus* is U.S.N.M. 105, near Sneedville, Hancock County, Tenn. The specimens figured herein are from locality cnn/19.

Types.—Holotype of *C. buttsi* (pygidium) : U.S.N.M. 94907. Paratypes: U.S.N.M. 94908. Holotype of *C. expansus:* U.S.N.M. 94910. Plesiotypes: U.S.N.M. 144565.

CREPICEPHALUS CONVERGENS Rasetti, new species

Plate 8, figures 5–8

Available material.—Several pygidia and cranidia, the former of small size, mostly preserving the test.

Description.—Cranidium fully typical of the genus. Glabella tapered, rounded in front, showing 2 pairs of shallow furrows even on the outer surface; occipital furrow straight, occipital ring rounded. Frontal area divided into preglabellar field and border of about equal widths (sag.) ; border slightly convex. Palpebral area and lobes as in other species of the genus ; posterior area not preserved.

Pygidium represented by better specimens than the cranidium. Axis occupying two-thirds of the length, somewhat tapered, extended into a short postaxial ridge which reaches the wide, indistinct border furrow. About 2 rings distinct, 1 or 2 more barely indicated. Pleural lobes with rounded anterior angles, fairly straight sides converging toward the rear, and concave posterior margin between the spines. Pleural platforms relatively small, with 3 short, well-marked furrows, no interpleural grooves; slope dropping rather steeply to border furrow and wide, flat border. Spines rapidly tapered, flat, relatively short. Surface finely granulate. Length of largest pygidium 6.5 mm., width 10.5 mm.

Discussion.—This form is chiefly characterized by the pygidium, which differs in outline, form of the spines, and relative length of axis from described species.

Occurrence.—Lower portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnk/1.

Types.—Holotype (pygidium): U.S.N.M. 144566. Paratypes: U.S.N.M. 144567.

CREPICEPHALUS cf. C. CONVERGENS Rasetti

Plate 8, figures 9–11

Several pygidia collected in strata higher than those yielding the types of the species differ consistently in several features aside from the different manner of preservation (these pygidia are exfoliated). The sides are even more strongly convergent than in *C. convergens,* thus bringing the spines closer together; these are also shorter and more obtuse in shape, and the margin between them more definitely notched.

Occurrence.—Uppermost beds of the lower limestone member (*Crepicephalus* zone) of the Nolichucky (loc. cnn/1, cnn/3).

Dispostion of material.—Figured specimens: U.S.N.M. 144568-9.

CREPICEPHALUS, species undetermined No. 1

Plate 8, figures 17, 18

Available material.—Represented by incomplete, exfoliated pygidia and one poorly preserved cranidium that may belong to the same species.

Description.—Pygidium twice as wide as long. Axis occupying about five-sixths of the length, somewhat tapered, showing 3 rings and a terminal section. Pleural lobes extended into a pair of broad-based, strongly outward-directed, and presumably very long spines. Pleural platforms relatively short, with 3 pairs of pleural furrows. Border furrow indistinct.

Discussion.—This form cannot be identified with any described species on account of the character of the pleural spines.

Occurrence.—Uppermost beds of the lower limestone member (*Crepicephalus* zone) of the Nolichucky (loc. cnn/4).

Disposition of material.—Figured specimens: U.S.N.M. 144570.

CREPICEPHALUS? species undetermined No. 2

Plate 8, figures 12, 13

Available material.—A few cranidia and pygidia tentatively assigned to one species, preserved in limestone as internal impressions.

Description.—Glabella rather strongly convex in both directions, straight-sided, tapered, rounded in front, unfurrowed. Occipital furrow well impressed, straight; occipital ring lacking node or spine. Preglabellar field very short; border sharply elevated, convex, somewhat arched transversely; border furrow lacking depressions. Palpebral area slightly upsloping, about 0.25 times glabellar width; palpebral lobes small, curved, opposite glabellar midpoint; ocular ridges faintly indicated. Anterior facial sutures slightly divergent; anterior angles of cranidium narrowly rounded. Posterior area not preserved.

Associated pygidium of the *Crepicephalus* type, twice as wide as the midlength. Axis long, showing 3 rings and a terminal section, extended into a short postaxial ridge that reaches the margin. Pleural platforms convex and downsloping, with 3 pairs of deep, wide furrows, ending at wide, shallow border furrow. Spines continue the straight, slightly convergent outline of pygidial sides and are sharply pointed without attaining great length; margin between spines forming a broad curve. Length of largest cranidium 16 mm.; of pygidium 7 mm., width 14 mm.

Discussion.—The pygidium seems definitely to belong in the genus; the cranidium, however, is unusual in the strongly elevated anterior border and slightly upsloping palpebral area. The first of these characters would rather suggest *Meteoraspis,* but in that genus the palpebral area rises above the axial furrow and then slopes downward in characteristic fashion.

Occurrence.—Uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone); locality cnn/3.

Disposition of material.—Figured specimens: U.S.N.M. 144571.

Genus COOSELLA Lochman, 1936

Type species.—*Coosella prolifica* Lochman.

COOSELLA ANDREAS (Walcott)

Plate 1, figures 1–4

Blountia andreas Walcott, 1916b, p. 398, pl. 64, fig. 2.
Coosella andreas (Walcott) Resser, 1938a, p. 70, pl. 13, fig. 11.

Available material.—The holotype is a cranidium. Two cranidia and two associated pygidia collected by the author allow a more complete description. The cranidia differ from the holotype in the slightly less downsloping attitude of the anterior border, but such differences are common in obviously conspecific populations.

Description.—The pygidium has a very prominent, tapered, rounded axis reaching more than two-thirds of the pygidial midlength; it shows 3 rings and a terminal section extended into a low, broad postaxial ridge. Pleural lobes with unusually strong convexity, sloping down steeply to a narrow, poorly defined, concave border. Pleural platforms furrowed for a short distance, with 2 pairs of furrows and 1 pair of interpleural grooves indicated, all ending on the line that marks the inner edge of the doublure. Posterior margin in dorsal view showing a narrow notch between rounded lobes, in posterior view strongly raised medially. Surface of test smooth. The strong convexity of the pygidium distinguishes the species from all others attributed to the genus.

Occurrence.—Uppermost beds of Maryville limestone (*Cedaria* zone). Type locality is U.S.N.M. 102a, east of Rogersville. Collected by the author at locality cnc/2.

Types.—Holotype: U.S.N.M. 62823. Plesiotypes: U.S.N.M. 144572.

COOSELLA RESSERI Rasetti, new name

Plate 1, figures 5–7

Uncaspis tennesseensis Resser (part), 1938a, p. 105, pl. 9, fig. 20 (only).

Available material.—The pygidium, holotype of *Uncaspis tennesseensis*, and 2 additional pygidia, all preserved in limestone but exfoliated.

Description.—Pygidial axis slightly tapered, very prominent, showing 3 rings plus a terminal section, extended into a low postaxial ridge. Pleural platforms convex and strongly downsloping, showing several pairs of shallow furrows and interpleural grooves, all curving backward. Pleural region extended into a pair of slightly concave, horizon-

tal, somewhat falcate lobes separated by a wide, rounded notch. Midlength of pygidium 5 mm., width 10 mm.

Discussion.—The cranidium referred by Resser to *Uncaspis tennesseensis* is an example of *Modocia dubia,* as mentioned in the synonymy of that species. The holotype pygidium is certainly not an *Uncaspis,* whatever the characters of this poorly understood genus may be, and seems definitely referable to *Coosella.* This assignment requires a change in the trivial name, because the binomial combination *Coosella tennesseensis* was used by Resser for another species. The pygidium has fundamentally the same structure as *Coosella andreas,* but is more strongly bilobate, and the notch between the lobes is much wider.

Occurrence.—Red beds at the base of the Nolichucky (*Cedaria* zone) at U.S.N.M. locality 27d, where it was also collected by the author (loc. cnd/1).

Types.—Holotype: U.S.N.M. 94846. Plesiotype: U.S.N.M. 144573.

COOSELLA PLANICAUDA Rasetti, new species

Plate 7, figures 1–5

Available material.—A few cranidia and numerous pygidia.

Description.—Glabella of usual shape, with traces of lateral furrows; occipital furrow deep and straight, occipital ring bearing a low node. Preglabellar field and border of about equal width (sag.); border strongly convex, with terrace lines. Palpebral lobes narrow, half the glabellar length; width of palpebral area about 0.3 times the glabellar width. Midpoint of palpebral lobes somewhat in advance of glabellar midpoint.

Pygidium with very little overall relief. Axis moderately convex, little more than half the pygidial length, moderately tapered, showing 2 or 3 rings and an unfurrowed terminal section, extended into a brief postaxial ridge. Pleural lobes almost flat, showing faint furrows in the narrow triangular portions anterior to the inner margin of the wide doublure, smooth in the remainder of the broad, slightly concave area; posterior outline well rounded except for a shallow median notch between the pair of wide lobes. Surface of test smooth. Length of largest pygidium 7.5 mm., width 11 mm.

Discussion.—This species possibly resembles *Coosia* more than *Coosella* in the shape of the pygidium, but the cranidial features rather indicate the present generic assignment.

Occurrence.—Lower and middle portions of the lower limestone member of the Nolichucky (*Crepicephalus* zone). Localities cnk/2, cnm/2.

Types.—Holotype: U.S.N.M. 144574. Paratypes: U.S.N.M. 144575–6.

COOSELLA PERPLEXA (Palmer)

Plate 15, figures 19–26

Crepicephalus? perplexus PALMER, 1954, p. 733, pl. 77, figs. 1, 2, 4.

Represented in the collections by numerous cranidia and pygidia and a few free cheeks. Careful comparison with topotype specimens and further material from Nevada identified by Palmer (private communication) failed to disclose any significant difference, hence the identification seems highly reliable.

Palmer tentatively referred the species to *Crepicephalus* rather than *Coosella* because of the stratigraphic position rather than morphology. The cranidia of the two genera are indistinguishable, and it has been customary to refer to *Crepicephalus* the forms with pygidia extended into a pair of lateral spines, to *Coosella* those with a pair of rounded lobes more or less separated by a median notch. Hence the reference to *Coosella* seems indicated in the present case. Other species of *Coosella,* e.g., *C. planicauda,* occur in the upper *Crepicephalus* zone, hence there is no stratigraphic discontinuity in the distribution of the genus.

Occurrence.—Basal beds of the *Aphelaspis* zone in collections cno/14, Russell Gap, and cno/15, Three Springs.

Types.—Plesiotypes: U.S.N.M. 144577–8.

COOSELLA, species undetermined

Plate 6, figure 19

A single pygidium was collected. It has a short axis and wide, flat pleural lobes with a slight median notch in the posterior margin. The axis is extended into a long, narrow postaxial ridge. This specimen resembles a pygidium of an unnamed species of *Coosella* figured by Palmer (1954, p. 730, pl. 79, fig. 1) but the sides are straighter and the posterior angles not so widely rounded.

Occurrence.—Lower portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnk/1.

Disposition of material.—Figured specimen: U.S.N.M. 144579.

Genus COOSINA Rasetti, 1956

Type species.—*Maryvillia ariston* Walcott (part).

COOSINA AMAGE (Walcott)

Plate 7, figures 14–22

Blountia amage WALCOTT, 1916b, p. 398, pl. 64, figs. 3, 3a.
Blountia alethes WALCOTT (part), 1916b, p. 397, pl. 64, figs. 1b, 1c (only).
Coosella amage (Walcott) RESSER, 1938a, p. 70, pl. 13, figs. 12, 13.

Available material.—*Blountia amage* was based on a proper combination of cranidium and pygidium, both represented by specimens

preserving the test. *Blountia alethes* was described on a cranidium of *Coosia* illegitimately combined with an exfoliated pygidium of the preceding species. Since Walcott designated the cranidium as the holotype, the name *alethes* belongs to the species of *Coosia,* as used by Resser. The present generic assignment seems the proper one for *Blountia amage.* This species was found to be exceedingly common at one locality, and the numerous and better preserved material allows a more complete description.

Description.—Glabella defined by a fairly deep axial furrow, strongly tapered, rounded in front; glabellar furrows obsolete on outer surface, faint on impression of interior. Occipital furrow wide, occipital ring simple. Frontal area as in type species except for the greater distinctness of the border furrow and border. Palpebral area approximately horizontal, about 0.4 times the glabellar width; palpebral lobes about 0.4 times the glabellar length. Posterior area somewhat more slender and more deeply furrowed than in type species.

Pygidium 1.4 times as wide as long. Axis elevated, slightly tapered, occupying 0.8 of the pygidial length, extended into a brief postaxial ridge, with about 5 distinct rings and a terminal section. Pleural lobes convex, downsloping to moderately wide concave border. Anterior marginal furrow deep and wide, three other pairs of furrows shallow even on interior casts, traces of interpleural furrows also visible; all furrows end sharply at a line that corresponds to the inner edge of the doublure on the ventral side. The lateral and posterior margin with almost even curvature, except for a slight indication of flattening medially. Surface of test smooth. Length of largest cranidium 14 mm., of largest pygidium 10 mm.

Occurrence.—The type locality is U.S.N.M. 107, 11 miles NW. of Knoxville. Type locality for *Blountia alethes,* U.S.N.M. 123b, near Rogersville. Illustrated plesiotypes from the middle portion of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnm/2.

Types.—Holotype: U.S.N.M. 62824. Paratype: U.S.N.M. 62825. Paratype pygidium of *Blountia alethes* assigned to the species: U.S.N.M. 62822. Plesiotypes: U.S.N.M. 144580, 144561.

COOSINA ARISTON (Walcott)

Plate 7, figure 27

Maryvillia ariston WALCOTT (part), 1916b, p. 401, pl. 64, figs. 5, 5′ (not fig. 5a).
Coosina ariston (Walcott) RASETTI, 1956, p. 1267 (includes complete synonymy); 1961, p. 111, pl. 21, figs. 12, 13.

Several pygidia seem identical with this species. The cranidium was not identified; it would be difficult to distinguish from that of the far more common associated species *C. amage.*

Occurrence.—Type locality is U.S.N.M. 120, on Shields Ridge, New Market quadrangle. Collected by the writer in the middle portion of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnm/2.

Types.—Holotype: U.S.N.M. 62829. Plesiotype: U.S.N.M. 144581.

Genus COOSIA Walcott, 1911

Type species.—*Coosia superba* Walcott.

COOSIA ALETHES (Walcott)

Plate 6, figures 15–18; plate 7, figures 6–13

Blountia alethes Walcott (part), 1916b, p. 397, pl. 64, figs. 1, 1a (only).
Coosia alethes (Walcott) Resser, 1938a, p. 71.

Available material.—Abundant new specimens show that Walcott's type cranidium is an immature individual of a species of *Coosia* that attains large dimensions and is common everywhere in the upper *Crepicephalus* zone of the Nolichucky.

Description.—Glabella well defined by the axial furrow, unfurrowed, not changing much in shape in cranidia from 2.3 to 18 mm. in length, except for a gradual decrease of the convexity. Occipital furrow straight, well impressed, occipital ring simple. Frontal area increasing in length relative to the entire cranidium from 0.30 to 0.37 in the above-mentioned size range. Border furrow becoming gradually wider and shallower; midlength of preglabellar field about equal to border width (sag.) in small cranidia, decreasing to about half of border in adults. Palpebral area decreasing in relative width with size; palpebral lobes regularly curved in early stages, becoming somewhat angular later. Entire thorax preserved in an immature specimen that may represent a holaspid and has 12 segments. The pygidium in this individual has a long axis and the pleural lobes show 3 or 4 distinct pairs of furrows. In larger pygidia the axis becomes shorter, equaling only half or less of the pygidial length, and extends into a postaxial ridge. It is composed of 3 rings and a terminal section distinct even on the outer surface. The pleural lobes are slightly downsloping and furrowed in a limited area near the axis, then flatten out into a wide, smooth, somewhat concave area that corresponds to the extent of the doublure. The anterior marginal furrow is the only one that extends almost to the lateral margin. The largest fairly complete cranidium is 18 mm. long, but fragments indicate larger individuals. A large, incomplete pygidium has a length of 22 mm. and a width of 44 mm. Surface of test smooth except for wavy terrace lines on cranidial and pygidial borders.

Discussion.—It may be questioned whether forms of *Coosia* de-

scribed under various names from other areas, such as *C. dakotensis* Resser, *C. albertensis* Resser, *C. modesta* Lochman, *C. grandis* Lochman are distinct from the present species. In any case, the trivial name *alethes* would be the proper one for the species from Tennessee since it has priority.

Occurrence.—Type locality is U.S.N.M. 123b, near Rogersville. Common in the uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone). Localities cnn/1 to cnn/4, cnn/19, and cnn/16; rare in somewhat lower beds (loc. cnm/2).

Types.—Holotype: U.S.N.M. 62821. Plesiotypes: U.S.N.M. 144582–6.

COOSIA ROBUSTA Walcott

Plate 7, figure 26

Coosia robusta Walcott, 1911, p. 97, pl. 16, figs. 2, 2a.
Coosia robusta Walcott, Resser, 1938a, p. 70, pl. 11, figs. 12, 13.

Several pygidia associated with the preceding species seem identical with the types; however, no cranidia could be identified. The pygidium differs from that of *C. alethes* in the longer axis and almost entirely convex surface. The largest pygidium found is 25 mm. long and 40 mm. wide.

Occurrence.—Type locality is U.S.N.M. 107, NW. of Knoxville. Collected from the uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at localities cnn/1, cnn/2.

Types.—Cotypes: U.S.N.M. 57590, 57591. Plesiotype: U.S.N.M. 144587.

COOSIA, species undetermined

Plate 5, figure 19

Known from a single pygidium. Axis stout, prominent, slightly tapered, rounded posteriorly, somewhat over half the pygidial length, extended into a short postaxial ridge. Pleural regions flat, with straight anterior and posterior outlines that give the entire pygidium a rectangular appearance. Pleural furrows, except the first pair, almost indistinct, curving backward. Surface of posterior portion of pleural regions with transverse wrinkles. Length 3.0 mm., width 8.0 mm.

This pygidium differs from the associated species of *Coosia* in its subquadrate shape.

Occurrence.—Upper portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnn/1.

Disposition of material.—Figured specimen: U.S.N.M. 144588.

Family TRICREPICEPHALIDAE Palmer, 1954

Genus TRICREPICEPHALUS Kobayashi, 1935

Type species.—*Arionellus (Bathyurus) texanus* Shumard.

TRICREPICEPHALUS THOOSA (Walcott)

Plate 6, figures 1–4

Crepicephalus thoosa Walcott, 1916a, p. 214, pl. 31, figs. 1, 1a–k.
Paracrepicephalus walcotti Lochman, 1936, p. 39, pl. 9, figs. 29, 31, 33.
Tricrepicephalus walcotti (Lochman) Resser, 1938a, p. 102, pl. 11, fig. 54.
Tricrepicephalus thoosa (Walcott) Resser, 1938a, p. 101, pl. 14, fig. 8.
Tricrepicephalus coria (Walcott) Palmer (part), 1954, p. 755 (includes synonymy).

Palmer placed a number of described forms of *Tricrepicephalus* in the synonymy of *Tricrepicephalus coria* (Walcott), the type of which is from the House Range, Utah. He pointed out that the species construed in this broad sense includes a considerable amount of variation.

Since the material from the type locality for *T. coria* is rather poorly preserved, the writer prefers to adopt for the southern Appalachians form a name based on specimens from that area, and as new material was collected from the type locality for *T. thoosa,* this is the name here used. The differences between the type specimens of *T. thoosa* and *T. walcotti* fall well within the range of variation in cranidial and pygidial features observed in individuals from a single bed, hence Lochman's name is placed in synonymy. It was also included by Palmer in the list of synonyms of *T. coria.*

Occurrence.—Type locality for *T. thoosa* is U.S.N.M. 125a, 4 miles NE. of Rogersville (presumably identical with author's locality cnn/1). Type locality for *T. walcotti* is U.S.N.M. 119, S. of Morristown. Collected by the author at localities cnk/1, cnm/2, cnn/1 to cnn/5. The species ranges throughout the lower limestone member (*Crepicephalus* zone) of the Nolichucky formation.

Types.—Holotype of *T. thoosa:* U.S.N.M. 61654. Holotype and paratype of *T. walcotti:* U.S.N.M. 61655, 61658. Plesiotypes: U.S.N.M. 144589–91.

Genus METEORASPIS Resser, 1935

Type species.—*Ptychoparia metra* Walcott.

METEORASPIS MUTICA Rasetti

Plate 6, figures 13, 14

Meteoraspis mutica Rasetti, 1961, p. 116, pl. 21, figs. 25–29.

The assignment of cranidium and pygidium to the same species is made certain by the frequent association in the same bed observed in Tennessee. The largest cranidium observed has a length of 11 mm., the largest pygidium a length of 5 mm. and a width of 9 mm.

Occurrence.—The types are from the Conococheague formation

near Winchester, Va. Plesiotypes from localities cnm/2 and cnn/1, in the upper portion of the lower limestone member of the Nolichucky (*Crepicephalus* zone).

Types.—Plesiotypes: U.S.N.M. 144592–3.

METEORASPIS BREVISPINOSA Rasetti, new species

Plate 6, figures 9–12

Available material.—Several cranidia and pygidia preserved in limestone, the larger ones lacking the test.

Description.—Glabella of usual shape and convexity, unfurrowed, defined by a deep axial furrow all around. Occipital furrow deep, occipital ring rounded, bearing a low node. Preglabellar field and palpebral area narrow, convex, downsloping; border elevated, convex, defined by a deep border furrow; the latter with a pair of shallow depressions. Posterior area deeply furrowed.

Pygidium subrectangular, about as wide as long. Axis very prominent, large, somewhat tapered, rounded posteriorly, almost reaching posterior margin; 3 rings and a terminal section defined by deep furrows. Pleural lobes steeply downsloping, with fairly straight sides slightly convergent backward, extended into a pair of blunt spines; margin between spines straight for a considerable length. A few broad and shallow pleural furrows indicated on internal impression; border furrow and border indistinct. On the outer surface the pleural lobes would probably appear almost entirely smooth, except for the anterior marginal furrow. Length of largest cranidium 11 mm., of largest pygidium 11 mm.

Discussion.—The cranidium differs little from *M. metra* and other described species, but the pygidium is characteristic, lacking the long spines of other species. The pygidium of *M. mutica* lacks spines but is quite different in other respects.

Occurrence.—Lower portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnk/1.

Types.—Holotype (pygidium): U.S.N.M. 144594. Paratypes: U.S.N.M. 144595.

Family ASAPHISCIDAE Raymond, 1924

Genus BLOUNTIA Walcott, 1916

Type species.—*Blountia mimula* Walcott.

BLOUNTIA ARCUOSA Resser

Plate 9, figures 1–8

Blountia arcuosa Resser, 1938a, p. 64, pl. 12, fig. 25.

Available material.—The hypodigm contains only cranidia. Excellent additional material allows a more complete description of the species.

Description.—Glabella very slightly expanding forward in the posterior half, well rounded anteriorly, exceedingly convex in the anterior portion, overhanging the frontal area; occipital furrow exceedingly faint on outer surface, occipital ring very short (sag.); glabellar furrows lacking. Preglabellar field vertical; border about as wide (sag.) as the preglabellar field, convex, with terrace lines. Anterior sections of facial sutures parallel; posterior section with gentle curvature, defining slender, sharply pointed, faintly furrowed posterior area. Palpebral lobes small and faintly elevated; palpebral area about 0.2 times the glabellar width.

Pygidium almost twice as wide as long. Axis long, not rising above the general convexity; axial furrow shallow. Pleural lobes with convexity increasing toward the margin, lacking distinct border furrow and border, sharply downrolled especially in the posterior portion. Furrows obsolete on outer surface; on interior cast, 6 or 7 rings are distinguishable on the axis and 3 faint pairs of furrows on the pleural lobes. Surface smooth.

Occurrence.—Type locality is U.S.N.M. 121a, 4 miles NE. of Rogersville. The species is not rare in the upper part of the lower limestone member of the Nolichucky formation (*Crepicephalus* zone) in the Rogersville area (localities cnm/1, cnm/2, cnn/2, cnn/3).

Types.—Holotype: U.S.N.M. 94960. Plesiotypes: U.S.N.M. 144555.

BLOUNTIA ALEXAS Walcott

Plate 9, figures 9–12

Blountia alexas Walcott, 1916b, p. 398, pl. 61, figs. 5, 5a.
Blountia alexas Walcott, Resser, 1938a, p. 65, pl. 12, fig. 27.

Available material.—The hypodigm consists of the holotype cranidium. Additional cranidia and pygidia allow a more complete description.

Description.—Glabella of moderate convexity, straight-sided, slightly tapered, rounded in front, unfurrowed. Occipital furrow almost indistinct on outer surface, occipital ring very short (sag.). Preglabellar field on the average somewhat shorter (sag.) than border, the ratio varying somewhat in different individuals; border slightly convex, wide (sag.), set off from preglabellar field by its upturned position. Palpebral area about 0.3 times the width of glabella at same level. Anterior facial sutures divergent, anterior angles of cranidium well rounded; posterior section of facial suture with gentle curvature; posterior area falcate, extending farther backward than occipital ring, with faint furrow in proximal portion only.

Pygidium with little convexity. Length 0.6 times width. Axis tapered, occupying two-thirds of length; axial furrow shallow laterally,

almost obsolete posteriorly. Pleural lobes with faint border furrow and wide border. Only traces of segmentation on outer surface. Surface smooth.

Occurrence.—Type locality is U.S.N.M. 125, 4 miles NE. of Rogersville. Plesiotypes from the lower portion of the lower limestone member (*Crepicephalus* zone) of the Nolichucky formation (loc. cnk/1, cnk/3, the latter presumably identical with type locality).

Types.—Holotype: U.S.N.M. 62785. Plesiotypes: U.S.N.M. 144596, 144701.

BLOUNTIA LATA (Resser)

Plate 9, figure 21

Blountiella lata Resser, 1938a, p. 65, pl. 12, fig. 37.
Blountia rogersvillensis Resser, 1938a, p. 64, pl. 12, figs. 29, 30.

The species was described under the two names on the basis of cranidia preserving the test or not, respectively, as recognized by Lochman and Duncan (1944). This trilobite was found as a rare member of the faunule of the upper portion of the lower limestone member of the Nolichucky. The previous descriptions and the illustrations supply the available information about the species.

Occurrence.—The type locality for *Blountiella lata* is U.S.N.M. 125 and that for *Blountia rogersvillensis* is U.S.N.M. 121a, both 4 miles NE. of Rogersville. The author collected the species from the uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnn/3.

Types.—Holotype: U.S.N.M. 94961. Holotype of *Blountia rogersvillensis:* U.S.N.M. 94959. Plesiotype: U.S.N.M. 144597.

BLOUNTIA MONTANENSIS Duncan

Plate 9, figures 13–20

Blountia montanensis Duncan, in Lochman and Duncan, 1944, p. 53, pl. 8, figs. 29–34.

This species, described from Montana, is common in the *Crepicephalus* zone in Tennessee. There is some variation in the length of the preglabellar field, elevation of the anterior border and depth of the axial furrow on the cranidium, but since all intermediate forms occur in the same beds, these features should be interpreted as intraspecific variability.

Occurrence.—Localities cnk/1, cnm/2, cnn/1, cnn/3. The species is more common in the lower portion of the lower limestone member of the Nolichucky (*Crepicephalus* zone) but ranges throughout this limestone.

Types.—Plesiotypes: U.S.N.M. 144598–9.

BLOUNTIA BRISTOLENSIS Resser

Plate 10, figures 1, 2; plate 11, figures 9–12

Blountia bristolensis Resser, 1938a, p. 65, pl. 12, fig. 24.
Maryvillia bristolensis Resser, 1938a, p. 87, pl. 12, fig. 38.
Blountia nixonensis Lochman, in Lochman and Duncan, 1944, p. 43, pl. 4, figs. 7–12.

Available material.—The hypodigm of *B. bristolensis* includes the holotype pygidium. *Maryvillia bristolensis* is based on a cranidium from the same collection. *Blountia nixonensis* was described from numerous cranidia and pygidia. The author's collections include numerous fragments and one articulated shield. The latter allows a description of the thorax.

Description.—Entire exoskeleton ovate; pygidium as large as cephalon. Thorax of 7 segments, not tapered, as wide as cephalon and pygidium. In the specimen, evidently an exuvia as it lacks the free cheeks, the cranidium was pushed over the thorax, concealing the entire first and part of the second thoracic segment. The entire thorax was exposed during preparation when the cranidium broke off. In the illustration the cranidium is shown restored. Thoracic axis slightly tapered, at much lesser rate than pygidial axis. Axial furrows on thorax rather deep. Pleurae unfurrowed, flat and horizontal in proximal two-thirds, presenting sharp geniculation and showing anterior facet that allowed enrollment of the animal. Termination of pleurae narrowly rounded, sharper in anterior pleurae. Length of exoskeleton, allowing for displacement of cranidium, 17.4 mm., of which 7.0 belong to the cephalon, 4.4 to the thorax, and 6.0 to the pygidium. The individual corresponds almost to the largest size of cranidia and pygidia in the author's collections.

Discussion.—A species of *Blountia* common in the basal beds of the *Aphelaspis* zone in Tennessee is identified with *B. bristolensis*. This and *Maryvillia bristolensis,* from the same collection, obviously are conspecific. Careful comparison of the author's material with *B. nixonensis* from Montana failed to reveal any differences.

The species, like *B. mimula,* has 7 thoracic segments. In the present case one may be certain that the individual is a holaspid. However, it should not be inferred that all species of *Blountia* have 7 segments. An undescribed *Blountia* from the Murphy's Creek formation of the Gaspé Peninsula of Quebec, collected by the author, has 9 thoracic segments. This *Blountia* occurs in association with *Cedaria* and *Crepicephalus* and is therefore considerably older.

Occurrence.—Type locality for *Blountia bristolensis* and *Maryvillia*

bristolensis is U.S.N.M. 36v, near Bristol, Va. Collected by the author at localities cnp/17 (complete specimen), cnp/14, and cnq/14.

Types.—Holotype of *Blountia bristolensis:* U.S.N.M. 94942. Holotype of *Maryvillia bristolensis:* U.S.N.M. 94963. Plesiotypes: U.S.N.M. 144600–1.

BLOUNTIA MIMULA Walcott

Plate 10, figures 3–7

Blountia mimula Walcott, 1916b, p. 399, pl. 61, figs. 4, 4a–c.
Blountia mimula Walcott, Resser, 1938a, p. 63, pl. 12, figs. 18, 19.

As far as can be determined, a species of *Blountia* collected from the lower *Aphelaspis* zone seems identifiable with the species. The holotype is an articulated exoskeleton of very small size and is the only specimen in the hypodigm that comes from the type locality. The paratypes are from a different locality and appear conspecific with the holotype as far as one can compare immature individuals. The cranidia and pygidia illustrated herein are larger than any of the types and differ only in the shallower axial furrow around the glabella, a modification gradually acquired during the growth of these trilobites.

Occurrence.—The holotype is from U.S.N.M. locality 120 on Shields Ridge. Under this label trilobites from both the *Crepicephalus* and *Aphelaspis* zones are mixed. The paratypes are from U.S.N.M. locality 107c, NW. of Knoxville. The specimens illustrated herein are from Oder's collection No. 2 in the Hurricane Hollow section, in association with *Aphelaspis walcotti,* in beds higher than those holding *Blountia bristolensis.*

Types.—Holotype: U.S.N.M. 62781. Paratypes: U.S.N.M. 62782–4. Plesiotypes: U.S.N.M. 144602.

Genus MARYVILLIA Walcott, 1916

Type species.—*Maryvillia arion* Walcott.

MARYVILLIA ARION Walcott

Plate 9, figures 22–26

Maryvillia arion Walcott, 1916b, p. 400, pl. 64, figs. 4–4c.
Maryvillia arion Walcott, Rasetti, 1956, p. 1267 (includes complete synonymy); 1961, p. 116, pl. 21, figs. 14, 15.

Occurrence.—Type locality is U.S.N.M. 123b, ½ mile E. of Rogersville (probably identical with author's locality cnn/2). A common and diagnostic fossil of the upper part of the *Crepicephalus* zone. Collected at localities cnk/1 (very rare), cnm/2, cnn/1, cnn/2, cnn/3, cnn/4, cnn/14.

Types.—Holotype: U.S.N.M. 62826. Plesiotypes: U.S.N.M. 144603–4.

Family KINGSTONIIDAE Kobayashi, 1933

Genus KINGSTONIA Walcott, 1924

Type species.—*Kingstonia apion* Walcott.

KINGSTONIA INFLATA Resser

Plate 8, figures 21–28

Kingstonia inflata Resser, 1938a, p. 84, pl. 12, figs. 5, 6.
Kingstonia rotundata Resser, 1938a, p. 83, pl. 12, figs. 9–10.

Available material.—The two names represent the same species, described from the appearance of the outer surface and from internal impressions respectively. Abundant material of this exceedingly common form allows a more complete description.

Description.—Cranidium very convex in both directions, barely showing a trace of the axial furrow on outer surface. Glabella defined on internal impressions, straight-sided, slightly tapered, very wide in proportion to cranidial width. Anterior border indicated only by its terraced surface, without change in slope from glabella and preglabellar field. Palpebral lobes almost indistinct; facial suture showing little change of direction before and after palpebral lobes in dorsal view; anterior sections strongly convergent; posterior section gently convex outward, defining a stout posterior area; posterior angles of cranidium obtuse. Posterior outline rounded in axial portion, with indentations corresponding to the axial furrow; convex along the margin of the posterior area.

Pygidium with axis occupying less than one-third of the maximum width, well defined anteriorly but merging with the pleural region posteriorly, not tapered. Pleural lobes increasingly convex toward the margin. Facet at anterior angles very distinct. Five axial rings and 3 or 4 broad, shallow pleural furrows visible on interior impressions. Length of largest cranidia 4.5 mm.

Several cranidia, one of which is figured, show through the dark surface of the test a regular pattern of yellow stains that presumably represent muscle attachments on the inner surface.

Occurrence.—Type localities for *K. inflata* are U.S.N.M. 121a, 125, 4 miles NE. of Rogersville. Type locality for *K. rotundata* is U.S.N.M. 123b, near Rogersville. Found by the writer throughout the lower limestone member of the Nolichucky (*Crepicephalus* zone) in the Rogersville area (locs. cnk/1, cnk/3, cnm/2, cnm/3, cnn/1, cnn/3).

Types.—Cotypes of *K. inflata:* U.S.N.M. 94934, 94953. Cotypes *K. rotundata:* U.S.N.M. 94935. Plesiotypes: U.S.N.M. 144605–7.

Genus ANKOURA Resser, 1938

Type species.—*Ankoura triangularis* Resser.

ANKOURA TRIANGULARIS Resser

Plate 3, figures 15–21

Ankoura triangularis Resser, 1938a, p. 58, pl. 9, fig. 33.

Available material.—Although the pygidia are quite common at the type locality, the much more fragile cranidia are difficult to obtain. Resser figured a fragmentary cranidium, from which the precise characters were not clearly understood. Lochman (1940) attributed to the species good limestone material from the Bonneterre dolomite; however, her form belongs to a different species. Hence a brief description of the cranidium of *Ankoura triangularis* is in order. This description is based on exfoliated topotype material, plus specimens preserving the test from another locality.

Description.—Glabella parallel-sided, rounded in front, well defined on internal impressions but barely indicated on the outer surface. Occipital furrow almost obsolete on outer surface; occipital ring very short, lacking a spine. Frontal area convex and downsloping; border barely represented on outer surface by a narrow striated band as in many species of *Kingstonia*. On internal impressions there is a shallow border furrow. Furrow on posterior area almost obsolete on outer surface.

Discussion.—The species differs from the material identified by Lochman in two important characters: the simple occipital ring and the absence of a flat border.

Occurrence.—The type locality is U.S.N.M. 27d; red beds at the base of the Nolichucky (*Cedaria* zone) E. of Rogersville. The specimens figured herein are partly from the type locality, partly from a limestone lens at an unspecified level near the base of the Nolichucky on Comby Ridge, Howard Quarter quadrangle (author's locality cnb/10).

Types.—Cotypes: U.S.N.M. 94851. Plesiotypes: U.S.N.M. 144608–9, 144702.

Family MENOMONIIDAE Walcott, 1916

Genus DRESBACHIA Walcott, 1916

Type species.—*Dresbachia amata* Walcott.

DRESBACHIA AMATA Walcott

Plate 8, figures 1–4

Dresbachia amata Walcott, 1916a, p. 167, pl. 26, figs. 5, 5a–c.
Dresbachia appalachia Resser, 1938, p. 74, pl. 10, figs. 32–34.
Dresbachia amata Walcott, Lochman, 1950, p. 338, pl. 48, figs. 11–14.

A few cranidia and more numerous free cheeks were collected from the lower limestone member of the Nolichucky (*Crepicephalus* zone) at localities cnk/1, cnk/3, cnm/2.

Types.—Holotype of *D. appalachia* (from loc. U.S.N.M. 22z, near Greendale, Va.): U.S.N.M. 94875. Plesiotypes: U.S.N.M. 144694.

Genus MENOMONIA Walcott, 1916

Type species.—*Conocephalites calymenoides* Whitfield.

MENOMONIA PROMINENS Resser

Plate 5, figures 14–17

Menomonia prominens Resser, 1938a, p. 88, pl. 9, figs. 42, 43.
Dresbachia speciosa Resser, 1938a, p. 75, pl. 9, figs. 28, 29.

Available material.—Resser's two names were based on the cranidia and free cheeks of the same species. Additional material allows a more complete description.

Description.—Glabella straight-sided, tapered, rounded in front, with 2 pairs of short lateral furrows; occipital furrow well impressed, occipital ring rounded. Preglabellar field slightly arched transversely, fairly long (sag.); border upturned, arched transversely. Palpebral lobes with their midpoint at the level of the anterior end of the glabella, strongly upsloping, rising higher than glabella. Posterior area tapered, large, strongly downsloping and hence giving strong relief to the cranidium, deeply furrowed; posterior cranidial margin curving backward. Free cheek with border well defined only anteriorly, almost parallel-sided, well rounded at the genal angle. The surface characters are described as they appear on internal impressions, as none of the specimens preserve the test. Large tubercles on the glabella are arranged more or less regularly in 4–5 pairs. Tubercles of the same size are irregularly scattered on the fixed cheeks, decreasing in number toward the distal end of the posterior area. The tubercles are more crowded on the anterior border. The free cheeks have larger granules near the eye and finer granules distally. The largest cranidium has a length of 4.8 mm.

Occurrence.—Type locality is U.S.N.M. 27d; red beds at the base of the Nolichucky E. of Rogersville (*Cedaria* zone). Collected by the author at the same locality (cnd/1).

Types.—Holotype and paratypes: U.S.N.M. 94857. Plesiotypes: U.S.N.M. 144695.

MENOMONIA TUBERCULATA Rasetti, new species

Plate 2, figures 19–24

Available material.—Several cranidia and free cheeks in limestone.

Description.—Glabella and occipital ring similar to preceding spe-

cies. Preglabellar field about as long (sag.) as border width (sag.); border elevated, arched transversely. Palpebral area almost as wide as anterior portion of glabella, less upsloping than in *M. prominens;* palpebral lobe moderately upsloping, not extending much farther forward than the anterior end of the glabella. Posterior area much less tapered than in *M. prominens,* more rounded distally, bearing a deep, wide furrow. Posterior outline of cranidium transverse; posterolateral angles not extending farther backward than occipital ring.

Free cheek almost subtriangular. Border distinct for more than half the length of the margin. Anterior section of facial suture much longer than in *M. prominens,* corresponding to the more posterior position of the eye. Posterior section with slight sigmoidal curvature, cutting posterior margin closer to genal angle than in preceding species. Elevated portions of surface covered with coarse tubercles, possibly representing the base of broken spines, those on the glabella being arranged more or less regularly in several rows. Length of largest cranidium 5 mm.

Discussion.—The present species resembles *M. calymenoides* rather than *M. prominens,* the differences from the latter having been already pointed out in the description. An accurate comparison with topotypes of *M. calymenoides* is not very significant because of the poor preservation of these small trilobites as internal casts in the Eau Claire sandstone. One definite difference seems to be that in *M. calymenoides* the anterior border has almost even width, whereas in the present species it tapers at the sides. The palpebral area seems to be proportionately wider.

Occurrence.—Uppermost beds of the Maryville limestone (*Cedaria* zone) at localities cnc/1 to cnc/6.

Types.—Holotype: U.S.N.M. 144696. Paratypes: U.S.N.M. 144697–8.

MENOMONIA, species undetermined

Plate 2, figures 25–27

A few incomplete cranidia and several free cheeks apparently represent a form of *Menomonia* different from the two previously discussed species.

Most of the cranidial features agree with *M. tuberculata,* except in the somewhat more anterior position of the eyes, narrower palpebral area, and lack of tubercles on the posterior area, where the surface is finely wrinkled. The free cheek resembles more closely that of *M. prominens* in general shape and also shows a wrinkled surface with, in addition, a few tubercles on the anterior part of the border.

Occurrence.—Uppermost beds of the Maryville limestone (*Cedaria* zone) at localities cnc/4, cnc/6.

Disposition of material.—Figured specimens: U.S.N.M. 144699–700.

Family NORWOODIIDAE Walcott, 1916

Genus NORWOODIA Walcott, 1916

Type species.—*Norwoodia gracilis* Walcott.

NORWOODIA ROGERSVILLENSIS Resser

Plate 4, figures 25, 26

Norwoodia rogersvillensis Resser, 1938a, p. 91, pl. 9, figs. 25, 26.
Norwoodia harlanensis Resser, 1938a, p. 91, pl. 9, fig. 31.

Available material.—The hypodigms consist of cranidia from the same locality. In addition to further cranidia, pygidia occur in the author's collection.

Description.—Glabella tapered, rounded in front, rather convex, defined by a well-impressed axial furrow. Glabellar furrows probably obsolete on outer surface. Occipital furrow shallow; occipital ring extended into a large, horizontal spine longer than the glabella. Frontal area as long as glabella, mostly consisting of downsloping preglabellar field; border wide (sag.), upturned. Palpebral area about half the glabellar width; ocular ridges distinct. Anterior sections of facial sutures very slightly divergent; posterior section directed outward and somewhat forward, reaching the margin well in advance of genal angle. Posterior area slightly expanding distally, well furrowed, extended into a slender and moderately long genal spine.

The pygidia are attributed to the species because of the close similarity to *N. gracilis* and other closely related species. Pygidium twice as wide as long, convex. Axis defined laterally, merging with the pleural region posteriorly, of 3 distinct rings. Pleural lobes convex, with 3 pairs of shallow furrows; border narrow but distinct. All the described cranidial and pygidial features refer to the impression of the interior since none of the specimens preserves the test.

Discussion.—Among the species of the southern Appalachians, the present one resembles *N. gracilis* Walcott, differing mainly in the proportionately wider and shorter glabella, shorter occipital spine, and different shape of the posterior area and genal spine.

Occurrence.—Found only in the red beds (*Cedaria* zone) at the base of the Nolichucky. Type locality is U.S.N.M. 27d, the same as the author's locality cnd/1.

Types.—Holotype: U.S.N.M. 94847. Holotype of *N. harlanensis:* U.S.N.M. 94850. Plesiotypes: U.S.N.M. 144610.

NORWOODIA, species undetermined

Plate 4, figure 24

Cranidia of *Norwoodia,* too incomplete for specific identification but certainly very close to the preceding species, are present in the uppermost beds of the Maryville limestone in the Rogersville area.

Occurrence.—Maryville limestone (*Cedaria* zone) ; localities cnc/2, cnc/4, cnc/6.

Disposition of material.—Figured specimen: U.S.N.M. 144611.

Genus NORWOODELLA Resser, 1938

Type species.—*Norwoodia saffordi* Walcott.

NORWOODELLA SAFFORDI (Walcott)

Plate 3, figures 1–6

Norwoodia saffordi Walcott, 1916a, p. 171, pl. 27, figs. 1–1f.
Norwoodella saffordi (Walcott) Resser, 1938a, p. 89, pl. 10, figs. 40, 41, 49, 50.

This species is readily distinguished from all others of the genus by the depth of the axial furrow and the fixed cheeks which rise above the furrow itself instead of sloping down from it. Limestone specimens are figured, in addition to the complete holotype exoskeleton flattened in shale. The thorax of this individual seemingly has 9 segments, not 8 as stated by Walcott. The material from Missouri attributed to this species by Lochman (1940) was incorrectly identified.

Occurrence.—Type locality is U.S.N.M. 103, near Rogersville. The species is common in the basal beds of the Nolichucky shale and interstratified limestone lenses (*Cedaria* zone). Collected at localities cnd/1, cne/1, cne/2.

Types.—Lectotype (herein designated): U.S.N.M. 61595. Paratypes: U.S.N.M. 61596–600. Plesiotypes: U.S.N.M. 144612–3.

NORWOODELLA ROTUNDICOLLIS Rasetti, new species

Plate 4, figures 1–7

Available material.—Numerous cranidia and a few free cheeks and pygidia, preserved in limestone but mostly lacking the test.

Description.—Glabella tapered, straight-sided, rounded in front, fairly convex, rising above the cheeks, unfurrowed on outer surface. Axial furrow on outer surface impressed laterally but obsolete in front; on interior impressions well defined all around. Occipital furrow impressed throughout; occipital ring subtriangular but rounded, lacking a spine. Frontal area convex and downsloping, somewhat over one-third the glabellar length, undivided by a border furrow even on internal impressions. Palpebral area downsloping, about 0.3 times the glabellar width; ocular ridges faint. Posterior area wide (exsag.),

parallel-sided, with a distinct furrow even on outer surface. Genal spine slightly curved, of moderate length. Free cheek as in other species of the genus. Surface of test perfectly smooth; internal impressions show fine anastomosing lines on frontal area and free cheeks. Length of largest cranidium 8 mm.

The pygidia attributed to the species are so similar to *N. saffordi,* which occurs in the same beds, that some doubt remains concerning their assignment. Pygidium somewhat fan-shaped, with regularly curved pleurae and anterior margin. Axis prominent, long, tapered, showing 3 rings plus a terminal section. Pleurae poorly fused, with 3 pairs of wide furrows and as many narrow interpleural grooves, all furrows and grooves extending to the margin, where the separate endings of the pleurae form a wavy outline. Border furrow and border lacking.

Discussion.—The cranidium resembles *N. declivis* Resser, which also appears to lack an occipital spine. However, this condition in the type material in shale may be due to imperfect preservation, and therefore it was deemed preferable not to attempt identification with that species. The pygidium resembles, besides *N. saffordi,* pygidia associated with the type cranidia of *N. kingstonensis* Resser. All these pygidia strongly differ from those of other species of the genus, such as *N. walcotti* and *N. halli* illustrated herein, which have well-fused pleural regions, a smooth posterior margin, and a border furrow, much like pygidia of *Norwoodia.*

Occurrence.—Red beds at the base of the Nolichucky (*Cedaria* zone) at locality cnd/1 (= U.S.N.M. loc. 27d).

Types.—Holotype: U.S.N.M. 144614. Paratypes: U.S.N.M. 144615.

NORWOODELLA WALCOTTI Resser

Plate 4, figures 16–23

Norwoodella walcotti Resser, 1938a, p. 89, pl. 10, figs. 42, 54.

Available material.—The hypodigm consists of cranidia flattened in shale. Good cranidia, free checks, and pygidia in limestone occur in the U.S.G.S. and author's collections.

Description.—Glabella entirely undefined on upper surface, except for a faint indication of its anterior boundary. Occipital furrow obsolete; occipital ring extended into a slender, horizontal spine. Frontal area undifferentiated, somewhat downsloping. Palpebral area, as determinable on exfoliated specimens, very narrow. Palpebral lobes small, somewhat elevated. Anterior sections of facial suture convergent, making the frontal portion of the cranidium very narrow, well rounded. Posterior section directed almost straight outward from palpebral lobe,

almost parallel to posterior cranidial margin, sharply curving backward, cutting margin near base of genal spine. Genal spine slender, of moderate length. Furrow on posterior area obsolete on outer surface, impressed on interior cast. Free cheek completely lacking border furrow on outer surface, entirely convex, extended into a short, slender strip that simulates a genal spine, but actually contributes to the cephalic margin in a region in advance of the base of the genal spine borne by the cranidium. Visual surface of eye convex, bean-shaped; facets indistinguishable.

Pygidium approximately semicircular, twice as wide as long. Facets well developed. Posterior outline with uniform curvature. Axis well defined anteriorly but merging with the pleural lobes posteriorly, showing 2 rings plus a terminal indistinctly segmented section. Pleural lobes entirely convex, lacking any furrows, showing barely a trace of differentiated border. Surface of cranidium and free cheeks perfectly smooth. Pleural lobes of pygidium with very fine, transverse terrace lines only visible under conditions of perfect preservation.

Discussion.—This species is quite distinctive in the lack of all furrows on the outer surface, and especially the narrowing of the cranidium in front of the eyes. The pygidium is much like *Norwoodia gracilis* and *N. rogersvillensis* and unlike *Norwoodella saffordi, N. kingstonensis,* and *N. rotundicollis.* This fact would perhaps justify redistributing the species hitherto referred to *Norwoodia* and *Norwoodella* on the basis of the pygidia, rather than the questionable character of the structure of the frontal area. This revision should only be undertaken when the pygidia of most species of this group are known with certainty. For the present species the assignment is certain, since only one species of the Norwoodiidae occurred in the beds yielding the material illustrated herein.

Occurrence.—Basal portion of the Nolichucky (*Cedaria* zone). The type locality is U.S.N.M. 107a, NW. of Knoxville. The specimens illustrated are from the collections cne/10, Comby Ridge (= U.S.G.S. collection 2407), and cne/12 near Heiskell (the latter presumably close to or identical with the type locality).

Types.—Holotype and paratypes: U.S.N.M. 94880. Plesiotypes: U.S.N.M. 144616–8.

NORWOODELLA HALLI Resser

Plate 4, figures 8–15

Norwoodella halli Resser, 1938a, p. 90, pl. 10, figs. 45, 46.
Norwoodella halli Resser, Lochman, 1940, p. 47, pl. 5, figs. 31–36.

The types are cranidia preserved in shale. Lochman gave a detailed description of the species and figured unflattened limestone material

from Missouri, including the pygidium. The assignment of the two parts of the shield is confirmed by the specimens illustrated herein.

Occurrence.—The type locality is U.S.N.M. 22t in the Thorn Hill section, in the interval 45–133 feet above the base of the formation. Also in author's collection cnd/10, Comby Ridge.

Types.—Holotype and paratypes: U.S.N.M. 94883. Plesiotypes: U.S.N.M. 144619.

Genus HOLCACEPHALUS Resser, 1939

Type species.—*Holcacephalus granulatus* Resser.

HOLCACEPHALUS GRANULATUS Resser

Plate 3, figures 12–14

Holcacephalus granulatus Resser, 1938a, p. 81, pl. 9, figs. 15–17.

Available material.—The species, quite common at the type locality, was not found elsewhere. All the available specimens lack the test.

Description.—Glabella definitely tapered, defined by a deep axial furrow, with two pairs of short, but deep lateral furrows, and another pair less distinct. Occipital furrow deep, occipital ring long (sag.), bearing a short, very slender spine. Preglabellar field downsloping, border narrow, well defined by the border furrow. Ocular ridges transverse; palpebral lobes at level of anterior third of glabella; palpebral area almost as wide as anterior portion of glabella. Posterior area slender, slightly expanded distally, bearing a genal spine that is broken off in almost all available specimens. Surface covered with relatively large granules.

Pygidium twice as wide as long, subelliptical; with posterior outline slightly indented medially. Axis occupying almost entire length, with 4 prominent rings. Pleural lobes slightly convex, lacking border furrow or border. Three pairs of pleurae are clearly separated by interpleural grooves; each pleura is furrowed and the posterior band bears a row of tubercles like those on the cranidium.

Discussion.—This species differs considerably from all others hitherto attributed to the genus in the tapered, deeply furrowed glabella.

Occurrence.—Red limestone beds at the base of the Nolichucky (*Cedaria* zone) at U.S.N.M. locality 27d (= author's locality cnd/1).

Types.—Cotypes: U.S.N.M. 94844. Plesiotypes: U.S.N.M. 144620.

HOLCACEPHALUS PRAECURSOR Rasetti, new species

Plate 3, figures 10, 11

Available material.—Several cranidia and pygidia.

Description.—Owing to the similarity to the preceding species, it is sufficient to point out the differences. The anterior border is somewhat wider and flat instead of convex; the ocular ridges are more prominent;

the cranidial surface has fewer and smaller granules than *H. granulatus;* these are barely apparent on the glabella and frontal area, being more conspicuous on the palpebral and posterior areas. The pygidium has the same structure as in *H. granulatus,* but here again the granules are indistinct. The species attains a larger size, with cranidia 3–4 mm. in length. This form may be ancestral to *H. granulatus.*

Occurrence.—Uppermost beds of Maryville limestone (*Cedaria* zone) at locality cnc/1.

Types.—Holotype: U.S.N.M. 144621. Paratypes: U.S.N.M. 144622.

Family CEDARIIDAE Raymond, 1937

Genus CEDARIA Walcott, 1924

Type species.—*Cedaria prolifica* Walcott.

CEDARIA TENNESSEENSIS Walcott

Plate 5, figures 4–8

Cedaria tennesseensis WALCOTT, 1925, p. 79, pl. 17, figs. 22–25.
Cedaria tennesseensis Walcott, RESSER, 1938a, p. 68, pl. 11, figs. 3–5.

Available material.—The types are cranidia, free cheeks, and pygidia flattened in shale. Fragmentary material in limestone was collected by the writer.

Description.—Cranidium of moderate convexity. Glabella as in other species of the genus. Frontal area sharply divided into preglabellar field and border by a narrow border furrow; border flat, its sagittal length more than half the length of the preglabellar field. Palpebral area and lobe without specific features. Posterior area broad (exsag.), the posterior section of the facial suture running outward and slightly forward; border furrow on posterior area turning forward for a considerable distance. Anterior sections of facial suture less divergent than in most other species of the genus. Free cheek with ocular platform and border of about equal widths, separated by sharp border furrow. Genal spine long and strong as in other species of *Cedaria.*

Pygidium 1.6 times as wide as long, almost elliptical, with anterior angles widely rounded. Axis short, in larger individuals not exceeding half of the pygidial length, showing about 3 rings plus a terminal section. Pleural regions almost flat, wide, with 3 pairs of broad, shallow furrows and a trace of a fourth, and indistinct interpleural grooves. The furrows run straight through the pleural platform, change to a more backward direction in passing onto the wide, slightly concave border, and almost reach the pygidial margin. Pygidial doublure very wide, its anterior margin well visible as an impression on the dorsal side. Pygidial border with very fine, wavy lines.

Discussion.—This species differs considerably from the type species,

C. prolifica, in the lesser divergence of the anterior section of the facial suture, wider cephalic border, broader (exsag.) posterior area, pygidium more transverse, with shorter axis, fewer pleural segments, and much wider border and doublure.

Occurrence.—The type locality is U.S.N.M. 107a, Copper Ridge, NW. of Knoxville (very close to author's locality cne/12). Collected by the writer at localities cne/10, cne/12, cne/13. All the limestone material is fragmentary, especially the cranidia.

Types.—Lectotype (designated herein): U.S.N.M. 70270. Paratypes: U.S.N.M. 70271–3. Plesiotypes: U.S.N.M. 144623.

Genus CEDARINA Lochman, 1940

Type species.—*Cedarina vale* Lochman.

CEDARINA, species undetermined

Plate 5, figure 18

Available material.—A few pygidia, all lacking the test.

Description.—Pygidium almost 3 times as wide as long. Axis elevated, tapered, composed of 3 rings plus a terminal section, almost reaching the posterior pygidial margin. Anterior outline of pleural lobes slightly curved, anterior angles sharp, posterior margin with shallow, rounded median notch. Three pairs of pleural furrows well impressed, shallow interpleural grooves distinct near border. Border furrow indistinct, border flat, narrow. Length of largest pygidium 3.3 mm., width 9.2 mm.

Discussion.—The pygidium closely resembles that of *Cedarina vale* Lochman from Missouri. The pygidia of other species of the genus described by Lochman from the West are all proportionately longer. No definite identification can be made without the cranidium.

Occurrence.—Rare in the red beds at the base of the Nolichucky (*Cedaria* zone) at locality cnd/1.

Disposition of material.—Figured specimen: U.S.N.M. 144624.

Genus LLANOASPIS Lochman, 1938

Type species.—*Llanoaspis modesta* Lochman.

LLANOASPIS WALCOTTI (Resser)

Plate 8, figures 14–16

Genevievella walcotti Resser, 1938a, p. 77, pl. 15, figs. 3–5.
Genevievella rogersvillensis Resser, 1938a, p. 78, pl. 15, figs. 16–18.
Rogersvillia rogersvillensis (Resser) Hupé, 1953, p. 182, fig. 159.

Palmer (1954) placed a number of described species of the genus, including *walcotti,* in the synonymy of the type species. While the writer agrees that not all the described forms are distinguishable, he believes that the one here discussed is readily separable by the shape

of the pygidium, which completely lacks the lateral expansion of the posterior border clearly apparent in the specimens of *L. modesta* figured by Lochman (1938) and Palmer (1954).

The type specimens of *walcotti* are preserved in limestone, while those of *rogersvillensis* are flattened in shale, but there seems to be no specific difference between the two.

Occurrence.—Type locality for *L. rogersvillensis* is U.S.N.M. 24m, near Rogersville. Type locality for *L. walcotti* is U.S.N.M. 107, NW. of Knoxville. The figured specimens are from the uppermost beds of the lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnn/3.

Types.—Holotype and paratypes of *L. rogersvillensis:* U.S.N.M. 94974–5. Holotype and paratypes of *L. walcotti:* U.S.N.M. 94970–1. Plesiotypes: U.S.N.M. 144625.

Genus GENEVIEVELLA Lochman, 1936

Type species.—*Genevievella neunia* Lochman.

GENEVIEVELLA, species undetermined

Plate 5, figures 9–11

Known from several cranidia. The shape and convexity of glabella, frontal area and posterior area are about the same as in the type species. However, the present form lacks the strong elevation of the palpebral area and palpebral lobes present in *G. neunia.* As the material is scarce, imperfectly preserved, and from different localities, it does not warrant naming a new species.

Occurrence.—A large cranidium was collected from locality cnc/4, and another from locality cnc/2, both in the uppermost Maryville limestone. Further material was collected in limestone beds or lenses at the base of the Nolichucky (localities cnd/1, cne/2). All these beds belong in the *Cedaria* zone.

Disposition of material.—Figured specimens: U.S.N.M. 144626–7.

Family ELVINIIDAE Kobayashi, 1935

Genus DUNDERBERGIA Walcott, 1924

Type species.—*Crepicephalus (Loganellus)nitidus* Hall and Whitfield.

DUNDERBERGIA TENNESSEENSIS Rasetti, new species

Plate 15, figures 1–12

Available material.—Several cranidia and free cheeks, two pygidia, and one tentatively assigned hypostome.

Description.—Glabella of fairly strong convexity, straight-sided, tapered, somewhat truncate in front, defined by deep axial furrows laterally, shallower furrow in front. Three pairs of lateral furrows;

posterior pair very oblique, moderately deep; third pair shorter and shallower, directed slightly backward; second pair very short and shallow, directed slightly forward. Occipital furrow deep, occipital ring bearing a node. Preglabellar field slightly convex longitudinally and more or less downsloping in different individuals. Border furrow well impressed, in some cranidia showing an indication of the median angle more marked in several other species of the genus. Border somewhat convex, not greatly tapered laterally; midlength (sag.) of border about half the length of preglabellar field. In anterior view the border appears fairly arched transversely in some cranidia, especially the larger ones, rather flat in smaller individuals. It was considered whether this might be a specific distinction; however, since the two kinds are mixed in the collections from both localities where the species was found, it was thought more likely that the differences are due either to growth stages, to intraspecific variability, or both. Palpebral area somewhat convex, on average horizontal, half as wide as glabella. Ocular ridges straight, slanted backward, more strongly so in the larger cranidia. Palpebral lobe defined by deep furrow even on upper surface, narrow, strongly curved, somewhat convex transversely, 0.20 to 0.25 times as long as glabella; distance from posterior margin greater than length of lobe. Anterior section of facial suture as divergent as in an average *Aphelaspis*. Posterior area slender, somewhat narrower (tr.) than occipital ring. Ocular platform moderately convex. Border on free cheek of uniform width, almost flat, defined by shallow furrow; genal spine strong, of moderate length.

All portions of the cranidial surface except in the furrows covered with granules, usually of two sizes, although in some of the cranidia only the larger granules are distinct. The border of the free cheek has, in addition to dense, fine granules, a few scattered, somewhat larger granules. Length of largest (holotype) cranidium 15 mm.

Pygidium twice as wide as long. Axis large, wider than the pleural lobe, elevated, subcylindrical, rounded at the extremity, extended into a short postaxial ridge reaching the posterior margin. First two axial rings well defined, the rest merging into a terminal section. Pleural platforms without much relief, with 2 pairs of broad, rather indefinite furrows. Border rather narrow, flat, poorly defined. In posterior view the posterior margin appears elevated medially. Surface finely granulate.

Discussion.—The cranidium seems definitely referable to *Dunderbergia* and shows most similarity to *D. bigranulosa* Palmer (1960) and *D. anytus* (Hall and Whitfield), both from Nevada. The pygidium also closely agrees with pygidia of *Dunderbergia* figured by Palmer. *D. bigranulosa* is from the *Dunderbergia* zone, while the stratigraphic position of *D. anytus* does not seem to be known with certainty.

Occurrence.—Uppermost *Aphelaspis* zone, in association with *Aphelaspis tarda.* The type locality is cnw/14, Shields Ridge. Also in collections cnw/20, Washburn, and cnu/7, Purchase Ridge, Scott County, Va.

Types.—Holotype: U.S.N.M. 144628. Paratypes: U.S.N.M. 144629–31.

DUNDERBERGIA LONGIFRONS Rasetti, new species

Plate 15, figures 13–18

Available material.—Several cranidia and one pygidium.

Description.—Glabella strongly convex transversely and fairly convex longitudinally, slightly tapered, rounded in front, with 2 pairs of shallow lateral furrows. Occipital furrow deep, occipital ring lacking a distinct node. Frontal area relatively short; preglabellar field steeply downsloping; border convex, elevated. Palpebral area convex transversely, on the average horizontal; ocular ridges low and broad; palpebral lobes well defined by furrow even on outer surface, slightly more anterior with respect to the glabella than in the preceding species. Anterior section of facial suture weakly divergent; posterior section and posterior area not entirely preserved.

Pygidial axis broad, elevated, showing two very distinct rings and a terminal section with a third shallow ring furrow; axis extended into a broad postaxial ridge. Pleural regions with 3 distinct pairs of broad furrows; interpleural grooves lacking. Border furrow broad, border narrow, poorly defined. The posterior outline shows a faint median notch in dorsal view and is elevated medially in posterior view.

Surface of both shields covered with moderately elevated granules. Length of largest (holotype) cranidium 6 mm. Length of pygidium 1.3 mm., width 2.4 mm.

Discussion.—The species differs from *D. tennesseensis* and most other forms of the genus in the proportionately longer glabella relative to the entire cranidium.

Occurrence.—U.S.G.S. collection 2970, Monroe County. The association of species at that locality indicates the middle *Aphelaspis* zone.

Types.—Holotype: U.S.N.M. 144632. Paratypes: U.S.N.M. 144633.

Family PTEROCEPHALIIDAE Kobayashi, 1935

Genus APHELASPIS Resser, 1935

Type species.—*Aphelaspis walcotti* Resser.

The study of the species of *Aphelaspis* from the southern Appalachians presents such taxonomic problems as may be expected when thousands of individuals from numerous localities and slightly differ-

ent horizons are available. Each thin limestone bed or lens, where the well-preserved material occurs, shows a population with a certain range of variability, but often statistically distinguishable from those occurring in lower or higher beds. In certain cases the range of variation within a population is such that extreme individuals overlap in several features those of different populations. Nevertheless, as material from a larger number of localities was studied, 17 well-characterized species emerged. Most of these could be found at a number of different localities in the same stratigraphic order, hence are valuable for correlation.

A favorable factor in the study of this difficult genus was offered by the frequent occurrence in a single bed or lens of a coquina of fragments of a single species. Hence the various parts could be assigned unequivocally for all the species described herein. Less frequently 2 species occurred in the same bed, and only 1 association of 3 species (*A. camiro, laxa,* and *quadrata*) was observed.

Difficulties in identification resulted from the presence in some beds of only immature forms of species that occur in much larger sizes at other localities. Cranidia less than 4 or 5 mm. in length are often indeterminable. Exfoliated specimens are difficult to compare accurately with individuals preserving the test; the latter were chosen almost exclusively for the descriptions and illustrations. Material preserved in shale or siltstone can seldom be specifically identified.

Virtually all the specimens collected could be assigned to the species discussed herein. However, it is to be expected that future collections from new localities will yield further new species, owing to the fact that fossiliferous limestone beds in shale may occur at slightly different horizons at different places.

In agreement with Palmer (1962b), *Proaulacopleura* Kobayashi, 1936, *Clevelandella* Resser, 1938, and *Labiostria* Palmer, 1954, are here considered subjective synonyms of *Aphelaspis.*

The characters of the genus have been described in great detail by Palmer (1954, 1962b). Only one point concerning ornamentation will be mentioned here. The upper surface of the test in the southern Appalachian species is either perfectly smooth, or finely punctate, in some species only in the furrows (*A. inermis, A. arsoides, A. palmeri*). The inner surface is invariably very finely granulate, and the internal impression therefore finely and densely pitted. Lack of comment on ornamentation in the specific descriptions means that the outer surface is entirely smooth.

The characters most frequently used for specific discrimination are the following.

(1) The width of the palpebral area relative to the glabellar width at the same level.

(2) The sagittal length of the frontal area relative to the length of glabella, including the occipital ring.

(3) The relative sagittal lengths of preglabellar field and border. This ratio and the preceding one, although of undoubted statistical significance, were found variable within a population for some of the species (e.g., *A tarda, A. camiro*). Such variations appeared uncorrelated with either stratigraphic position or size of the cranidia.

(4) The (exsagittal) length of the palpebral lobes relative to the length of glabella inclusive of occipital ring.

(5) The (exsagittal) length of the palpebral lobe relative to the exsagittal distance between the posterior end of the palpebral lobe and the posterior cranidial margin.

(6) The (transverse) width of the posterior area relative to the width of the occipital ring.

(7) The angle of divergence of the anterior sections of the facial suture and the more or less sharp change of direction of the suture in crossing the anterior border furrow. The posterior section of the facial suture has the same course in all species.

(8) The slope of the palpebral area, also a somewhat variable feature within a population.

(9) The slope and convexity of the preglabellar field and the more or less sharp angle formed by the border with respect to the preglabellar field. These features show large intraspecific variability, e.g., in *A. laxa* and *A. tarda*.

(10) The free cheeks in some cases offered useful characteristics in the features of the border and genal spine.

(11) The pygidia may be virtually indistinguishable for several species. In other cases species whose cranidia are very similar may show quite different pygidia.

All the species previously described from Virginia and Tennessee by Walcott (1916a) and Resser (1938a) could be found again, represented by more abundant and better preserved material, and with three exceptions are discussed herein. *Saratogia aruno* Walcott and *Clevelandella nitida* Resser are specifically undetermined forms of *Aphelaspis* possessing an occipital spine, presumably identical with either *A. arses* or *A. arsoides*. *Aphelaspis hamblenensis* is based on a complete exoskeleton flattened and weathered in shale; since individuals so preserved do not preserve the specific features, the name should be restricted to the holotype. In these three cases the stratigraphic position of the type specimens is unknown.

APHELASPIS WALCOTTI Resser

Plate 18, figures 10–20

Aphelaspis walcotti RESSER, 1938a, p. 59, pl. 13, fig. 14.
Aphelaspis walcotti Resser, PALMER, 1962b, p. 33, pl. 4, figs. 24, 28, 33.
Aphelaspis simulans RESSER, 1938a, p. 59, pl. 13, figs. 19–21.

Available material.—The hypodigm of *A. walcotti* consists of several cranidia, free cheeks, and pygidia, moderately well preserved and exfoliated. The types of *A. simulans* also include cranidia, free cheeks, and pygidia. Abundant material from the author's collections at various localities is also available.

Description.—Cranidium with less relief than average in the genus. Glabella defined by a shallow axial furrow on outer surface, weakly convex. Preglabellar field moderately downsloping and somewhat convex. Border flat, forming sharp angle with preglabellar field. Frontal area on average 0.6 times the length of glabella plus occipital ring. Sagittal length of border averaging slightly less than the length of preglabellar field. Palpebral area of average width, from slightly upsloping to horizontal. Ocular ridges very faint, almost transverse to slightly slanted backward. Palpebral lobe averaging somewhat more than one-third the length of glabella plus occipital ring; distance from posterior end of palpebral lobe to posterior margin greater than length of palpebral lobe. Anterior section of facial suture with average divergence; anterior angles of cranidium more widely rounded than in most species. Width (tr.) of posterior area less than width of occipital ring.

Free cheek with ocular platform of low convexity. Border slightly concave, upturned, not defined by furrow or sharp change in slope. Genal spine flat on upper side, of less than average length, rather rapidly tapered.

Pygidium 3 times as wide as long. Anterior margin almost straight; anterior angles sharp. Axis short, showing 2 or 3 rings plus a terminal section. Pleural lobes flat, with furrows and interpleural grooves, almost indistinct on outer surface, well marked on internal impression. Border flat, very narrow medially.

Length of largest cranidium collected 15 mm.

Discussion.—Careful examination of the types of *Aphelaspis simulans* and additional topotype material preserved in the U.S. National Museum indicates that the species may be definitely synonymized with *A. walcotti*. *Aphelaspis simulans* is based on a population showing a slightly greater relief of the cranidial parts than the average in *A. walcotti*, in particular, definitely upsloping palpebral area; however, the differences are not consistent among individual cranidia and fall within the range of variability observed within a single population. The pygidium also fully agrees with that of typical *A. walcotti*.

The species is closest to *A. bridgei, A. quadrata,* and *A. tarda.* The differences will be discussed in describing these species.

Palmer (1954) assigned to *Aphelaspis walcotti* material from Texas which seems to include excessive variation to represent a single species. The Texas pygidia differ considerably from the Tennessee forms, hence it appears doubtful that the species exists in Texas. Cranidia from Wyoming illustrated by Shaw (1956) certainly do not belong to the species.

Occurrence.—The type locality is U.S.N.M. 10u, near Saltville, Va. The type locality for *A. simulans* is U.S.N.M. 117d, near Washburn, Grainger County. Collected by the author at localities cnq/4, cnr/15, cnr/16, cnq/16, cnr'/17, and cnq/20.

Types.—Holotype and paratypes: U.S.N.M. 94923. Holotype and paratypes of *Aphelaspis simulans:* U.S.N.M. 94925–6. Plesiotypes: U.S.N.M. 144632–4.

APHELASPIS BRIDGEI Rasetti, new species

Plate 13, figures 1–7

Available material.—Large numbers of cranidia and less numerous free cheeks and pygidia well preserved in limestone.

Description.—Glabella defined by a shallow axial furrow, of usual shape. Occipital furrow shallow, occipital ring bearing a small node. Frontal area about 0.55 times as long as glabella. Preglabellar field somewhat convex longitudinally; border sharply defined by border furrow and change in slope, slightly convex, approximately horizontal; sagittal length of border almost equaling preglabellar field. Palpebral area slightly downsloping, 0.4 times as wide as glabella. Average exsagittal length of palpebral lobe 0.34 times length of glabella plus occipital ring and 0.84 times distance from posterior end of palpebral lobe to posterior cranidial margin. Ocular ridges faint, somewhat slanted backward. Width (tr.) of posterior area 0.8 times the width of the occipital ring.

Free cheek with flat border defined by shallow border furrow; genal spine flat on upper side, of moderate length.

Pygidium about 2.8 times as wide as long. Axis tapered, showing 2 or 3 well-defined rings and a terminal section. Anterior outline of pleural region almost straight, without apparent geniculation. Anterior angles rounded, posterior margin regularly curved. Three pairs of pleural furrows very distinct; interpleural grooves faint. Furrows and grooves not extending to narrow, flat border.

Surface of all parts of test smooth. Length of large cranidium 10 mm. Length of largest pygidium 4.3 mm., width 12 mm.

Discussion.—This species is very close to *A. walcotti,* from which

it may be distinguished, at least statistically, by the slightly downsloping palpebral area, flat rather than concave border of the free cheeks, and more deeply furrowed pygidium. In some respects the species is transitional between *A. lata* and *A. walcotti.*

Occurrence.—U.S.G.S. collection 2804, from N. slope of Shields Ridge on New Market–Piedmont road, in upper part of lower limestone unit of the Nolichucky. The association with *Blountia bristolensis* and *Glaphyraspis ornata* shows that the species belongs to the lower portion of the *Aphelaspis* zone. The author was unable to collect fossils from this portion of the zone at the locality. The nearby locality at Russell Gap yielded fossils of the basal *Aphelaspis* zone, including, in ascending order, *Aphelaspis lata* and *A. minor.* The present species presumably occurs in higher beds, but lower than those which yielded *Aphelaspis camiro, A. laxa,* and *A. quadrata* at their type locality, U.S.N.M. 120, which is also on the New Market–Piedmont road.

Types.—Holotype: U.S.N.M. 144635. Paratypes: U.S.N.M. 144636.

APHELASPIS QUADRATA Resser

Plate 18, figures 1–9

Aphelaspis quadrata Resser, 1938a, p. 59, pl. 13, figs. 16–17.

Available material.—The holotype is a large, somewhat incomplete cranidium. The collection from the type locality includes several cranidia and pygidia, from which a clear picture of the specific characters can be gathered. The species was collected by Dr. Oder and the writer from the Three Springs, Washburn, and Smith Hollow sections. Free cheek and pygidium were unequivocally identified.

Description.—Glabella of average shape and convexity, defined by a well-impressed axial furrow. Preglabellar field downsloping, of moderate and fairly uniform convexity. Border averaging two-thirds of the sagittal length of preglabellar field, upturned and hence forming a sharp angle with the preglabellar field, almost flat; border furrow uniformly curved. Frontal area on average 0.50 times as long as glabella inclusive of occipital ring. Palpebral area slightly convex, horizontal to slightly upsloping. Ocular ridges definitely slanted backward. Length of palpebral lobe 0.25 times length of glabella plus occipital ring, and 0.7 times distance from posterior end of palpebral lobe to posterior margin. Anterior section of facial suture with average divergence. Width (tr.) of posterior area equals width of occipital ring.

Free cheek with fairly convex ocular platform. Border flat, upturned. Genal spine relatively short, rapidly tapered.

Pygidium 2.3 times as wide as long. Anterior margin definitely curving backward. Axis elevated, tapered, showing 3 rings plus a terminal section. Pleural lobes with distinct furrows and shallower interpleural grooves even on outer surface. Border flat, narrower medially; margin with slight median inbend.

Length of largest cranidium about 15 mm.

Discussion.—This species may be compared with *A. laxa* and *A. walcotti.* From *laxa* it differs consistently in the somewhat more convex glabella, less bulging preglabellar field, more posterior position of the eyes, and shorter (tr.) posterior area. The pygidium is proportionately narrower and more strongly furrowed. Compared with *A. walcotti, A. quadrata* has a cranidium with greater relief, lesser relative sagittal length of border relative to preglabellar field, and the pygidium has a more curved anterior margin.

Occurrence.—The type locality is U.S.N.M. 120, Shields Ridge. Although material under this label includes collections from different horizons, the association of the species with *A. camiro* and *A. laxa* is proved by the occurrence of the three species on the same piece of rock. Also collected by the author at localities cns/15, cns/16, cnr/20 and cnr′/20, in association with the equally common *A. camiro* and rare specimens of *A. laxa.*

Types.—Holotype and paratypes: U.S.N.M. 94924. Plesiotypes: U.S.N.M. 144637–8.

APHELASPIS TARDA Rasetti, new species

Plate 20, figures 1–18

Available material.—Large numbers of cranidia, free cheeks, and pygidia from several localities, both preserving the test and exfoliated.

Description.—Glabella of average shape and convexity; occipital ring bearing a median node. Frontal area averaging 0.65 times the glabellar length, but showing wide variation in this ratio, uncorrelated with size, locality, or horizon. Preglabellar field more or less convex longitudinally; border flat, forming sharp angle with preglabellar field. Sagittal length of border on average half of that of preglabellar field; this ratio is also highly variable. Palpebral area and lobe always more or less upsloping; palpebral area from 0.3 to 0.4 times as wide as glabella. Ocular ridges transverse to slightly slanted backward. Length of palpebral lobe about 0.4 times glabellar length and equal to distance to posterior margin. Width (tr.) of posterior area 0.8 times the width of occipital ring.

Free cheeks with border furrow distinct and border of variable width, flat to somewhat convex. Genal spine subcylindrical, rather flat on upper side, wide at the base, of moderate length.

Pygidium 2.5 times as wide as long. Axis showing 2 or 3 distinct rings on outer surface. Anterior outline of pleural lobes gradually curving backward without sharp geniculation, anterior angles more or less rounded. Pleural platforms with very faint furrows on outer surface; border furrow and border indefinite.

Length of largest cranidium 18 mm. Length of largest pygidium 4 mm., width 10 mm.

Discussion.—The numerous populations of this species observed show individual variability, especially in the relative proportions of border, preglabellar field, and glabellar length. Single cranidia with short preglabellar field and long border may be confused with *A. walcotti* and possibly other species. However, statistically the species is fairly well defined. The considerable length of the preglabellar field in most individuals, the upsloping palpebral area, definite flat border and border furrow on the free cheeks, and the characteristic pygidium with well-rounded anterior angles clearly distinguish a population of *A. tarda* from one of *A. walcotti*. The two species are rather widely separated stratigraphically, and no transition forms were observed in intermediate beds.

Occurrence.—Common at every locality where fossiliferous beds of the upper *Aphelaspis* zone are developed. The type locality is cnw/20, Washburn. Also present in collections cnu/1, cnv/1, cnw/1, cnw/14, cnu/15, cnv/15, cnx/20, cnu/21, cnv/21 and Oder's collection No. 14A. The species is also common in beds cnu/7, cnv/7 and cnv'/7 in the Purchase Ridge section, Scott County, Va.

Types.—Holotype: U.S.N.M. 144639. Paratypes: U.S.N.M. 144640–2.

APHELASPIS LAXA Resser

Plate 12, figures 18–21; plate 13, figures 8–15

Aphelaspis laxa Resser, 1938a, p. 60, pl. 13, fig. 18.

Available material.—The holotype is an exfoliated cranidium lacking the palpebral lobes and part of the anterior border. Several paratype cranidia are much better preserved, and further topotype material exists in the U.S. National Museum collections. The species also occurs in several of the author's collections, represented by cranidia, free cheeks, and pygidia.

Description.—Glabella of low convexity, rising little above the level of the cheeks, but defined at least laterally by a rather deep axial furrow. Frontal area about 0.6 times the glabellar length. Preglabellar field strongly convex longitudinally, hence sloping down steeply to border furrow. Border almost flat, horizontal; sagittal length of border

more than half the length of preglabellar field. Palpebral area 0.4 times as wide as glabella, approximately horizontal; ocular ridges faint, with transverse course. Sagittal length of palpebral lobe 0.3 times the glabellar length, and about 0.6 times the distance from posterior end of palpebral lobe to posterior margin. Width (tr.) of posterior area 1.1 times the width of occipital ring.

Free cheek with relatively convex ocular platform, and wide, flat border upturned with respect to platform. Genal spine broad at base, rather rapidly tapered, flat on upper side, in most specimens somewhat curving upward. Depression at end of posterior border furrow deeper than in most species of the genus.

Pygidium definitely identified from collections where the species occurs alone. Pygidium about 3 times as wide as long; anterior margin fairly straight, anterior angles narrowly rounded. Axis tapered, showing 2 and sometimes 3 rings plus a terminal section. Two or three pairs of broad, shallow pleural furrows usually visible; some specimens also show a trace of interpleural grooves.

Length of largest cranidia 16 mm. Length of largest pygidium 5 mm., width 15 mm.

Discussion.—The species is well distinguished, at least statistically, by the low glabella, strongly convex preglabellar field, anterior position of the eyes, and considerable width (tr.) of the posterior area. However, single cranidia, especially if incompletely preserved, may be confused with such species as *A. walcotti, A. quadrata,* and *A. tarda.* The pygidium resembles those of *A. walcotti* and *A. bridgei.*

Occurrence.—The type locality is U.S.N.M. 120 on Shields Ridge; beds holding this species are not now exposed at that locality. The stratigraphic position of the species is well established by its occurrence in the author's collections cns/4, cns/15, cns/16, cns'/15, cnr/20, and cnr'/20.

Types.—Holotype and paratypes: U.S.N.M. 94929. Plesiotypes: U.S.N.M. 144643–5.

APHELASPIS PALMERI Rasetti, new species

Plate 14, figures 13–19

Available material.—Several cranidia, free cheeks, hypostomes, and pygidia.

Description.—Glabella of average shape and convexity; occipital ring bearing a small node. Preglabellar field convex longitudinally, steeply downsloping in anterior portion, forming sharp angle with horizontal, slightly convex border. Preglabellar field about one and one-half times as long (sag.) as border; entire frontal area about

three-fourths the length of glabella plus occipital ring. Border furrow showing in most specimens a slight median inbend. Palpebral area half of the glabellar width, slightly upsloping; ocular ridge transverse. Palpebral lobe 0.4 times the length of glabella plus occipital ring; distance to posterior cranidial margin slightly greater than length of palpebral lobe. Anterior facial sutures slightly more divergent than the average in the genus; anterior angles of cranidium more widely rounded than in most species. Posterior area as wide (tr.) as occipital ring. Free cheek with wide border well defined anteriorly, the border furrow fading out posteriorly; genal spine convex on upper face, rather long, somewhat curving inward.

Pygidium somewhat more than twice as wide as long. Axis occupying somewhat less than a third of the width, tapered, showing at least on internal impression 3 rings plus a terminal section, extended into a broad, low postaxial ridge. Anterior outline of pleural lobes and furrows curving backward, producing well-rounded anterior angles. Doublure fairly wide laterally, reduced medially. Posterior margin rather straight in median portion, with suggestion of a slight median notch.

Surface of cranidium and free cheeks punctate in the furrows, especially in the anterior border furrow where the puncta are larger. Length of largest (holotype) cranidium 20 mm. Length of pygidium 2.6 mm., width 5.5 mm.

Discussion.—The cranidium is somewhat similar to *A. laxa* in the longitudinal profile of the frontal area, differing from that species in the proportionately longer (sag.) border, more widely rounded anterior angles, longer palpebral lobe, lesser distance from palpebral lobe to posterior margin, narrower (tr.) posterior area, and punctate surface. The pygidium is unlike *A. laxa* and much more like *A. tarda* in the lesser relative width and rounded sides. The rather strong divergence of the anterior facial sutures and median inbend of the border furrow give the cranidia of this species some resemblance to *Aphelaspidella macropyge,* but the pygidium is definitely of the *Aphelaspis* type.

Occurrence.—The type locality is U.S.G.S. 2970, Monroe County, where it occurs in association with *Aphelaspidella macropyge, Aphelaspis arses,* and *Paraphelaspis vigilans.* These species indicate the lower portion of the middle *Aphelaspis* zone. A few, imperfect cranidia in the collection cnq'/4 from the Lost Creek section may belong to this species, but, especially in the absence of the pygidia, cannot be distinguished with certainty from *A. laxa.* The stratigraphic position would confirm the assignment indicated above.

Types.—Holotype: U.S.N.M. 144646. Paratypes: U.S.N.M. 144647.

APHELASPIS CAMIRO (Walcott)

Plate 12, figures 1–17

Crepicephalus camiro Walcott (part), 1916a, p. 205, pl. 32, figs. 2, 2′.
Uncaspis camiro (Walcott) Kobayashi, 1935, p. 279.
Aphelaspis camiro (Walcott) Resser, 1938a, p. 60, pl. 13, fig. 27.

Available material.—Resser properly restricted the name to Walcott's holotype cranidium, excluding the pygidium which not only does not belong to the species, but probably is a trilobite of the *Crepicephalus* zone. The hypodigm includes a number of paratype cranidia well preserved in limestone. The species was collected at other localities by Dr. Oder and the author. From these collections the proper free cheek and pygidium could be identified unequivocally. Many of these pygidia were then discovered in the collection from the type locality in the U.S. National Museum.

Description.—Glabella somewhat smaller in proportion to the cranidium than in other species of the genus. Occipital ring bearing a small node near the posterior margin. Frontal area unusually long, averaging 0.8 times the glabellar length; as in other species, however, this ratio varies considerably among the individuals from one bed. Anterior sections of facial sutures diverging at average angle, making the cranidium very wide between the anterior angles. Border furrow better impressed than usual in the genus. Border slightly convex, its sagittal length averaging two-thirds the length of preglabellar field; border furrow showing in most, but not all, specimens a definite median inbend, and generally pitted on the outer surface. Preglabellar field as a whole rather flat, showing a low median boss. Palpebral area upsloping, about half the glabellar width. Ocular ridges transverse to slightly slanted backward. Palpebral lobe averaging 0.3 times the glabellar length, and about 0.5 times the distance from posterior end of palpebral lobe to posterior margin. Posterior area at least as wide (tr). as occipital ring. Length of largest observed cranidium 22 mm.

Free cheek with distinct, flat border set off by definite furrow, deeper in anterior portion, and long, slowly tapered genal spine, flat on the upper side.

Pygidium on average 1.75 times as wide as long, with a somewhat pointed shape. Axis relatively large, prominent, tapered, rounded posteriorly, showing 3 very distinct rings plus a terminal section. Anterior outline of pleural lobes after a short transverse course turning backward like the first pair of pleural furrows. Two other pairs of furrows may be faintly indicated. Border furrow and border poorly defined. Length of largest pygidium 3.8 mm., width 6.8 mm.

Discussion.—This is one of the most distinctive species of *Aphelaspis*. Larger cranidia may be distinguished by the long frontal area.

upsloping palpebral area, flat preglabellar field with a more or less distinct preglabellar boss, and anterior position of the eyes. The pygidium is unique in its relatively long and narrow shape and well-rounded sides. Immature cranidia, however, are not always easily distinguishable from those of associated species.

Occurrence.—The type locality is U.S.N.M. 120, Shields Ridge (see discussion of *A. quadrata* and *A. laxa*). Also collected by the author at localities cns/4, cns/15, cns/16, cnr/20, and cnr′/20.

Types.—Holotype and paratypes: U.S.N.M. 61672. Plesiotypes: U.S.N.M. 144648–51.

APHELASPIS ROTUNDATA Rasetti, new species

Plate 14, figures 1–12

Available material.—Numerous cranidia, free cheeks, and pygidia, and a few hypostomes. Most of the specimens lack the test.

Description.—Cranidium with low relief. Glabella and occipital ring without distinctive features. Preglabellar field slightly downsloping, with little convexity; border furrow better defined than in most species; border elevated, somewhat convex. Total length (sag.) of frontal area averaging 0.6 times the length of glabella plus occipital ring; midlength (sag.) of border about 0.3 times the midlength of preglabellar field. Palpebral area averaging somewhat less than half the glabellar width, upsloping; palpebral lobe also upsloping, defined by shallow furrow even on outer surface. Exsagittal length of palpebral lobe about 0.4 times the length of glabella plus occipital ring; exsagittal distance to posterior margin equal to length of palpebral lobe. Posterior area slender, about as wide (tr.) as occipital ring. Anterior sections of facial suture on the average more divergent than in most species, but there is considerable variability in this character among the population from a single thin bed. Free cheek with well-defined, flat border; genal spine flat dorsally at least in basal part, very long.

Pygidium twice as wide as long. Outline oval, lacking definite geniculation on anterior margin, widely rounded laterally, not notched but elevated medially. Axis stout, composed of 3 rings plus a terminal section, extended into a broad postaxial ridge that reaches the margin. Pleural platforms downsloping, giving pygidium considerable relief compared to other species. Pleural furrows and grooves shallow, the first furrow curving backward to follow the curvature of the margin. Border flat, poorly defined; doublure wide laterally, tapering medially.

Surface of test smooth, except for the genal coeca showing faintly

on outer surface on preglabellar field and ocular platform, well marked on internal impression. Length of largest cranidium 21 mm.; length of largest pygidium 7 mm., width 14 mm.

Discussion.—This is a large species, whose cranidia somewhat resemble *A. camiro.* They differ in the narrower and more elevated anterior border, proportionately longer palpebral lobes, and lesser width (tr.) of the posterior area. The free cheek and genal spine are also very similar to that species. The pygidium is quite distinctive, with a proportionately narrower axis and regularly oval rather than subtrapezoidal outline.

Unless careful attention is paid to the divergence of the anterior sections of the facial suture, cranidia of *Aphelaspis rotundata* may be confused with those of the associated species *Aphelaspidella macropyge.* Even though there is some variability in the divergence of the sutures in either species, usually well-preserved cranidia can be classified on this character alone. The pygidia are immediately distinguishable, although the pygidium of *Aphelaspis rotundata,* with its doublure wider than in most species of the genus, approaches in shape the pygidium of *Aphelaspidella.*

Occurrence.—Medial portion of the *Aphelaspis* zone, in association with *Aphelaspis arses, Aphelaspidella macropyge,* and *Paraphelaspis vigilans.* The type locality is cns/20, Washburn. Also present in collections cns/20a, Washburn, cnq"/4, Lost Creek, and cns'/15, cns"/15, Three Springs.

Types.—Holotype: U.S.N.M. 144652. Paratypes: U.S.N.M. 144653–4.

APHELASPIS WASHBURNENSIS Rasetti, new species

Plate 17, figures 15–23

Available material.—Several cranidia, free cheeks, and pygidia.

Description.—Glabella relatively small in proportion to cranidium, of low convexity but defined by a fairly deep axial furrow. Frontal area averaging 0.75 times the length of glabella plus occipital ring. Preglabellar field tumid, strongly downsloping in anterior portion; border well defined by sharp change in slope, about half as long (sag.) as preglabellar field. Palpebral area somewhat upsloping, unusually wide (somewhat more than half the glabellar width); ocular ridges transverse; palpebral lobes about 0.3 times the length of glabella plus occipital ring; distance from posterior end of palpebral lobe to posterior margin about equaling length of palpebral lobe. Anterior section of facial suture diverging at average angle; anterior angles of cra-

nidium fairly sharp. Posterior area slender, considerably wider (tr.) than occipital ring.

Free check with relatively narrow and well-defined border; border furrow becoming obsolete along posterior portion of lateral margin. Genal spine rather broad-based, flat on dorsal side, of average length.

Pygidium slightly more than twice as wide as long; axis prominent, showing 2 rings plus a terminal, indistinctly segmented section, occupying more than two-thirds of pygidial length. Pleural regions with 2 pairs of broad pleural furrows and traces of interpleural grooves; border flat, fairly wide.

Surface of test smooth except for more or less distinct puncta in the depressions, especially the anterior border furrow. Length of holotype cranidium 15 mm.

Discussion.—The combination of cranidium and pygidium forms a distinctive species. The cranidium differs from most of the known species of *Aphelaspis* in the relative width of the palpebral area; other species that have a wide palpebral area (*A. lata, A. buttsi*) are quite different in other cranidial features. The low glabella and tumid preglabellar field recall *A. laxa,* in which, however, the palpebral area is narrow and the palpebral lobes are more anteriorly situated. The pygidium resembles none of the above-mentioned species, being similar to *A. rotundata* and *A. palmeri.*

As far as can be ascertained from the scarce and mostly fragmentary material, the species is rather variable in most of its features. At both localities where it was collected, *A. washburnensis* occurs in association with another species of *Aphelaspis,* possibly the same in both cases. This second species seems somewhat intermediate between *A. walcotti* and *A. quadrata,* but the material was deemed insufficient to decide whether it should be identified with either of these two species or described as a new one. Therefore this form appears as *Aphelaspis* sp. undet. in the faunal lists.

Occurrence.—The type locality is cnq'/20, Washburn. In this section the species occurs in association with *Aphelaspidella macropyge* and *Glaphyraspis declivis,* above the strata holding *A. walcotti* and below those with *A. camiro, A. laxa,* and *A. quadrata.* In the Three Springs section, a limestone lens holding *Aphelaspis washburnensis* and possibly *Aphelaspidella macropyge* was collected at the same level (cns/15) as beds yielding *Aphelaspis camiro, A. laxa,* and *A. quadrata,* but the latter 3 species were not associated with *A. washburnensis* in the same lens. From this evidence it is clear that *A. washburnensis* occurs near the base of the middle *Aphelaspis* zone.

Types.—Holotype: U.S.N.M. 144655. Paratypes: U.S.N.M. 144656–7.

APHELASPIS BUTTSI (Kobayashi)

Plate 16, figures 1–7

Olenus cf. *truncatus* (Brünnich) Butts, 1926, pl. 9, figs. 6, 7.
Proaulacopleura buttsi Kobayashi, 1936, p. 93, pl. 15, fig. 6.
Proaulacopleura buttsi Kobayashi, Resser, 1938a, p. 95, pl. 16, fig. 18.
Aphelaspis buttsi (Kobayashi) Palmer, 1962b, p. 35, pl. 4, figs. 23, 26, 31, 32; pl. 6, fig. 15.

Large numbers of specimens, many of them complete exoskeletons like the holotype, are available from the type locality in Alabama. This material is all flattened in shale, hence identification with limestone specimens inevitably leaves some uncertainty. However, all the features of cranidium, free cheek, and pygidium, excepting the convexity that cannot be compared, match so perfectly that reference of the Tennessee material to the species seems justified. Palmer (1962b) referred to *A. buttsi,* his excellent limestone specimens from Nevada, which are identical in all respects with those from the writer's collections.

Occurrence.—The species is very abundant in collection cno/15, Three Springs, from beds containing a mixture of genera of the *Crepicephalus* and *Aphelaspis* zones. Cranidia of an *Aphelaspis* collected from the essentially equivalent beds cno/14 at Russell Gap may belong to the species, but they cannot be distinguished with certainty from *A. lata* in the absence of associated pygidia. This is the oldest *Aphelaspis* species found in Tennessee. The type locality is U.S.N.M. 91o, near Center, Ala.

Types.—Holotype: U.S.N.M. 93048. Plesiotypes: U.S.N.M. 144658.

APHELASPIS LATA Rasetti, new species

Plate 16, figures 8–20

Available material.—Large numbers of cranidia and several free cheeks and pygidia, both preserving the test and exfoliated.

Description.—Cranidium proportionately wide and short, its sagittal length equaling the width between the palpebral lobes, which is slightly greater than the width between the anterior angles. Glabella somewhat wider and shorter than in most species, of moderate convexity. Fixed cheeks not rising above the level of the axial furrow. Preglabellar field of moderate, uniform longitudinal convexity; border somewhat convex, defined by change in slope and shallow border furrow. Length of frontal area 0.6 times the length of glabella; sagittal length of border slightly less than half the length of preglabellar field. Border furrow somewhat angular on midline. Palpebral area horizontal to slightly downsloping, wider than in most

species, half as wide as glabella. Ocular ridges transverse or even slightly slanted forward. Palpebral lobe averaging 0.4 times the glabellar length. Distance from posterior end of palpebral lobe to posterior margin equal to length of palpebral lobe. Anterior section of facial suture of average divergence. Posterior area as wide (tr.) as occipital ring.

Free cheek with slightly convex border like the cranidium; genal spine flat, of average length.

Pygidium somewhat less than 3 times as wide as long, transversely subelliptical. Axis relatively long, showing 2 or 3 rings plus a terminal section, well defined on outer surface. Pleural lobes with well-impressed furrows and very shallow interpleural grooves visible on outer surface. Posterior margin slightly indented medially.

Length of largest cranidium collected 8 mm. Length of largest pygidium 3.6 mm., width 10 mm.

Discussion.—The cranidium of this species is almost indistinguishable from *A. buttsi* except for the shallower glabellar and axial furrows. Even this difference can be determined statistically only when numerous well-preserved specimens in limestone are available. The pygidium, however, is markedly distinct in possessing one less segment both in the axis and pleural lobes, and in its posterior outline which is slightly notched medially, like *A. walcotti* and several other species, rather than somewhat pointed as in *A. buttsi*. The interpleural grooves are less distinct than in that species.

Occurrence.—The type locality is cnp/14, Shields Ridge. Also collected at localities cnp/15, Three Springs, and cnp/20, Washburn. A few, small cranidia apparently identical with topotypes of the same size were recovered from considerably higher beds at locality cnr/4, Lost Creek. Since several species of *Aphelaspis* are distinguishable only from the pygidia, the identification must be considered tentative.

Types.—Holotype: U.S.N.M. 144659. Paratypes: U.S.N.M. 144660–2, 144734.

APHELASPIS TRANSVERSA Rasetti, new species

Plate 16, figures 21–27

Description.—Cranidium wide and short, of the same general proportions as in *A. lata*. Glabella of considerable transverse convexity, defined by a rather deep axial furrow at the sides, a shallower furrow in front, truncate. Occipital furrow deeper than usual in the genus; occipital ring bearing a small node. Preglabellar field with considerable convexity on midline; border furrow straight at the sides, forming a rounded, obtuse angle medially. Border sharply upturned from preglabellar field, almost flat; sagittal border length two-thirds

of length of preglabellar field. Frontal area averaging slightly over 0.6 times the glabellar length. Palpebral area rising above the axial furrow, somewhat convex, on average somewhat upsloping, half as wide as glabella. Ocular ridges stronger than in most species, transverse to slightly slanted forward. Palpebral lobes 0.4 times the glabellar length; distance from posterior end of palpebral lobe to posterior margin equal to length of palpebral lobe. Posterior area as wide (tr.) as occipital ring. Free cheek with flat genal spine of average rate of tapering.

Pygidium about 3 times as wide as long. Axis with 2 rings plus a terminal section. Pleural lobes showing only 1 distinct pair of pleural furrows.

Length of largest cranidium observed 7 mm.

Discussion.—This species resembles *A. lata* but is clearly distinguished by the depth of the axial furrow, convexity of the palpebral area, wider anterior border, and smoother pygidium.

Occurrence.—Locality cnp/17, Hurricane Hollow, in the basal bed of the *Aphelaspis* zone, a few feet above strata with typical *Crepicephalus* fauna.

Types.—Holotype: U.S.N.M. 144663. Paratypes: U.S.N.M. 144664.

APHELASPIS MINOR Rasetti, new species

Plate 19, figures 18–25

Available material.—Large numbers of cranidia and free cheeks, and a few pygidia.

Description.—Glabella of average shape and convexity; occipital furrow fairly well impressed, occipital ring bearing a low node. Preglabellar field moderately convex longitudinally; border furrow well impressed, slightly angular on midline; border convex, its midlength (sag.) less than the length of preglabellar field. Length of frontal area averaging 0.50 times length of glabella plus occipital ring. Palpebral area upsloping; palpebral lobes slightly elevated above palpebral area, set off by shallow furrow, half the length of glabella plus occipital ring. Distance from posterior end of palpebral lobe to posterior cranidial margin less than length of palpebral lobe. Ocular ridges transverse. Anterior sections of facial suture with average divergence. Posterior area about as wide (tr.) as occipital ring. Free cheek with rather flat border defined by sharp change in slope. Genal spine relatively long, rather flat on dorsal side.

Pygidium exactly 3 times as wide as long. Axis well tapered, rounded posteriorly, showing 2 rings plus a terminal section, reaching the border furrow. Pleural platforms rather convex, faintly furrowed.

Anterior outline without definite geniculation. Border and doublure very narrow throughout.

Length of largest of hundreds of cranidia observed, 7 mm. Length of largest pygidium 2.5 mm., width 7.5 mm.

Discussion.—The cranidia may not be easy to distinguish from immature examples of some of the larger species, but the combination of cranidium and pygidium characterizes the species as definitely distinct from all others. The cranidium is extremely similar to that of *A. inermis,* the distinguishing features being pointed out in the description of that species. The pygidium instead is very much like *A. walcotti* and *A. bridgei.*

Occurrence.—Lower part of the *Aphelaspis* zone, above the beds with *A. lata* and below those carrying *A. walcotti.* Type locality is cnq/17, Hurricane Hollow. Also in collections cnq/14, Shields Ridge, cnq/15, Three Springs, and cnp′/20, Washburn.

Types.—Holotype: U.S.N.M. 144665. Paratypes: U.S.N.M. 144666–8.

APHELASPIS INERMIS Rasetti, new species

Plate 19, figures 8–17

Available material.—Numerous cranidia and free cheeks, and a few tentatively assigned pygidia.

Description.—Glabella of average shape and convexity; occipital furrow shallow; occipital ring bearing a node, lacking spine. Frontal area averaging slightly less than half the glabellar length. Preglabellar field somewhat convex longitudinally especially on midline. Border defined by shallow furrow and change in slope, slightly convex, rather narrow for the genus. Anterior section of facial suture moderately divergent, straight to border furrow. Palpebral area slightly upsloping, about 0.3 times the glabellar width. Palpebral lobes set off by very shallow furrow, somewhat elevated, averaging 0.3 times the glabellar length and somewhat less than distance from posterior margin. Width (tr.) of posterior area equal to width of occipital ring. Free cheek with slightly convex border defined by shallow furrow. Genal spine oval in cross section, rather thick and long.

Pygidia associated with the cranidia in more than one collection are transversely subelliptical, about 2.5 times as wide as long. Axis very prominent, equally long and wide, rounded posteriorly, with 1 distinct ring. Pleural lobes with 2 pairs of furrows and indistinct interpleural grooves, all ending in flat border which is wider laterally than medially.

Surface of test pitted in furrows of cranidium and free cheek, but not as coarsely as in *A. arsoides.* Length of unusually large cranidium 9 mm. Most of the specimens do not exceed 6 mm.

Discussion.—This species is very similar to *A. arsoides* in all proportions. Apart from lack of an occipital spine, it may be distinguished at least statistically by the lesser divergence of the anterior section of the facial suture, greater convexity of the preglabellar field, slightly upsloping palpebral area, and convex instead of flat genal spine. It is also very similar to *A. minor,* with which it had been confused before large collections were made. It may be distinguished from that species by the usually slanted instead of transverse course of the ocular ridge, sharper anterior angles of the cranidium, slightly smaller palpebral lobe, and lesser average slope of the palpebral area. The pygidia are quite different, the one of *A. minor* being proportionately shorter and wider, with narrower border and furrows extending almost to the margin. The pygidium of *A. inermis* is more like that of *A. arses.* The present species and *A. minor* occupy different stratigraphic positions, and no transition forms are known from intermediate beds.

Occurrence.—The type locality is cns/2, Shields Ridge. Also present in collections cnr/4, cns/4 and cnt/4. It occurs in association with *A. tumifrons* or *A. arsoides.*

Types.—Holotype: U.S.N.M. 144669. Paratypes: U.S.N.M. 144670–1.

APHELASPIS TUMIFRONS Resser

Plate 19, figures 1–7

Aphelaspis tumifrons Resser, 1938a, p. 60, pl. 13, fig. 15.

Available material.—The hypodigm includes the holotype and several other cranidia in fair state of preservation. Abundant and well-preserved new specimens from various localities allow a more complete description.

Description.—Glabella poorly defined on upper surface by a very shallow axial furrow. Occipital furrow shallow; occipital ring bearing a node. Frontal area averaging 0.45 times the glabellar length. Preglabellar field with definite median boss. Border defined by somewhat gradual change in slope, of average width medially, almost vanishing at the sides. Anterior cranidial margin slightly pointed medially. Palpebral area approximately horizontal, about 0.3 times the glabellar width; palpebral lobe more or less upsloping, not defined by palpebral furrow on outer surface. Average exsagittal length of palpebral lobe 0.4 times the glabellar length and 0.8 times the distance to posterior margin. Ocular ridges wide, almost undefined on outer surface, somewhat slanted backward. Transverse width of posterior area 0.8 times width of occipital ring. Free cheek with somewhat convex ocular platform, broad and vaguely defined border furrow, and fairly long, cylindrical genal spine.

Pygidium more than twice as wide as long. Axis strongly tapered, usually showing 1 distinct ring plus a terminal unsegmented section, almost reaching posterior margin. Anterior outline of pleural lobe with sharp geniculation situated about midway from axial furrow to anterior angle. Two pairs of broad pleural furrows and somewhat indistinct pleural grooves are visible on upper surface. Border narrow all along posterior margin, poorly defined by shallow border furrow.

In some specimens fine puncta are present in the furrows on cranidium and free cheeks. Length of largest cranidium observed among several hundred specimens 10 mm. The overwhelming majority of the cranidia do not exceed 7 mm. Length of largest pygidium 1.6 mm., width 4.0 mm.

Discussion.—This is a distinctive species, that can seldom be confused with other forms of *Aphelaspis* even if only a small sample is available. The main characteristics are the shallowness of the axial furrow, the tumid preglabellar field, the poorly defined anterior border, and the relatively anterior position of the eyes.

Occurrence.—The species is usually extremely abundant when present, and represents an excellent index fossil for the upper portion of the middle *Aphelaspis* zone. The type locality is U.S.N.M. 119, S. of Morristown, Hamblen County. Present in the author's collections cns/1, cnt/1, cns/2, cnt/4, cnt/7, cns/15, cnt/15, cnt'/15, cnt/20, cnt/21, and in Oder's collection No. 14.

Types.—Holotype: U.S.N.M. 94927. Plesiotypes: U.S.N.M. 144672.

APHELASPIS PUNCTATA Rasetti, new species

Plate 18, figures 21–29

Available material.—Numerous cranidia and free cheeks and a few pygidia.

Description.—Glabella of usual shape and convexity; axial furrow with deep pits at anterior corners of glabella. Frontal area markedly convex in front of glabella; border furrow well impressed, forming rounded angle on midline; border convex, averaging in midlength (sag.) one-third of length of preglabellar field. Entire frontal area over half the length of glabella plus occipital ring. Palpebral area somewhat upsloping; palpebral lobes elevated above palpebral area, half the glabellar length, defined by distinct furrow. Distance from posterior end of palpebral lobe to posterior cranidial margin less than length of palpebral lobe. Anterior sections of facial suture with average divergence; anterior angles of cranidium very sharp. Posterior area equal in width (tr.) to occipital ring. Free cheek with narrow, convex border. Genal spine rapidly tapered, fairly flat on dorsal side;

posterior border furrow with shallow extension on proximal portion of genal spine.

Associated pygidium with large axis, wider than pleural lobes, elevated, rounded at the extremity, showing 3 poorly defined rings plus a terminal section. Anterior outline of pleural lobes showing geniculation not far from axial furrow, then bending backward rather sharply; posterior margin with maximum curvature on midline. One pair of pleural furrows well impressed, two other pairs shallow and rather indistinct. Border narrow, poorly defined by border furrow.

Surface of cranidium and free cheeks almost entirely covered with fine, dense puncta. Surface of pygidium also punctate. Length of largest cranidium 8 mm. Length of pygidium 2.1 mm., width 3.7 mm.

Discussion.—The cranidium of this species would be distinctive even without the unique feature of the punctate surface because of the deep pits in the axial furrow, the roll in front of the glabella, and the elevated palpebral lobes. All these features tend to give the species an aspect approaching *Dytremacephalus angulatus*. The pygidium is also distinctive in shape, having a proportionately larger axis than other species of *Aphelaspis*.

Occurrence.—Uppermost beds of the *Aphelaspis* zone, in association with *Aphelaspis tarda*. The type locality is cnw/14, Shields Ridge, but the species is less rare at locality cnw/20, Washburn.

Types.—Holotype: U.S.N.M. 144673. Paratypes: U.S.N.M. 144674–5.

APHELASPIS ARSES (Walcott)

Plate 13, figures 16–23

Saratogia arses Walcott, 1916a, p. 196, pl. 35, figs. 4–4b.
Clevelandella arses (Walcott) Resser, 1938a, p. 69, pl. 13, fig. 22.

Available material.—The hypodigm consists exclusively of the holotype, a good cranidium in limestone. Collections by the author supplied numerous cranidia and free cheeks and a few pygidia.

Description.—Glabella of average shape and convexity. Occipital furrow well defined throughout, deeper than in most species of the genus. Occipital ring bearing a small node and, in addition, a long, slender, somewhat upturned spine. Frontal area averaging half the length of glabella (exclusive of spine). Preglabellar field slightly convex longitudinally. Border narrow, defined by shallow furrow and change in slope, in most specimens definitely convex. Anterior sections of facial suture quite straight from palpebral lobe to border furrow. Palpebral area slightly convex, horizontal to slightly upsloping, averaging 0.3 times the glabellar width. Ocular ridges broad but distinct, slanted backward. Palpebral lobes set off by distinct furrow on upper

surface, relatively narrow, about 0.3 times the glabellar length and equaling the distance to posterior cranidial margin. Posterior area about as wide (tr.) as occipital ring. Free cheek with slightly convex border defined by shallow furrow; genal spine oval in cross section, fairly long, tapering to sharp point.

Pygidium associated with the cranidia transversely subelliptical, twice as wide as long. Axis prominent, showing 2 rings plus a terminal section, almost reaching margin. Pleural lobes with 2 more or less distinct pairs of broad furrows and very weak interpleural grooves. Anterior outline regularly curved, anterior angles rounded. Border furrow and border undefined.

Surface of test smooth. Length of largest cranidium (exclusive of spine) 7 mm. Length of pygidium 2 mm., width 4 mm.

Discussion.—The assignment of the species to *Aphelaspis* was justified in the discussion of the genus. *Aphelaspis arses* may be distinguished from most species of the genus, apart from the occipital spine, by the better than average definition of the occipital ring and palpebral lobe. The closest relatives are two species described herein, *A. arsoides* and *A. inermis;* the differences are mentioned in their discussion.

Occurrence.—The type locality is U.S.N.M. 173, near Maryville. The exposures in that area were very poor and may now be concealed in built-up areas. The author's material was collected from localities cnr/4 and cns/4, Lost Creek, cns/20, Washburn, and cns'/15, Three Springs.

Types.—Holotype: U.S.N.M. 61617. Plesiotypes: U.S.N.M. 144676, 144733.

APHELASPIS ARSOIDES Rasetti, new species

Plate 11, figures 15–21; plate 12, figure 22

Available material.—Large numbers of cranidia and free cheeks from several localities, and a few pygidia.

Description.—Glabella rather flat, defined by shallow axial furrow. Occipital furrow shallow; occipital ring extended into long, slender, almost horizontal spine, not bearing a node. Frontal area from 0.5 to 0.7 times the glabellar length. Preglabellar field with very slight longitudinal convexity; border of average width, defined by furrow and change in slope, more or less convex. Anterior sections of facial suture straight to border furrow, diverging at somewhat greater angle than in most species, including *A. arses.* Palpebral area horizontal to slightly downsloping, about 0.3 times the glabellar width. Ocular ridges distinct, slanted backward. Palpebral lobe almost undefined by furrow on upper surface, about 0.3 times the glabellar length, and equaling the distance to posterior margin. Posterior area somewhat

narrower (tr.) than occipital ring. Free cheek with flat border well defined by lateral border furrow, which, however, becomes indistinct before meeting posterior border furrow, as in all species of *Aphelaspis*. Genal spine flat, of average length. Facial suture cutting posterior margin somewhat farther from genal angle than in *A. arses*.

Surface distinctly pitted in furrows on cranidium and free cheeks, especially in border furrow. Length of unusually large cranidium exclusive of spine, 13 mm.; the majority do not exceed 8 mm.

Pygidium transversely ovate, two and one-half times as wide as long. Axis stout, showing 2 rings and a terminal section, almost reaching the margin. Pleural lobes almost flat and horizontal. Anterior and posterior outlines slightly and regularly curved, lateral angles well rounded. Anterior pleural furrow distinct, distally curving backward to parallel the margin; another pair of furrows indistinct. The surface in the depressions in some specimens is pitted as in the cranidium and free cheeks. Length of largest pygidium 3.5 mm., width 8.5 mm.

Discussion.—This species can be distinguished from the closely related *A. arses* by the shallower axial furrow, almost horizontal palpebral area, indistinct palpebral furrow, the characteristic pitted surface in the depressions of the test, and somewhat different shape and flat border of the free cheek.

Occurrence.—This species occupies a somewhat higher stratigraphic position than *A. arses* and is frequently associated with *A. tumifrons*. The type locality is cns/2. Also present in collections cns/1, cnt/1, cnt/4, cns/15, cnt/15, cnt'/15, cnt/20, cnt'/20, cnt/21, and Oder's collection No. 14.

Types.—Holotype: U.S.N.M. 144677. Paratypes: U.S.N.M. 144678–80.

Genus APHELASPIDELLA Rasetti, new genus

Description.—Cranidium similar to *Aphelaspis,* except in the very strong divergence of the anterior sections of the facial suture. Free cheek as in *Aphelaspis,* with long genal spine. Pygidium proportionately much larger than in *Aphelaspis*. Axis occupying less than half the length, extended into a postaxial ridge. Pleural lobes wide, with little relief, with shallow furrows and grooves and a wide, concave border; doublure very wide.

Discussion.—The very close relationship to *Aphelaspis* is obvious. However, the different course of the anterior section of the facial suture and the pygidial characters are important enough to deserve generic recognition.

Type species.—*Aphelaspidella macropyge* Rasetti, n. sp.

Occurrence.—*Aphelaspis* zone of the southern Appalachians.

APHELASPIDELLA MACROPYGE Rasetti, new species

Plate 11, figures 1–8

Available material.—Numerous cranidia, free cheeks, and pygidia excellently preserved in limestone.

Description.—Cranidium of low general convexity. Glabella straight-sided, subtruncate in front, of low convexity, defined by a shallow axial furrow. Glabellar furrows barely indicated on outer surface; occipital furrow shallow, occipital ring short (sag.) and simple. Frontal area 0.8 times the glabellar length; preglabellar field convex, slightly downsloping; border furrow deep, with a median inbend; border somewhat convex, wide medially, tapering in width at the sides. Palpebral area half as wide as the glabella, slightly upsloping. Ocular ridges faint, transverse. Palpebral lobes 0.3 times the length of glabella plus occipital ring, defined by a very shallow palpebral furrow. Anterior sections of facial suture forming an angle of almost 60° with the median line; anterior angles of cranidium more widely rounded than in any species of *Aphelaspis;* marginal portion of suture about one-third the length of anterior cranidial margin, as in most *Aphelaspis* species. Posterior section of facial suture first directed backward, curving outward, then again somewhat backward, defining slender posterior area identical with that of most *Aphelaspis* species. Free cheek with well-defined lateral border.

Pygidium twice as wide as long, subelliptical. Axis rapidly tapered, showing 3 rings and a terminal section, less than half the pygidial length, extended into a long postaxial ridge. Three pairs of increasingly shallow pleural furrows and less distinct interpleural grooves are visible; the furrows extend, very broad and shallow, even across the wide, concave border. The inner edge of the doublure is clearly apparent on the upper surface.

Surface of test smooth, except for a dense row of puncta in the anterior border furrow. Length of largest cranidium 18 mm. Length of largest pygidium 9 mm., width 18 mm.

Occurrence.—The type locality is author's locality cnr/4, Lost Creek. Also common in collections cns/20, cns/20a, Washburn, and present in collections cns"/15, Three Springs, and U.S.G.S. 2970. In the U.S. National Museum there is a collection of cranidia and pygidia of the species from locality 173, marked "Maryville, Tenn." which is also the type locality for *Aphelaspis arses.*

Types.—Holotype: U.S.N.M. 144681. Paratypes: U.S.N.M. 144682.

Genus PARAPHELASPIS Rasetti, new genus

Description.—Cranidium with considerable relief. Glabella well tapered, truncate in front, fairly convex transversely, defined by a deep

axial furrow laterally. Occipital furrow and ring as in *Aphelaspis*. Frontal area less than half the glabellar length, downsloping. Preglabellar field slightly convex; border narrow, elevated. Palpebral area narrow, upsloping; palpebral lobe elevated, opposite anterior third of glabella. Posterior area narrower (tr.) than occipital ring, broadly triangular, rather strongly downsloping. Anterior section of facial suture as in *Aphelaspis*. Free cheek wide, steeply downsloping; ocular platform somewhat convex; border narrow. Facial suture cutting posterior margin rather far from genal angle; genal spine short and slender. Size small. Surface smooth except for puncta in the depressions.

Discussion.—The close affinity with *Aphelaspis* is obvious. Nevertheless the genus appears to deserve recognition because of the greater relief of the cranidial parts, in particular the elevation of the palpebral area and lobe and the downsloping attitude of the free cheek and posterior area. Another distinguishing feature is the anterior position of the eyes. The cranidia of *Paraphelaspis* resemble immature cranidia of *Aphelaspis* rather than adult individuals of that genus. Possibly we have a case of paedogenesis, *Paraphelaspis* representing an offshoot of the *Aphelaspis* stock preserving immature features in sexually mature individuals.

One should also mention the resemblance of the genus to *Kujandaspis* Ivshin (type species: *Kujandaspis kujandensis* Ivshin, 1956), which seems also to represent another close relative of *Aphelaspis*. In *Kujandaspis* the glabella is relatively smaller and the eyes do not have such an anterior position as in *Paraphelaspis*.

Type species.—*Paraphelaspis vigilans* Rasetti, n. sp.

Occurrence.—*Aphelaspis* zone of the southern Appalachians.

PARAPHELASPIS VIGILANS Rasetti, new species

Plate 21, figures 14–28

Available material.—Numerous cranidia and free cheeks.

Description.—Glabella strongly tapered, truncate in front, defined by a deep axial furrow at the sides, a shallower furrow in front. One or two shallow pairs of lateral furrows visible even on outer surface, of the same pattern as in *Aphelaspis*. Occipital furrow well marked; occipital ring bearing a node. Frontal area 0.4 to 0.5 times as long as glabella plus occipital ring, proportionately longer in larger cranidia. Preglabellar field with a more or less pronounced convexity in front of the glabella; border furrow regularly curved; border length (sag.) less than half the preglabellar field; border convex, elevated. Palpebral area very narrow, proportionately wider in larger cranidia, more or less strongly upsloping; ocular ridges distinct, very short, directed somewhat forward. Palpebral lobe somewhat less than 0.3

times as long as glabella plus occipital ring, set off by shallow but distinct furrow even on outer surface; its anterior end almost at the level of the front of the glabella, its posterior end slightly anterior to level of glabellar midpoint. Distance to posterior margin about twice length of palpebral lobe. Anterior section of facial suture straight to border furrow, divergent as the average in *Aphelaspis;* posterior section directed straight outward and backward, curving rather sharply backward before cutting posterior margin at right angle, defining much longer (exsag.) and narrower (tr.) posterior area than in *Aphelaspis* species; width of posterior area less than width of occipital ring.

Free cheek proportionately wide, evidently steeply sloping. Ocular platform convex near the eye. Border furrow shallow and broad; border narrow, convex as in cranidium. Facial suture cutting margin at considerable distance from short, slender genal spine. The pygidium has not been identified.

Length of largest among hundreds of cranidia observed 5.5 mm.

Discussion.—It was mentioned in the generic description that *Paraphelaspis* resembles immature individuals of *Aphelaspis* in several respects. This also agrees with the fact, apparent from the description and the illustrations, that the similarity to *Aphelaspis* increases with increasing size of the cranidia of *Paraphelaspis,* especially in the features of greater relative length of the frontal area and width of the palpebral area. Nevertheless, there are still considerable differences between the largest cranidia of *Paraphelaspis vigilans* and individuals of the same size of all the known species of *Aphelaspis.* In particular, immature cranidia of the two species of *Aphelaspis* that occur in association with *Paraphelaspis* are known and are quite different from *Paraphelaspis.* Of all species of *Aphelaspis, A. inermis* is possibly closest to *Paraphelaspis.*

Occurrence.—The type locality is cns/20, Washburn. Also present in collections cns/20a, Washburn, cnr/4, Lost Creek, cns′/15, cns″/15, Three Springs, and U.S.G.S. 2970. The species has been found only in association with *Aphelaspidella macropyge.*

Types.—Holotype: U.S.N.M. 144683. Paratypes: U.S.N.M. 144684–5.

Genus DYTREMACEPHALUS Palmer, 1954

Type species.—*Dytremacephalus granulosus* Palmer.

DYTREMACEPHALUS ANGULATUS Rasetti, new species

Plate 21, figures 1–9

Available material.—Large numbers of cranidia, a few free cheeks and pygidia in excellent state of preservation.

Description.—Glabella tapered, straight-sided, truncate in front, of moderate convexity, defined by deep axial furrows at the sides, a

shallow furrow in front. A pair of deep pits in furrow at anterior corners of glabella. Three shallow pairs of lateral furrows visible on upper surface. Occipital furrow deep at the sides, shallow medially; occipital ring long (sag.), bearing a node. Preglabellar field swollen in posterior portion, rising above the frontal portion of the axial furrow, downsloping in anterior portion; border furrow wide with strong curvature on midline, giving it an angular aspect. Border about half as long (sag.) as preglabellar field, upturned, convex, tapering at the sides. Entire frontal area half as long as glabella inclusive of occipital ring. Palpebral area slightly more than half as wide as glabella, slightly convex and upsloping from the axial furrow. Ocular ridges distinct, moderately slanted backward. Palpebral lobes defined by furrow even on outer surface, fairly wide, not rising above palpebral area, 0.4 times as long as glabella. Distance from palpebral lobe to posterior cranidial margin considerably shorter than palpebral lobe. Anterior sections of facial suture moderately divergent as in *Aphelaspis,* straight to border furrow. Posterior area as in *Aphelaspis,* narrower (tr.) than occipital ring. Free cheek with well-defined, convex border and border furrow; ocular platform more convex than in species of *Aphelaspis;* genal spine short, rapidly tapered, flat on upper side.

Thorax preserved in complete exoskeletons in shale. One small individual appears to have 12 segments; however, the larger thorax illustrated herein, attached to the pygidium but lacking the cephalon, shows 13 segments, and this seems to be the number in the holaspid, as in the species of *Aphelaspis* where the thorax is known. The pleurae are straight proximally, curving backward to short falcate extension distally, and are furrowed through all their length, much as in *Aphelaspis.*

Pygidium with considerable convexity. Axis occupying one-third of the width, almost reaching margin, strongly elevated, showing 3 to 5 distinct rings plus terminal section, rounded posteriorly. Pleural platforms steeply downsloping, with strong furrows and distinct interpleural grooves. Border flat, wide at the sides, almost vanishing medially, as the axis almost attains the margin. Anterior margin curving backward, almost attaining longitudinal course; angles fairly sharp; posterior margin straight laterally, forming fairly sharp angle medially.

Surface of cranidium finely and densely granulate except in the furrows. Border of cranidium and free cheek with terrace lines. Ocular platform granulate like the cranidium. Ornamentation of pygidium indistinct. Length of largest cranidium 6.5 mm. Fragments indicate that the species attains a somewhat larger size. Length of largest pygidium 2.4 mm., width 6 mm.

Discussion.—This trilobite, obviously a very close relative of *Aphe-*

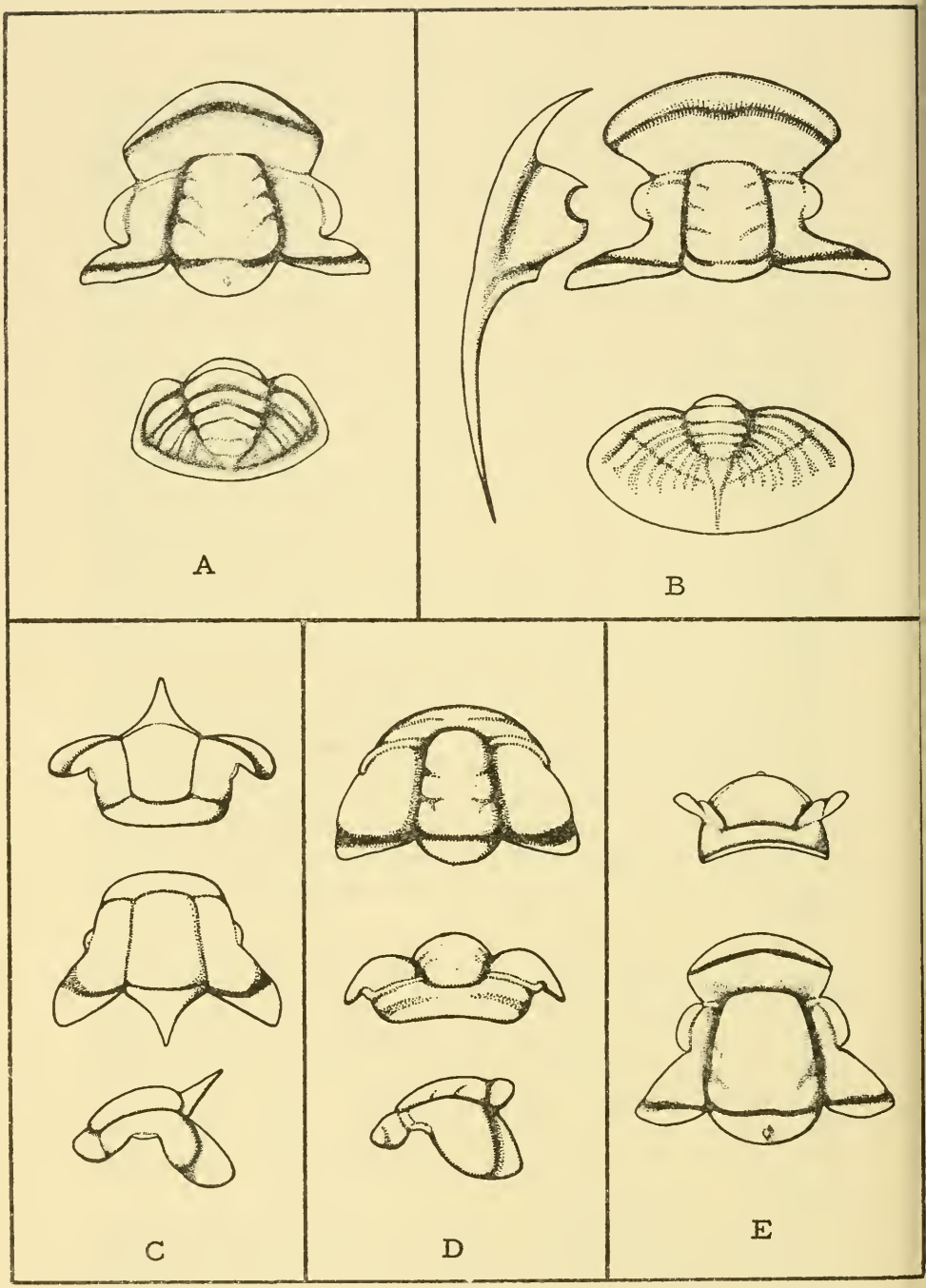


FIG. 2.—A, *Dytremacephalus angulatus* Rasetti, n. sp. Cranidium, pygidium. B, *Aphelaspidella macropyge* Rasetti, n. gen., n. sp. Cranidium, free cheek, pygidium. C, *Loxoparia obliqua* Rasetti, n. gen., n. sp. Frontal, dorsal, and lateral views of cranidium. D, *Hawkinsia minuta* Rasetti, n. gen., n. sp. Dorsal, frontal, and lateral views of cranidium. E, *Paraphelaspis vigilans* Rasetti, n. gen., n. sp. Frontal and dorsal views of cranidium.

laspis, seems best referred to *Dytremacephalus,* although the palpebral area is wider than in *D. granulosus* and the palpebral lobe larger and more posterior in position. The frontal and palpebral areas are more like *D. laevis* Palmer (1954). In Nevada, Palmer (1965) finds two species of *Dytremacephalus* in the lower part of the *Dunderbergia* zone. In view of the somewhat questionable assignment of the present species to the genus, this fact should not be attributed much significance for correlation. *Dytremacephalus angulatus* differs from all species of *Aphelaspis* in the deep axial furrows, more posterior position of the eyes, granulate surface, and shortness of the genal spine.

One should also note the considerable similarity of the cranidia of this trilobite to *Acrocephalaspis fidus* Ivshin (1956) from Kazakhstan, where it occurs in association with *Aphelaspis,* and hence may be taken to be approximately of the same age as the present species. Unfortunately Ivshin's material includes only cranidia. Ivshin compared *Acrocephalaspis* with *Acrocephalites,* but, judging from the illustrations, his new genus seems very close to *Aphelaspis.* It is also possible that *Aphelaspis* and *Acrocephalites* are closely related.

Occurrence.—Mainly characteristic of the uppermost portion of the *Aphelaspis* zone in Tennessee, usually associated with *Aphelaspis tarda.* The type locality is cnw/14, Shields Ridge. Also present in collections cnw/1, cnx/1, cnv/15, and U.S.G.S. 2969. A single specimen was found in the collection cnt/4, from somewhat lower beds here assigned to the upper portion of the middle *Aphelaspis* zone.

Types.—Holotype: U.S.N.M. 144686. Paratypes: U.S.N.M. 144687–9.

DYTREMACEPHALUS SULCIFRONS Rasetti, new species

Plate 12, figures 23–25

Available material.—Two cranidia from different localities.

Description.—Cranidium as a whole and glabella with greater longitudinal convexity than in preceding species. Glabella with 2 fairly deep pairs of lateral furrows, a third pair very short and shallow, more rounded anteriorly than in *D. angulatus.* Shallow portion of axial furrow shorter than in preceding species. Palpebral area, palpebral lobes, and course of facial sutures as in *D. angulatus.* Surface ornamentation of the same type. Length of cranidium 6 mm.

Discussion.—The differences from *D. angulatus* were pointed out in the description. This may be an extreme case of variation within that species; however, in the absence of intermediate forms, it is described as a representative of an associated, rare species. It resembles the type species of the genus.

Occurrence.—The holotype is from collection cnw/14, Shields Ridge; the paratype from collection cnx/1, Big Creek.

Types.—Holotype: U.S.N.M. 144690. Paratype: U.S.N.M. 144691.

DYTREMACEPHALUS STRICTUS Rasetti, new species

Plate 21, figures 10–13

Available material.—Several cranidia and one tentatively assigned pygidium.

Description.—Glabella as in *D. angulatus,* defined by a deeper furrow in front. Occipital ring unusually short (sag.), set off by a deep occipital furrow, bearing a small node. Pits at anterior corners of glabella marked in some individuals. Preglabellar field convex longitudinally, somewhat shorter than in *D. angulatus;* border furrow not distinctly angulate as in that species; border somewhat less elevated. Palpebral area somewhat convex, upsloping, from one-third to one-half the glabellar width; ocular ridges slightly slanted backward. Palpebral lobe, posterior area, and facial sutures as in *D. angulatus.* Granulation of surface rather indistinct.

The pygidium tentatively assigned to the species is proportionately shorter and wider than *D. angulatus* and has fewer segments both in the axis and the pleural lobes.

Discussion.—The species was compared in the description with *D. angulatus,* from which the cranidium differs essentially in the proportionately larger glabella. As it appears from the illustrations, considerable variation occurs among the specimens, all from one small piece of rock.

Occurrence.—Locality U.S.G.S. 2970, Vonore quadrangle, Monroe County, in association with *Aphelaspidella macropyge, Aphelaspis palmeri,* and other species.

Types.—Holotype: U.S.N.M. 144692. Paratypes: U.S.N.M. 144693.

PTYCHOPARIIDA OF UNCERTAIN AFFINITIES

Genus BONNETERRINA Lochman, 1936

Type species.—*Bonneterrina prima* Lochman.

BONNETERRINA APPALACHIA (Walcott)

Plate 2, figures 10–18

Lonchocephalus appalachia Walcott, part, 1916a, p. 190, pl. 35, figs. 6, 6a, 6c.
Lonchocephalus appalachia Walcott, Resser, 1938a, p. 86, pl. 10, fig. 30.
Bonneterrina appalachia (Walcott) Palmer, 1954, p. 726, pl. 80, fig. 9.

The species is one of the most common and readily recognizable fossils of the uppermost beds of the Maryville formation in the Rogers-

ville area. A considerable amount of variability is present in the cranidia; since the various forms intergrade and occur in the same bed, it would be improper to split the species, even though the extremes in the range of variation might suggest such action.

The main variable features are the convexity of the glabella and the entire cranidium; the depth of the axial furrow; the direction of the occipital spine, varying from almost horizontal to upturned at 45 degrees; the distinctness of the occipital furrow; the relative width and convexity of the anterior border. The figured cranidia show some of these features. The largest cranidium has a length of 15 mm. exclusive of the spine.

The pygidium, although less common than the cranidium, can be assigned with virtual certainty. It is about twice as wide as long, regularly rounded posteriorly. Axis occupying almost entire length, tapered, with 3 prominent rings and a terminal section, bearing a large upright spine on the first ring. Pleural lobes convex and downsloping, with 3 pairs of broad pleural furrows and 2 pairs of narrower interpleural grooves, all reaching almost to the margin; border furrow shallow, border narrow, poorly defined. Length of largest pygidium 9 mm., width 18 mm.

The pygidium closely resembles that of *Shickshockia cristata* (Rasetti, 1946), and the cranidium also has similar features. It is questionable whether *Shickshockia* should be maintained as a distinct genus.

Occurrence.—Uppermost beds of Maryville and basal beds of Nolichucky formation (*Cedaria* zone). Type locality is U.S.N.M. 123a, 4 miles NE. of Rogersville. Collected by the author at localities cnc/1 to cnc/6 in the Maryville limestone and localities cnd/1, cnd/2 in the red beds of the Nolichucky.

Types.—Holotype: U.S.N.M. 61719. Paratypes: U.S.N.M. 61721, 61722. Plesiotypes: U.S.N.M. 144703–6.

Genus CHEILOCEPHALUS Berkey, 1898

Type species.—Cheilocephalus stcroixensis Berkey.

CHEILOCEPHALUS BREVILOBUS (Walcott)

Plate 17, figures 1–5

Lisania? breviloba Walcott, 1916b, p. 404, pl. 66, figs. 3–3c.
Pseudolisania breviloba (Walcott) Kobayashi, 1935, p. 162.
Pseudolisania breviloba (Walcott) Resser, 1938a, p. 96, pl. 16, fig. 17.
Cheilocephalus breviloba (Walcott) Palmer, 1954, p. 759, pl. 88, figs. 1–4 (includes complete synonymy up to 1954).
Cheilocephalus brevilobus (Walcott) Lochman and Hu, 1962b, p. 436, pl. 69, figs. 1–24.

The species is common in the basal beds of the *Aphelaspis* zone in Tennessee. The largest cranidium observed has a length of 20 mm. and a width between the tips of the posterior area of 40 mm. The largest pygidium has a length of 21 mm. and a width of 34 mm.

The free cheek has never been described. Fragments are common in association with other parts of the exoskeleton, but it is difficult to prepare good specimens. The free cheek has a concave border not differentiated from the ocular platform by a furrow. The facial suture cuts the posterior margin very close to the genal angle. This is extended into a short, flat, triangular genal spine. Hence the suture does not have a proparian course, as some authors have conjectured.

Occurrence.—The types are from an unspecified horizon in the Nolichucky formation at U.S.N.M. locality 118a, near Greeneville, Greene County. Collected by the author at localities cno/14, cnp/14, cnq/14, cnp/17.

Types.—Holotype: U.S.N.M. 62852. Paratypes: U.S.N.M. 62853–4. Plesiotypes: U.S.N.M. 144707–8.

CHEILOCEPHALUS BRACHYOPS Palmer

Plate 17, figures 6–11

Cheilocephalus brachyops PALMER, 1965, p. 105, pl. 1, figs. 12–15, 17.

A species of *Cheilocephalus* that occurs in the upper *Aphelaspis* zone fully agrees in all characters of cranidium and pygidium with the species, described from the *Dunderbergia* zone in Nevada.

Occurrence.—Collections cnx/1, Big Creek, and cnw/14, Shields Ridge.

Types.—Plesiotypes: U.S.N.M. 144709–10.

CHEILOCEPHALUS, species undetermined

Plate 17, figures 12–14

Rare specimens of *Cheilocephalus* that occur in the middle portion of the *Aphelaspis* zone possess a frontal area short as in *C. brachyops,* but flat and lacking the raised border of that species. The surface shows indistinct ornamentation. The pygidium is like both *C. brevilobus* and *C. brachyops.* A close comparison is made uncertain by the fact that all the specimens in question are small and obviously immature. Hence it will be left undecided whether this form should be assigned to a new species.

Occurrence.—The figured specimens are from locality cnr/4, Lost Creek. Also present in collections cns/4, cns/2, and U.S.G.S. 2970.

Disposition of material.—Figured specimens: U.S.N.M. 144711.

Genus COENASPIS Resser, 1938

Type species.—*Coenaspis spectabilis* Resser.

COENASPIS SPECTABILIS Resser

Plate 5, figures 1–3

Coenaspis spectabilis Resser, 1938a, p. 69, pl. 16, fig. 9.

The only new information about this rare trilobite is its stratigraphic position.

Occurrence.—Beds of the lower *Cedaria* zone at the top of the Maryville formation. The type locality is U.S.N.M. 123a, near Rogersville. One cranidium was collected by the writer at locality cnc/3, close to or identical with the preceding.

Types.—Holotype: U.S.N.M. 94978.

Genus HAWKINSIA Rasetti, new genus

Description.—Very small trilobites. Cranidium subtrapezoidal, rather convex. Glabella moderately convex, defined by deep axial furrow, tapered, with short, shallow lateral furrows. Occipital furrow deep, occipital ring simple. Frontal area short (sag.), convex and downsloping, barely differentiated into preglabellar field and border. Ocular ridges well marked, subtransverse, curved. Palpebral area convex, as wide as glabella; palpebral lobes small and inconspicuous, situated far in advance of glabellar midpoint. Posterior area large, deeply furrowed. Facial sutures showing little change of direction between anterior and posterior section in dorsal view; in lateral view there is a marked angle. Anterior sections convergent, curving inward, rounding off the anterior cranidial outline. Posterior section first running outward and backward, gradually curving backward and finally slightly inward, giving the cranidium a sharp posterolateral angle.

Type species.—*Hawkinsia minuta* Rasetti, n. sp.

Discussion.—Although the known specimens of the type species are quite small, the fact that they are all about the same size suggests that they are not immature. In any case, *Hawkinsia* could not be the immature form of any of the larger trilobites known from the same beds. No plausible affinities of the genus can be suggested. The name is derived from Hawkins County, where the type species occurs.

Occurrence.—Upper Cambrian (*Cedaria* zone) of the southern Appalachians.

HAWKINSIA MINUTA Rasetti, new species

Plate 3, figures 22–25

Available material.—Several cranidia preserved in limestone.

Description.—The generic description includes most of the known

characters of the species. The glabella shows 2 pairs of short, rather shallow lateral furrows; those of the posterior pair show a tendency to bifurcate. The occipital ring is rounded, lacking spine or node. The frontal area is divided about equally into preglabellar field and border by an excessively shallow furrow, which becomes obsolete medially. The surface of the test is very finely granulate. Length of holotype cranidium 2.2 mm., width at posterior end 3.3 mm.

Occurrence.—Uppermost beds of the Maryville limestone (*Cedaria* zone) at locality cnc/1.

Types.—Holotype: U.S.N.M. 144712. Paratypes: U.S.N.M. 144713.

Genus ITHYCEPHALUS Resser, 1939

Type species.—*Ithycephalus typicalis* Resser.

ITHYCEPHALUS TYPICALIS Resser

Plate 1, figures 10–12

Ithycephalus typicalis Resser, 1938a, p. 82, pl. 9, fig. 10.

A perfect cranidium of this rare species is figured.

Occurrence.—Type locality U.S.N.M. 27d; red beds at the base of the Nolichucky (*Cedaria* zone) east of Rogersville. The figured specimen is from the same beds and locality (author's locality cnd/1). One specimen was also collected from the underlying uppermost beds of the Maryville limestone (loc. cnc/1).

Types.—Holotype: U.S.N.M. 94841. Plesiotype: U.S.N.M. 144714.

Genus MODOCIA Walcott, 1924

Type species.—*Arionellus (Crepicephalus) oweni* Meek and Hayden.

Three genera have been considered synonyms of *Modocia: Armonia* Walcott, 1924 (type species, *Armonia pelops* Walcott); *Metisia* Resser, 1937 (type species, *Ptychoparia metisensis* Walcott); and *Semnocephalus* Resser, 1942 (type species, *Solenopleura? weedi* Walcott (part)).

A question arises concerning the status of the genus *Syspacheilus* Resser, 1938 (type species, *Syspacheilus typicalis* Resser). Palmer (1954) discussed the problem of assigning a pygidium to *Syspacheilus*. He attributed to cranidia identified as *Syspacheilus camurus* Lochman pygidia indistinguishable from *Coosella*. Lochman and Hu (1961) attributed to *S. dunoirensis* (Miller) and a new species, *Syspacheilus praecedens,* short pygidia of the generalized ptychoparioid type.

The latter assignment seems unquestionable, in view of the abun-

dance of the material and of the almost identical association of cranidia and pygidia observed by the author in other areas. Then, if Palmer's pygidium is correctly attributed, we must conclude that there are two genera of trilobites with indistinguishable cranidia and very different pygidia, not an unusual situation. In that case it would be impossible at present to decide which one is *Syspacheilus,* since there is no reliable assignment of a pygidium to the type species.

Whatever the solution of this problem may be, the author sees no reason to maintain the use of *Syspacheilus* for the species with a short pygidium, typified by *Syspacheilus praecedens,* which are almost identical with *Metisia metisensis* (Rasetti, 1963). If these forms are sufficiently distinct from *Modocia oweni* to warrant generic recognition, then they should be referred to *Metisia* accepted as a valid genus. Possibly the same arguments apply to *Talbotina* (at least as represented by *T. juweli* Lochman, in Lochman and Duncan, 1944) and *Ithyektyphus* Shaw (1956), (Lochman and Hu, 1960).

In conclusion, it seems best at present to restrict the use of *Syspacheilus* to the type species until the characters of the genus are clarified.

MODOCIA DUBIA (Resser)

Plate 1, figures 22–26

Asaphiscus? agatho Walcott (part), 1916b, p. 391, pl. 63, fig. 9a (only).
Ehmania dubia Resser, 1938a, p. 75, pl. 9, figs. 18, 19.
Uncaspis tennesseensis Resser, 1938a (part), p. 105, pl. 9, fig. 21 (only).

Three species of *Modocia* are common in the red beds at the base of the Nolichucky, and two of them were also collected at various localities in the underlying beds of the Maryville formation. Through association in several instances it was possible to obtain an unambiguous assignment of the pygidia to the respective cranidia.

Description.—Entire cranidium of moderate convexity. Glabella moderately convex, proportionately wide and short, strongly tapered, rounded in front, bearing a trace of furrows on outer surface. Preglabellar field flat; border not greatly elevated or convex, about as wide (sag.) medially as the preglabellar field. Palpebral area slightly convex and downsloping; ocular ridges faint; palpebral lobes one-third the glabellar length, placed about parallel to the axial furrow, defined by a sharp palpebral furrow, situated well in advance of glabellar midpoint. Posterior area long (exsag.), deeply furrowed. The anterior sections of the facial sutures are barely divergent. The surface of the test is densely and finely granulate. Length of larger cranidia 12 mm.

Pygidium twice as wide as long. Axis stout and prominent, showing two distinct rings, and in some specimens a less distinct third ring,

plus a terminal section, almost reaching posterior margin. Pleural regions of low convexity, with almost equally deep pleural furrows and interpleural grooves, curving back distally and almost reaching the margin. Border furrow and border almost indistinct. Length of a large pygidium 6.5 mm., width 13 mm.

Discussion.—This form differs from the type species in many details of the cranidium, such as the lesser prominence of the glabella, lesser divergence of the anterior sections of the facial suture, and more anterior position of the eyes.

Occurrence.—The type locality is U.S.N.M. 27d; red beds at the base of the Nolichucky (*Cedaria* zone) near Rogersville. Collected by the author at the same locality (cnd/1) and also in the uppermost beds of the underlying Maryville limestone (localities cnc/1 to cnc/6).

Types.—Holotype and paratypes: U.S.N.M. 94845. Paratype of *Asaphiscus ? agatho:* U.S.N.M. 62820. Paratype of *Uncaspis tennesseensis:* U.S.N.M. 94846. Plesiotypes figured herein: U.S.N.M. 144715–6.

MODOCIA BIDENTATA Rasetti, new species

Plate 1, figures 13–21

Available material.—Numerous cranidia and pygidia in limestone.

Description.—Glabella rather convex, rising above the cheeks, relatively narrow and long, unfurrowed. Occipital furrow well marked; occipital ring short, simple. Frontal and palpebral areas downsloping; preglabellar field longer (sag.) than border width; border well defined, slightly convex, tapered in width at the sides. Palpebral area about half the glabellar width; ocular ridges faint; palpebral lobes located somewhat in advance of glabellar midpoint. Anterior sections of facial suture somewhat divergent; posterior section curving backward, producing blunt posterior area.

Pygidium of same general proportions as in preceding species, not greatly convex transversely. Axis as in preceding species. Pleural regions with pleural furrows and interpleural grooves of progressively decreasing strength. First pleural segment extended into a pair of short, backward-directed marginal spines.

Surface of test smooth. Length of largest cranidium 17 mm. Length of largest pygidium 8.5 mm., width 17 mm.

Discussion.—The cranidial proportions are fully typical of *Modocia.* The chief distinguishing feature is the pair of short pygidial spines. This character is not uncommon in several genera of late Medial Cambrian and Dresbachian ptychoparioid trilobites, e.g., in species of *Ehmaniella.*

Occurrence.—Red beds at the base of the Nolichucky (*Cedaria* zone) E. of Rogersville (locality cnd/1).

Types.—Holotype (pygidium): U.S.N.M. 144717. Paratypes: 144718.

MODOCIA CRASSIMARGINATA Rasetti, new species

Plate 2, figures 1–9

Available material.—Numerous cranidia and pygidia well preserved in limestone.

Description.—Glabella rather plump, defined by a deep axial furrow, rounded in front, unfurrowed; occipital furrow well impressed, occipital ring simple. Preglabellar field downsloping, short (sag.), on the average shorter than the border width (sag.), although there is variability in this character. Border convex, wide (sag.). Ocular ridges faintly indicated; palpebral lobes narrow, defined by a shallow palpebral furrow, about 0.3 times the glabellar length, somewhat in advance of level of glabellar midpoint. Palpebral area convex, on average downsloping, 0.4 times the glabellar width. Anterior sections of facial suture somewhat divergent, curving inward after crossing the border furrow, rounding off the anterior cranidial angles. Posterior section first directed outward, curving backward, rounding off the extremity of the posterior area which is deeply furrowed.

Pygidium with a stout, barely tapered, well-rounded axis showing 3 rings and a terminal section, not reaching the margin. Pleural regions transversely downsloping and convex longitudinally, showing 3 pairs of well-impressed furrows and 2 pairs of slightly shallower interpleural grooves, all fading out toward the margin without the presence of any defined border furrow or border.

Surface of test with inconspicuous ornamentation. Some of the cranidia show a punctate surface, the puncta being small and so dense as to produce the effect of a fine granulation; other cranidia appear almost smooth. Pygidia where the test is preserved show a very fine granulation.

Length of the largest cranidia 17mm. Length of largest pygidium 6.5 mm., width 14 mm.

Discussion.—Species of this type were assigned to *Syspacheilus* (see discussion of *Modocia*); for example, the present form does not seem to differ greatly from *Syspacheilus camurus* Lochman (1940), *S. dunoirensis* (Miller), as figured by Lochman and Hu (1961), and *S. praecedens* Lochman and Hu (1961). From the latter two forms, where the pygidium is known, the present species differs in the more deeply furrowed pleural lobes. *Armonia pelops* Walcott is also close to

the present species, but an accurate comparison is difficult since all the type material is more or less flattened. It would seem that *Armonia pelops* has a proportionately narrower glabella and a more nearly triangular pygidium. *Metisia metisensis* (Walcott) is almost identical in the proportions and convexity of all the cranidial parts, but the surface ornamentation is coarser, and the pygidium has a definite border and is not turned down marginally as in the present form.

Occurrence.—Uppermost beds of Maryville limestone (*Cedaria* zone). Type locality cnc/2; also common at localities cnc/1, cnc/3 to cnc/6. Also occurring in the red beds at the base of the Nolichucky at locality cnd/1.

Types.—Holotype: U.S.N.M. 144719. Paratypes: U.S.N.M. 144720–23.

MODOCIA ? AGATHO (Walcott)

Plate 1, figures 27–30

Asaphiscus? agatho WALCOTT (part), 1916b, p. 391, pl. 63, fig. 9 (only).
Ehmania? agatho (Walcott) RESSER, 1938b, p. 29.

Available material.—Walcott based the species on the holotype cranidium and assigned to it a pygidium on the same piece of limestone. The author's collections, however, indicate that the pygidium belongs to the more common, associated species *Modocia dubia.* A pygidium believed to belong to the species is present in the collection from the type locality. The author collected several cranidia and one pygidium.

Description.—Glabella of moderate convexity, fairly straight-sided, moderately tapered, rounded in front, with a bare trace of lateral furrows on outer surface. Occipital furrow well marked; occipital ring subtriangular, rounded. Frontal area downsloping, rather flat, divided into preglabellar field and border by a shallow furrow, not accompanied by much change in slope. Ocular ridges present; palpebral area convex, on average horizontal, one-third the glabellar width. Palpebral lobes 0.3 times the glabellar length, narrow, defined by shallow palpebral furrow, situated at the level of glabellar midpoint and hence more posterior in position than in the 3 preceding species. Anterior sections of facial suture definitely divergent; posterior section directed outward from palpebral lobe, curving backward distally; posterior area almost parallel-sided, rounded distally, deeply furrowed; surface smooth.

Pygidium tentatively assigned to the species 2.2 times as wide as long. Anterior margin fairly straight. Axis stout, not greatly tapered, showing 2 rings plus a terminal section. Pleural regions with little convexity, almost horizontal, showing several pairs of furrows and interpleural grooves; only the first pair of furrows fairly deep. All furrows and grooves extend to a shallow border furrow that sets off a slightly elevated border. Surface very finely granulate.

Length of largest cranidium 6 mm. Length of pygidium 3.5 mm., width 7.5 mm.

Discussion.—This species cannot be given a satisfactory generic assignment. The cranidium differs from typical *Modocia* in the lack of a convex anterior border, horizontal rather than downsloping palpebral area, more posterior position of the eyes, and parallel-sided rather than tapered posterior area. In all these features it closely resembles cranidia of *Marjumia typa.* However, if the pygidium is correctly assigned, it is rather indicative of *Modocia;* spinose pygidia of the *Marjumia* type were not recovered from the Maryville formation.

Occurrence.—The type locality is U.S.N.M. 123a, near Rogersville. Also collected by the author in the same area at localities cnc/2 to cnc/5. The species belongs to the lower *Cedaria* zone faunule of the uppermost Maryville limestone.

Types.—Holotype: U.S.N.M. 62819. Plesiotypes: U.S.N.M. 144724–6.

Genus LOXOPARIA Rasetti, new genus

Description.—Cranidium subtrapezoidal, moderately convex. Glabella moderately convex, unfurrowed, rising above the cheeks, with slightly concave side outline, subtruncate in front, reaching the border. Occipital furrow well marked; occipital ring extended into spine. Frontal area flat, consisting only of border; border furrow present at the sides, merging with axial furrow medially. Palpebral area somewhat over half the glabellar width, convex, downsloping; ocular ridges barely distinct, strongly slanted; palpebral lobes short and narrow, inconspicuous, situated in advance of glabellar midpoint. Anterior sections of facial sutures directed forward from palpebral lobes, curving inward; anterior angles of cranidium widely rounded. Posterior section of facial suture directed outward and backward, fairly straight for half its course, then curving backward and finally somewhat inward. Posterior area of fixed cheeks large, downsloping, extending backward much farther than glabella, sharply pointed. Furrow on posterior area deep, first directed outward and then curving forward; posterior margin of posterior area straight, strongly slanted outward and backward.

Type species.—*Loxoparia obliqua* Rasetti, n. sp.

Discussion.—The shape of the glabella and frontal area are suggestive of *Llanoaspis* and related forms; however, the characters of the palpebral area, palpebral lobes, and course of the posterior section of the facial sutures are radically different. The affinities of this trilobite are obscure.

Occurrence.—Upper Cambrian (*Cedaria* zone) of the southern Appalachians.

LOXOPARIA OBLIQUA Rasetti, new species

Plate 3, figures 7–9

Available material.—Three cranidia preserved in limestone.

Description.—The generic description and the illustrations present all the observable characters of the species. The axial and border furrows are shallow on the outer surface. The occipital ring has a subtriangular shape, extending into a broad-based, short spine. Surface of test perfectly smooth. Length of largest cranidium 7 mm.

Occurrence.—Red beds at the base of the Nolichucky (*Cedaria* zone) at locality cnd/1.

Types.—Holotype: U.S.N.M. 144727. Paratypes: U.S.N.M. 144728.

UNDETERMINED TRILOBITES

Undetermined Cranidium No. 1

Plate 8, figure 29

Known from a single, incomplete specimen. Glabella large, rising well above the cheeks, almost straight-sided, strongly tapered, rounded in front. Occipital furrow deep and straight; occipital ring short (sag.), extended into an uptilted spine of unknown length. Posterior glabellar furrows fairly deep, bifurcated, with the shorter anterior branch transverse, the longer posterior branch turning backward. Two other pairs of lateral furrows short, the anteriormost one very shallow. Preglabellar field almost vanishing medially; border slightly convex, not greatly arched transversely. Palpebral area and lobe not preserved. Incomplete posterior area deeply furrowed, the furrow turning forward in the distal part. Surface covered with medium-sized granules. Length of cranidium, exclusive of occipital spine, 4 mm.

Although this trilobite cannot be referred to any described genus, the incomplete material does not warrant a new name. Possibly the nearest known forms are certain species of *Genevievella.*

Occurrence.—Uppermost beds of the lower limestone member of Nolichucky (*Crepicephalus* zone) at locality cnn/3.

Disposition of material.—Figured specimen: U.S.N.M. 144729.

Undetermined Cranidium No. 2

Plate 8, figure 19

Known from a single, incomplete specimen. Glabella very convex, defined by a deep axial furrow, strongly tapered to a pointed anterior end which is somewhat truncate. Surface of glabella mostly broken off; lateral furrows, if present, must have been very shallow. Occipital fur-

row broad and deep; occipital ring short (sag.), but extended into a very long, uptilted spine. Frontal area consisting of convex, downsloping, preglabellar field and elevated, convex, transversely arched border. Ocular ridges wide and fairly prominent, directed slightly forward from the glabella, curving slightly to assume a transverse direction. Palpebral area somewhat wider than glabella, rising above the axial furrow and strongly convex transversely. Palpebral lobes and posterior area not preserved. Surface of glabella and fixed cheeks covered with granules of different sizes. Length of cranidium 4.2 mm. exclusive of occipital spine.

This cranidium, remarkable for the pointed glabella, wide palpebral area, and forward-directed ocular ridges, cannot be assigned to any described genus. No affinities can be suggested, beyond its inclusion in the great ptychoparioid group.

Occurrence.—Lower portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnk/1.

Disposition of material.—Figured specimen: U.S.N.M. 144730.

Undetermined Pygidium No. 1

Plate 6, figure 8

Known from a single example. Pygidium 2.5 times as wide as long. Axis prominent, tapered, showing 3 rings plus a terminal section, reaching the border furrow. Pleural region with a straight anterior outline, rounded anterior angles, and posterior margin fairly straight on either side, slightly pointed medially. Three pairs of rather deep pleural furrows and shallow interpleural grooves are present. Border furrow shallow, border very narrow.

This pygidium somewhat resembles the pygidia of *Llanoaspis,* differing in its shortness and small number of pleural furrows. No cranidium to which it may be assigned was collected from the same beds.

Occurrence.—Lower portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnk/1.

Disposition of material.—Figured specimen: U.S.N.M. 144731.

Undetermined Pygidium No. 2

Plate 6, figures 20, 21

Known from several examples. Pygidium of low convexity, 1.75 times as wide as long. Axis long, tapered, straight-sided, extended into a sharp postaxial ridge that reaches the posterior margin. Seven or eight axial rings separated by shallow furrows are distinguishable. Pleural regions with straight anterior outline, well-rounded anterior angles, and regularly semicircular posterior margin except for a shal-

low median notch. Five pairs of shallow, broad pleural furrows end very sharply on the line corresponding to the margin of the doublure. The remaining portion of the pleural regions is smooth and flat or slightly concave. Surface of test smooth. Length of largest pygidium 6 mm., width 10.7 mm.

This pygidium may belong to *Coosia* or a related trilobite. It differs from the usual pygidia of *Coosia* in the great relative length of the axis. No corresponding cranidium was collected.

Occurrence.—Upper portion of lower limestone member of the Nolichucky (*Crepicephalus* zone) at locality cnm/2. One specimen was collected from the lower portion of the same limestone at locality cnk/1.

Disposition of material.—Figured specimens: U.S.N.M. 144732.

REFERENCES

Bell, W. Charles, and Ellinwood, H. L.

1962. Upper Franconian and lower Trempealeauan Cambrian trilobites and brachiopods, Wilberns formation, central Texas. Journ. Paleontol., vol. 36, pp. 383–423.

Bridge, Josiah.

1956. Stratigraphy of the Mascot–Jefferson City zinc district. U.S. Geol. Surv. Prof. Pap. 277, pp. 1–76.

Butts, Charles.

1926. Geology of Alabama. Geol. Surv. Alabama, Spec. Rep. No. 14, pp. 40–230.

Hall, G. M., and Amick, H. C.

1934. The section on the west side of Clinch Mountain, Tennessee. Journ. Tennessee Acad. Sci., vol. 9, pp. 157–168, 195–220.

Hall, James.

1863. Preliminary notice on the fauna of the Potsdam sandstone. New York State Cabinet Nat. Hist., 16th Rep., pp. 119–222.

Hall, James, and Whitfield, R. P.

1863. Paleontology. U.S. Geol. Explor. 40th Parallel, Rep., vol. 4, pp. 199–231.

Hupé, Pierre.

1953. Classification des trilobites. Annales de Paléontologie, vol. 3, pp. 44–246.

Ivshin, N. K.

1956. Upper Cambian trilobites of Kazakhstan (in Russian). Acad. Sci. Kazakhstan Soviet Socialist Republic (Alma-Ata), pp. 1–98.

Kobayashi, Teiichi.

1935. The Cambro-Ordovician formations and faunas of South Chosen. Paleontology. Part III. Journ. Fac. Sci. Imp. Univ. Tokyo, sec. 2, vol. 4, pt. 2, pp. 48–344.

1936. On the *Parabolinella* fauna from the province Jujuy, Argentina, with a note on the Olenidae. Japanese Journ. Geol. Geogr., vol. 13, pp. 85–102.

Lochman, Christina.

1936. New trilobite genera from the Bonneterre dolomite (Upper Cambrian) of Missouri. Journ. Paleontol., vol. 10, pp. 35–43.

1938. Upper Cambrian faunas of the Cap Mountain formation of Texas. Journ. Paleontol., vol. 12, pp. 72–85.

1940. Fauna of the basal Bonneterre dolomite (Upper Cambrian) of southeastern Missouri. Journ. Paleontol., vol. 14, pp. 1–53.

1950. Upper Cambrian faunas of the Little Rocky Mountains, Montana. Journ. Paleontol., vol. 24, pp. 322–349.

Lochman, Christina, and Duncan, Donald.

1944. Early Upper Cambrian faunas of central Montana. Geol. Soc. Amer. Spec. Pap., No. 54, pp. 1–181.

Lochman, Christina, and Hu, Chung-Hung.

1960. Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming, Pt. I. Journ. Paleontol., vol. 34, pp. 793–834.

1961. Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming. Pt. II. Journ. Paleontol., vol. 35, pp. 125–146.

1962a. Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming. Pt. III. Journ. Paleontol., vol. 36, pp. 1–28.

1962b. An *Aphelaspis* zone faunule from Logan, Montana. Journ. Paleontol., vol. 36, pp. 431–441.

Lochman, Christina, and Wilson, J. L.

1958. Cambrian biostratigraphy in North America. Journ. Paleontol., vol. 32, pp. 312–350.

Oder, Charles R. L., and Bumgarner, James J.

1961. Stromatolitic bioherms in the Maynardville (Upper Cambrian) limestone, Tennessee. Bull. Geol. Soc. Amer., vol. 72, pp. 1021–1028.

Palmer, A. R.

1954. The faunas of the Riley formation in central Texas. Journ. Paleontol., vol. 28, pp. 709–786.

1955. Upper Cambrian agnostidae of the Eureka District, Nevada. Journ. Paleontol., vol. 29, pp. 86–101.

1960. Trilobites of the Upper Cambrian Dunderberg shale, Eureka District, Nevada. U.S. Geol. Surv. Prof. Pap. 334-C, pp. 53–109.

1962a. Comparative ontogeny of some opisthoparian, gonatoparian, and proparian Upper Cambrian trilobites. Journ. Paleontol., vol. 36, pp. 87–96.

1962b. *Glyptagnostus* and associated trilobites in the United States. U.S. Geol. Surv. Prof. Pap. 374-F, pp. 1–49.

1965. The ptychoparioid trilobites of the Late Cambrian Pterocephaliid biomere in the Great Basin of the western United States. U.S. Geol. Surv. Prof. Pap. 493, pp. 1–105.

Raasch, G. O., and Lochman, Christina.

1943. Revision of three early Upper Cambrian trilobite genera. Journ. Paleontol., vol. 17, pp. 221–235.

Rasetti, Franco.

1946. Early Upper Cambrian trilobites from western Gaspé. Journ. Paleontol., vol. 20, pp. 442–462.

1954. Phylogeny of the Cambrian trilobite family Catillicephalidae and the ontogeny of *Welleraspis*. Journ. Paleontol., vol. 28, pp. 599–612.

1956. Revision of the trilobite genus *Maryvillia* Walcott. Journ. Paleontol., vol. 30, pp. 1266–1269.

1959. Trempealeauian trilobites from the Conococheague, Frederick, and Grove limestones of the central Appalachians. Journ. Paleontol., vol. 33, pp. 375–398.

1961. Dresbachian and Franconian trilobites of the Conococheague and Frederick limestones of the central Appalachians. Journ. Paleontol., vol. 35, pp. 104–124.

1963. Middle Cambrian ptychoparioid trilobites from the conglomerates of Quebec. Journ. Paleontol., vol. 37, pp. 575–594.

Resser, Charles E.

1937. Third contribution to nomenclature of Cambrian trilobites. Smithsonian Misc. Coll., vol. 95, No. 22, pp. 1–29.

1938a. Cambrian system (restricted) of the southern Appalachians. Geol. Soc. Amer. Spec. Pap. 15, pp. 1–130.

1938b. Fourth contribution to nomenclature of Cambrian fossils. Smithsonian Misc. Coll., vol. 97, No. 10, pp. 1–43.

RODGERS, JOHN

1953. Geologic map of east Tennessee with explanatory text. Tennessee Dept. Conservation, Div. Geol., Bull. 58, pt. II, pp. 1–168, maps.

RODGERS, JOHN, and KENT, D. F.

1948. Stratigraphic section at Lee Valley, Hawkins County, Tennessee. Tennessee Dept. Conservation, Div. Geol., Bull. 55, pp. 1–45.

SHAW, ALAN B.

1956. A Cambrian *Aphelaspis* fauna from Steele Butte, near Boulder, Wyoming. Journ. Paleontol., vol. 30, pp. 48–52.

VOGDES, A. W.

1890. A bibliography of Paleozoic Crustacea from 1698 to 1889. U.S. Geol. Surv., Bull. 63.

WALCOTT, C. D.

1899. Paleozoic Fossils. Sec. 1, Cambrian fossils. U.S. Geol. Surv. Monogr. 32, pt. 2, pp. 440–466.

1911. Cambrian Geology and Paleontology II. No. 4. Cambrian faunas of China. Smithsonian Misc. Coll., vol. 57, No. 4, pp. 69–108.

1916a. Cambrian Geology and Paleontology III. No. 3. Cambrian trilobites. Smithsonian Misc. Coll., vol. 64, No. 3, pp. 157–256.

1916b. Cambrian Geology and Paleontology III. No. 5. Cambrian trilobites. Smithsonian Misc. Coll., vol. 64, No. 5, pp. 303–456.

1925. Cambrian Geology and Paleontology V. No. 3. Cambrian and Ozarkian trilobites. Smithsonian Misc. Coll., vol. 75, No. 3, pp. 59–146.

EXPLANATION OF PLATES

Plate 1

Page

Figs. 1–4. *Coosella andreas* (Walcott) 48
1, Cranidium, ×4. 2–4, Dorsal, lateral, and posterior views of pygidium, ×4 (coll. cnc/2) ; U.S.N.M. 144572, plesiotypes.

Figs. 5–7. *Coosella resseri* Rasetti, new name 48
5–7, Lateral, posterior, and dorsal views of pygidium lacking test, ×2 (coll. cnd/1) ; U.S.N.M. 144573, plesiotype.

Figs. 8, 9. *Kormagnostus simplex* Resser 38
8, Cephalon, ×5. 9, Pygidium, ×5 (coll. cnc/5) ; U.S.N.M. 144546, plesiotypes.

Figs. 10–12. *Ithycephalus typicalis* Resser 106
10–12, Dorsal, lateral, and anterior views of cranidium, ×5 (coll. cnd/1) ; U.S.N.M. 144714, plesiotype.

Figs. 13–21. *Modocia bidentata* Rasetti, n. sp. 108
14–16, Dorsal, lateral, and posterior views of pygidium, ×2 (coll. cnd/1) ; U.S.N.M. 144717, holotype. 13, Cranidium, ×1.5. 17, Pygidium, ×2. 18, Cranidium, ×2. 19–21, Dorsal, frontal, and lateral views of cranidium, ×2 (coll. cnd/1) ; U.S.N.M. 144718, paratypes. All specimens lacking test.

Figs. 22–26. *Modocia dubia* (Resser) 107
22, 23, Dorsal and lateral views of cranidium, ×2. 24, Free cheek, ×2. 26, Pygidium, ×2 (coll. cnc/5) ; U.S.N.M. 144715, plesiotypes. 25, Exfoliated cranidium, ×2 (coll. cnd/1) ; U.S.N.M. 144716, plesiotype.

Figs. 27–30. *Modocia? agatho* (Walcott) 110
27, 28, Lateral and dorsal views of cranidium, ×4 (coll. cnc/5) ; U.S.N.M. 144724, plesiotype. 29, Pygidium, ×3 (coll. cnc/2) ; U.S.N.M. 144725, plesiotype. 30, Cranidium, ×4 (coll. cnc/4) ; U.S.N.M. 144726, plesiotype.

Plate 2

Figs. 1–9. *Modocia crassimarginata* Rasetti, n. sp. 109
1–3, Dorsal, lateral, and frontal views of cranidium, ×2 (coll. cnc/2) ; U.S.N.M. 144719, holotype. 4, 5, Exfoliated cranidia, ×2 (coll. cnc/1) ; U.S.N.M. 144721, paratypes. 6, 7, Dorsal and posterior views of pygidium, ×2 (coll. cnc/3) ; U.S.N.M. 144722, paratype. 9, Exfoliated pygidium, ×2 (coll. cnd/1) ; U.S.N.M. 144723, paratype. 8, Partly exfoliated cranidium, ×2 (coll. cnd/1) ; U.S.N.M. 144723, paratype.

Figs. 10–18. *Bonneterrina appalachia* (Walcott) 102
10, Large cranidium, ×1.5 (coll. cnc/6) ; U.S.N.M. 144703, plesiotype. 11, 12, Dorsal and lateral views of cranidium with strong relief, ×2 (coll. cnc/5) ; U.S.N.M. 144704, plesiotype. 13, Free cheek, ×2 (coll. cnc/5) ; U.S.N.M. 144704, plesiotype. 14, 15, Dorsal and lateral views of pygidium, ×4 (coll. cnc/1) ; U.S.N.M. 144705, plesiotype. 16, 17, Lateral and dorsal views of cranidium with weak relief and shallow occipital furrow, ×2 (coll. cnd/1) ; U.S.N.M. 144706, plesio-

Page

type. 18, Exfoliated pygidium, ×2 (coll. cnd/1); U.S.N.M. 144706, plesiotype.

Figs. 19–24. *Menomonia tuberculata* Rasetti, n. sp. 62
19–21, Dorsal, lateral, and frontal views of cranidium, ×5 (coll. cnc/2); U.S.N.M. 144696, holotype. 22, Free cheek, ×5 (coll. cnc/2); U.S.N.M. 144697, paratype. 23, 24, Lateral and dorsal views of cranidium with somewhat shorter preglabellar field, ×5 (coll. cnc/5); U.S.N.M. 144698, paratype.

Figs. 25–27. *Menomonia*, sp. undet. 63
25, 26, Dorsal and lateral views of cranidium, ×5 (coll. cnc/4); U.S.N.M. 144699. 27, Free cheek, ×5 (coll. cnc/6); U.S.N.M. 144700.

Plate 3

Figs. 1–6. *Norwoodella saffordi* (Walcott) 65
1, Artificial cast of counterpart of holotype, ×3 (U.S.N.M. coll. 103); U.S.N.M. 61595. 2, 3, Exfoliated cranidia, ×5 (coll. cnd/1); U.S.N.M. 144612, plesiotypes. 4, Cranidium, ×5. 5, 6, Pygidia, ×7.5 (coll. cne/2); U.S.N.M. 144613, plesiotypes.

Figs. 7–9. *Loxoparia obliqua* Rasetti, n. gen., n. sp. 112
Dorsal, frontal, and lateral views of cranidium, ×5 (coll. cnd/1); U.S.N.M. 144727, holotype.

Figs. 10, 11. *Holcacephalus praecursor* Rasetti, n. sp. 68
10, Partly exfoliated cranidium, ×7.5 (coll. cnc/1); U.S.N.M. 144621, holotype. 11, Exfoliated pygidium, ×10 (coll. cnc/1); U.S.N.M. 144622, paratype.

Figs. 12–14. *Holcacephalus granulatus* Resser 68
12, 13, Exfoliated cranidia, ×10. 14, Exfoliated pygidium, ×10 (coll. cnd/1); U.S.N.M. 144620, plesiotypes.

Figs. 15–21. *Ankoura triangularis* Resser 61
15, 16, Dorsal and lateral views of exfoliated pygidium, ×7.5. 17, Exfoliated pygidium, ×7.5 (coll. U.S.N.M. 27d); U.S.N.M. 144702, plesiotypes. 18, 19, Lateral and dorsal views of exfoliated cranidium, ×7.5 (coll. U.S.N.M. 27d); U.S.N.M. 144608, plesiotype. 20, Incomplete cranidium preserving test, ×7.5. 21, Pygidium, ×7.5 (coll. cnb/10); U.S.N.M. 144609, plesiotypes.

Figs. 22–25. *Hawkinsia minuta* Rasetti, n. gen. n. sp. 105
22, Cranidium, ×10 (coll. cnc/1); U.S.N.M. 144713, paratype. 23–25, Frontal, lateral, and dorsal views of cranidium, ×10 (coll. cnc/1); U.S.N.M. 144712, holotype.

Plate 4

Figs. 1–7. *Norwoodella rotundicollis* Rasetti, n. sp. 65
1, 2, Dorsal and lateral views of exfoliated cranidium, ×3 (coll. cnd/1); U.S.N.M. 144614, holotype. 3, Exfoliated cranidia, ×3. 4, Free check, ×5. 5, Cranidium, ×5. 6, Exfoliated pygidium, ×10. 7, Exfoliated pygidium, ×8 (coll. cnd/1); U.S.N.M. 144615, paratypes.

Figs. 8–15. *Norwoodella halli* Resser 67
8–10, Frontal, lateral, and dorsal views of cranidium, ×7.5. 11, 12, Free cheeks, ×5. 13–15, Pygidia, ×7.5 (coll. cnd/10); U.S.N.M. 144619, plesiotypes.

Page

Figs. 16–23. *Norwoodella walcotti* Resser 66
16–18, Dorsal, lateral, and frontal views of cranidium, ×4. 19, 20, Pygidia, ×5. 21, Free cheek, ×5 (coll. cne/10); U.S.N.M. 144616, plesiotypes. 22, Free cheek, ×5 (coll. cne/12); U.S.N.M. 144617, plesiotype. 23, Cranidium, ×4 (coll. U.S.G.S. 2407); U.S.N.M. 144618, plesiotype.

Fig. 24. *Norwoodia,* sp. undet. 65
Incomplete, exfoliated cranidium, ×4 (coll. cnc/4); U.S.N.M. 144611.

Figs. 25, 26. *Norwoodia rogersvillensis* Resser 64
25, Exfoliated cranidium, ×5. 26, Exfoliated pygidium, ×10 (coll. cnd/1); U.S.N.M. 144610, plesiotypes.

PLATE 5

Figs. 1–3. *Coenaspis spectabilis* Resser 105
Dorsal, frontal, and dorsolateral views of rubber reproduction of partially exfoliated holotype cranidium, ×4 (coll. U.S.N.M. 123a); U.S.N.M. 94978.

Figs. 4–8. *Cedaria tennesseensis* Walcott 69
4, 5, Cranidia flattened in shale, ×2 (coll. U.S.N.M. 107a); U.S.N.M. 70273, paratypes. 6, Free cheek, ×3. 7, Exfoliated pygidium, ×2. 8, Pygidium, ×3 (coll. cne/10); U.S.N.M. 144623, plesiotypes.

Figs. 9–11. *Genevievella,* sp. undet. 71
9, 10, Dorsal and lateral views of cranidium, ×3 (coll. cnc/4); U.S.N.M. 144626. 11, Exfoliated cranidium, ×5 (coll. cnd/1); U.S.N.M. 144627.

Figs. 12, 13. *Olenoides,* sp. undet. 39
Pygidia, ×4 (coll. U.S.G.S. 2406); U.S.N.M. 144548.

Figs. 14–17. *Menomonia prominens* Resser 62
14, Exfoliated cranidium, ×5. 15, 16, Lateral and posterior views of cranidium, ×5. 17, Free cheek, ×5 (coll. cnd/1); U.S.N.M. 144695, plesiotypes.

Fig. 18. *Cedarina,* sp. undet. 70
Exfoliated pygidium, ×3 (coll. cnd/1); U.S.N.M. 144624.

Fig. 19. *Coosia,* sp. undet. 53
Pygidium, ×5 (coll. cnn/1); U.S.N.M. 144588.

Fig. 20. *Amiaspis erratica* Lochman 43
Cranidium, ×10 (coll. cnn/16); U.S.N.M. 144558, plesiotype.

Figs. 21–24. *Amiaspis obsolescens* Rasetti, n. sp. 43
21–23, Dorsal, lateral, and frontal views of cranidium, ×8 (coll. cnm′/20); U.S.N.M. 144559, holotype. 24, Cranidium, ×8 (coll. cnn/16); U.S.N.M. 144560, paratype.

PLATE 6

Figs. 1–4. *Tricrepicephalus thoosa* (Walcott) 54
1, Exfoliated cranidium, ×1.5, coll. cnn/3); U.S.N.M. 144589, plesiotype. 2, Exfoliated pygidium, ×2.2 (coll. cnn/3); U.S.N.M. 144589, plesiotype. 3, Cranidium, ×2 (coll. cnn/14); U.S.N.M. 144590, plesiotype. 4, pygidium preserving unusually smooth test on pleural regions, ×2.2 (coll. cnm/2); U.S.N.M. 144591, plesiotype.

Figs. 5, 6. *Crepicephalus buttsi* Resser 45
5, Exfoliated pygidium, ×1. 6, Exfoliated pygidium, ×1.5 (coll. cnn/19); U.S.N.M. 144565, plesiotypes.

PLATE 9

Page

and frontal views of cranidium, ×2. 6–8, Pygidia, ×4 (U.S.N.M. coll. 120); U.S.N.M. 144648, plesiotypes. 9, Cranidium, ×2.5. 10, Free cheek, ×2 (coll. cnr'/20); U.S.N.M. 144649, plesiotypes. 11, Hypostome, ×3 (coll. cnr/15); U.S.N.M. 144650, plesiotype. 12, 13, Dorsal and frontal views of cranidium, ×4. 14, Free cheek, ×4. 15, Hypostome, ×4. 16, Cranidium, ×2. 17, Exfoliated cranidium, ×2 (coll. cns/16); U.S.N.M. 144651, plesiotypes.

Figs. 18–21. *Aphelaspis laxa* Resser 80
18, Exfoliated free cheek, ×1.5. 19, Cranidium, ×4 (coll. cns/16); U.S.N.M. 144643, plesiotypes. 20, Free cheek, ×1.5. 21, Pygidium, ×4 (coll. cnr'/20); U.S.N.M. 144644, plesiotypes. (See also pl. 13.)

Fig. 22. *Aphelaspis arsoides* Rasetti, n. sp. 94
Pygidium, ×3 (coll. cnt/20); U.S.N.M. 144680, paratype. (See also pl. 11.)

Figs. 23–25. *Dytremacephalus sulcifrons* Rasetti, n. sp. 101
Dorsal, lateral, and frontal views of cranidium, ×4 (coll. cnw/14); U.S.N.M. 144690, holotype.

Plate 13

Figs. 1–7. *Aphelaspis bridgei* Rasetti, n. sp. 77
1–3, Dorsal, frontal, and lateral views of cranidium, ×3 (coll. U.S.G.S. 2804); U.S.N.M. 144635, holotype. 4, Cranidium, ×3. 5, Free cheek, ×3. 6, 7, Pygidia, ×3 (coll. U.S.G.S. 2804); U.S.N.M. 144636, paratypes.

Figs. 8–15. *Aphelaspis laxa* Resser 80
8, Cranidium, ×3. 9–11, Dorsal, frontal, and lateral views of cranidium, ×4. 13, 15, Pygidia, ×2. 14, Lateral view of cranidium, ×2 (coll. U.S.N.M. 120); U.S.N.M. 144645, plesiotypes. 12, Free cheek, ×2 (coll. cnr'/20); U.S.N.M. 144644, plesiotype. (See also pl. 12.)

Figs. 16–23. *Aphelaspis arses* (Walcott) 93
16–18, Dorsal, frontal, and lateral views of cranidium, ×4. 19, Cranidium, ×4. 20, Pygidium, ×4. 21, Free cheek, ×4. 22, Free cheek and pygidium, ×4 (coll. cns/4); U.S.N.M. 144676, plesiotypes. 23, Cranidium, ×4 (coll. cnr/4); U.S.N.M. 144733, plesiotype.

Plate 14

Figs. 1–12. *Aphelaspis rotundata* Rasetti, n. sp. 84
1–3, Dorsal, lateral, and frontal views of partly exfoliated cranidium, ×2.8 (coll. cns/20); U.S.N.M. 144652, holotype. 5, 6, Exfoliated cranidia, ×1.5. 4, Exfoliated hypostome, ×4. 7, Free cheek, ×3. 8, Exfoliated free cheek, ×3. 9, Exfoliated pygidium, ×2. 10, 11, Lateral and dorsal views of exfoliated pygidium, ×2.5 (coll. cns/20); U.S.N.M. 144653, paratypes. 12, Pygidium attributed to the species, ×3 (coll. cnq''/4); U.S.N.M. 144654, paratype.

Figs. 13–19. *Aphelaspis palmeri* Rasetti, n. sp. 81
13–15, Dorsal, lateral, and frontal views of cranidium, ×2 (coll. U.S.G.S. 2970); U.S.N.M. 144646, holotype. 16, Free cheek, ×3. 17, Partly exfoliated cranidium, ×4. 18, 19, Exfoliated pygidia, ×4 (coll. U.S.G.S. 2970); U.S.N.M. 144647, paratypes.

Figs. 20–24. *Glaphyraspis declivis* Rasetti, n. sp. 42
20–22, Lateral, dorsal, and frontal views of cranidium, ×7.5 (coll. Oder

Page

No. 2) ; U.S.N.M. 144556, holotype. 23, Cranidium, ×7.5. 24, Free cheek, ×7.5 (coll. Oder No. 2) ; U.S.N.M. 144557, paratypes.

PLATE 15

PLATE 16

PLATE 17

Page

Figs. 12–14. *Cheilocephalus,* sp. undet. 104
12, Cranidium, ×4. 13, 14, Pygidia, ×4 (coll. cnr/4) ; U.S.N.M. 144711.

Figs. 15–23. *Aphelaspis washburnensis* Rasetti, n. sp. 85
15–17, Dolsal, lateral, and frontal views of cranidium, ×2 (coll. cnq'/20) ; U.S.N.M. 144655, holotype. 18, Cranidium, ×1.5. 19, Free cheek, ×4. 20, Pygidium, ×2 (coll. cnq'/20) ; U.S.N.M. 144656, paratypes. 21, 22, Partly exfoliated cranidium, ×3. 23, Pygidium, ×3 (coll. cns/15) ; U.S.N.M. 144657, paratypes.

PLATE 18

Figs. 1–9. *Aphelaspis quadrata* Resser 78
1–3, Small cranidium, ×4. 4, Exfoliated free cheek, ×2. 5, Free cheek, ×2. 6, 7, Exfoliated pygidia, ×3. 8, Pygidium, ×4 (coll. cns/16) ; U.S.N.M. 144637, plesiotypes. 9, Pygidium, ×4 (coll. U.S.N.M. 120; U.S.N.M. 144638, plesiotype.

Figs. 10–20. *Aphelaspis walcotti* Resser 76
10, Cranidium, ×3. 11, Free cheek and partly exfoliated cranidium, ×4. 12, Exfoliated pygidium, ×2. 16, Cranidium, ×4 (coll. cnq/16) ; U.S.-N.M. 144632, plesiotypes. 13–15, Lateral, frontal, and dorsal views of cranidium, ×2. 20, Pygidium, ×3 (coll. cnq/20) ; U.S.N.M. 144633, plesiotypes. 17, Free cheek, ×3. 18, Pygidium, ×4. 19, Free cheek, ×2 (coll. cnr/15) ; U.S.N.M. 144634, plesiotypes.

Figs. 21–29. *Aphelaspis punctata* Rasetti, n. sp. 92
21, 22, 24, Frontal, dorsal, and lateral views of cranidium, ×4 (coll. cnw/14) ; U.S.N.M. 144673, holotype. 23, Cranidium, ×4 (coll. cnw/14) ; U.S.N.M. 144674, paratype. 25, 29, Free cheeks, ×4. 26, cranidium, ×3. 27, Cranidium, ×4. 28, Pygidium, ×5 (coll. cnw/20) ; U.S.-N.M. 144675, paratypes.

PLATE 19

Figs. 1–7. *Aphelaspis tumifrons* Resser 91
1, 2, Dorsal and frontal views of cranidium, ×4. 3, 4, Lateral and dorsal views of cranidium, ×4. 5, Free cheek, ×4. 6, 7, Pygidia, ×4 (coll. cnt/4) ; U.S.N.M. 144672, plesiotypes.

Figs. 8–17. *Aphelaspis inermis* Rasetti, n. sp. 90
8, 9, Frontal and dorsal views of cranidium, ×4 (coll. cns/2) ; U.S.N.M. 144669, holotype. 10–12, Dorsal, lateral, and frontal views of cranidium, ×4. 13, Frontal view of large, partly exfoliated cranidium, ×2. 14, Dorsal view of the same specimen, ×3. 15, Free cheek, ×3 (coll. cns/2) ; U.S.N.M. 144670, paratypes. 16, Pygidium, ×4. 17, Cranidium, ×2 (coll. cns/4) ; U.S.N.M. 144671, paratypes.

Figs. 18–25. *Aphelaspis minor* Rasetti, n. sp. 89
18–20, Dorsal, frontal, and lateral views of cranidium, ×4 (coll. cnq/17) ; U.S.N.M. 144665, holotype. 21, Cranidium, ×4. 22, 23, Frontal and dorsal views of cranidium, ×4. 24, Pygidium, ×4 (coll. cnq/14) ; U.S.N.M. 144667, paratypes. 25, Free cheek, ×4 (coll. cnq/15) ; U.S.-N.M. 144668, paratype.

PLATE 20

Figs. 1–18. *Aphelaspis tarda* Rasetti, n. sp. 79
5, Several cranidia, the one at left preserving one free cheek being the holotype, ×3. 6, Cranidium, ×5; U.S.N.M. 144639, holotype. 1, Num-

Page

erous meraspid cranidia in various stages, ×7.5. 2, 3, Dorsal and frontal views of cranidium, ×3. 4, Cranidium, ×4. 7, Free cheek, ×2. 8, 17, Free cheeks, ×3. 9, Hypostome, ×5. 10–12, Pygidia, ×4 (all above specimens from collection cnw/20) ; U.S.N.M. 144640, paratypes. 13–15, Dorsal, lateral, and frontal views of cranidium, ×2 (coll. cnu/1) ; U.S.N.M. 144641, paratype. 16, Pygidium, ×3 (coll. cnu/7) ; U.S.N.M. 144642, paratype. 18, Pygidium, ×3 (coll. cnv/7) ; U.S.N.M. 144642, paratype.

PLATE 21

Figs. 1–9. *Dytremacephalus angulatus* Rasetti, n. sp. 98

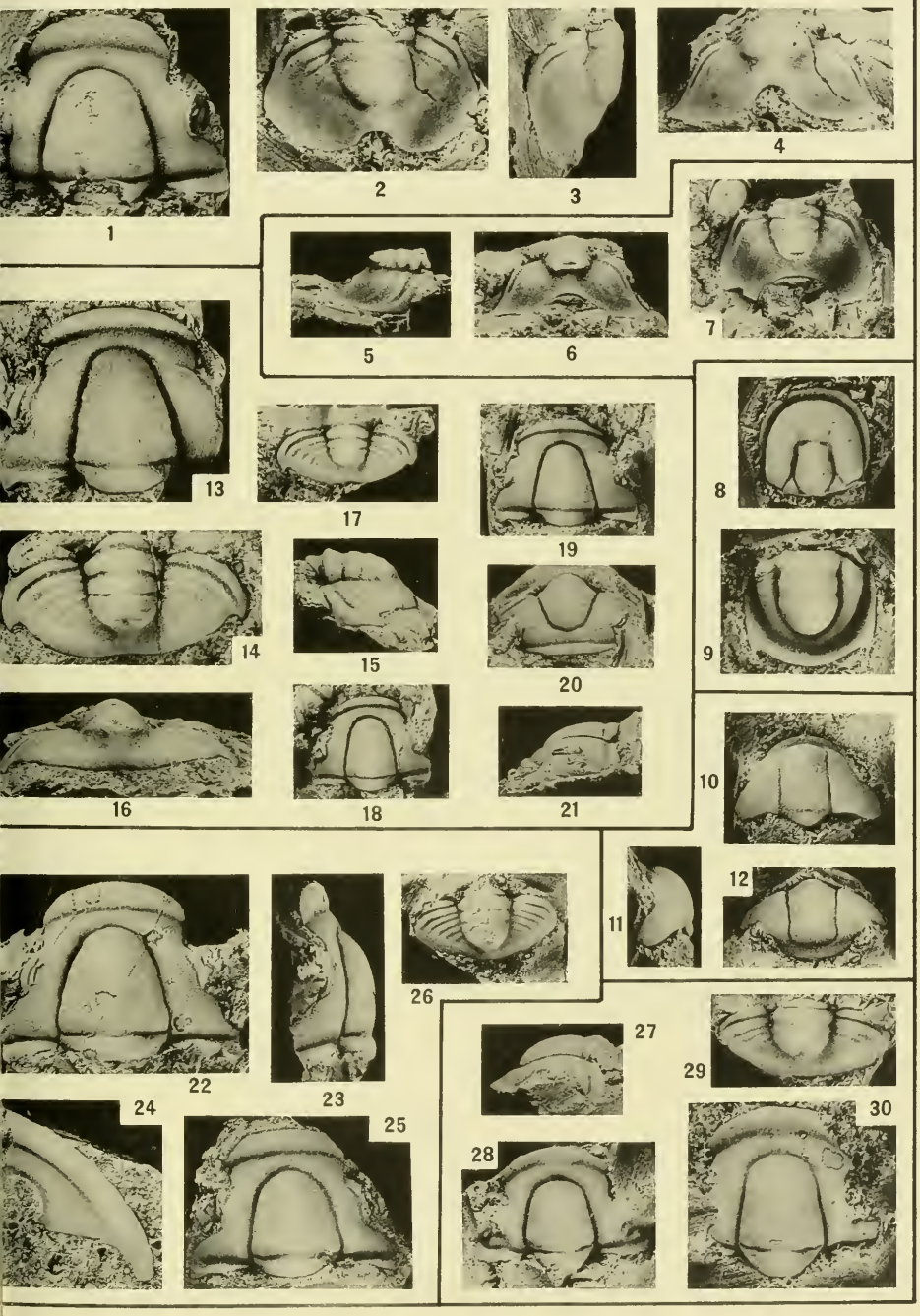
1–3, Dorsal, lateral, and frontal views of cranidium, ×5 (coll. cnw/14) ; U.S.N.M. 144686, holotype. 4, Cranidium, ×5. 7, Pygidium, ×5 (coll. cnw/14) ; U.S.N.M. 144687, paratypes. 5, Free cheek, ×5. 6, 8, Pygidia, ×5 (coll. cnx/1) ; U.S.N.M. 144688, paratypes. 9, Rubber cast of impression of thorax and pygidium, ×4 (coll. U.S.G.S. 2969) ; U.S.N.M. 144689, paratype.

Figs. 10–13. *Dytremacephalus strictus* Rasetti, n. sp. 102

10, Cranidium, ×5 (coll. U.S.G.S. 2970) ; U.S.N.M. 144692, holotype. 11–12, Cranidia, ×5. 13, Exfoliated cranidium, ×5 (coll. U.S.G.S. 2970) ; U.S.N.M. 144693, paratypes.

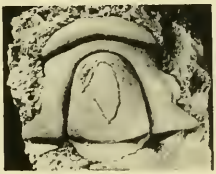
Figs. 14–28. *Paraphelaspis vigilans* Rasetti, n. gen., n. sp. 97

14–16, Dorsal, lateral, and frontal views of cranidium, ×6 (coll. cns/20) ; U.S.N.M. 144683, holotype. 17, Exfoliated free cheek, ×4. 18, 19, Frontal and dorsal views of cranidium, ×7.5. 20, 21, Dorsal and frontal views of cranidium, ×5. 22, Cranidium, ×7.5. 23, Exfoliated cranidium, ×5. 24, 25, Free cheeks, ×5 (coll. cns/20) ; U.S.N.M. 144684, paratypes. 26, 27, Lateral and dorsal views of cranidium, ×7.5. 27, Cranidium, ×4 (coll. cnr/4) ; U.S.N.M. 144685, paratypes.

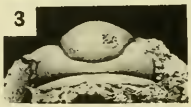


TRILOBITES OF THE CEDARIA ZONE.

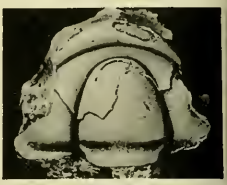
(SEE EXPLANATION OF PLATES AT END OF TEXT.)

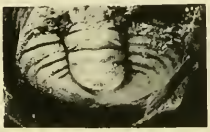

1


2


3


4

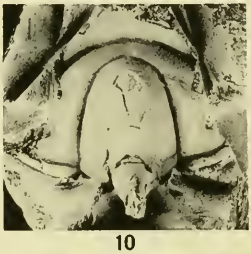

8

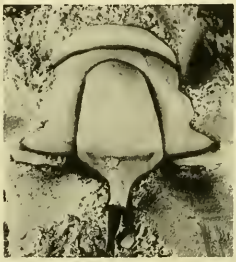

6


7


5


9

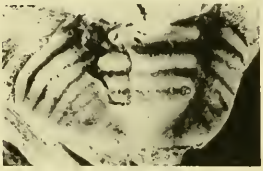

10


11

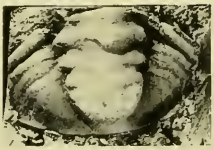

12


13


16


14


15

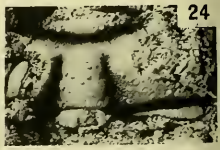

18


17

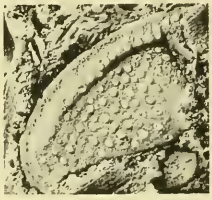

19


20


23

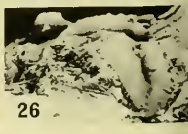

24


27


22

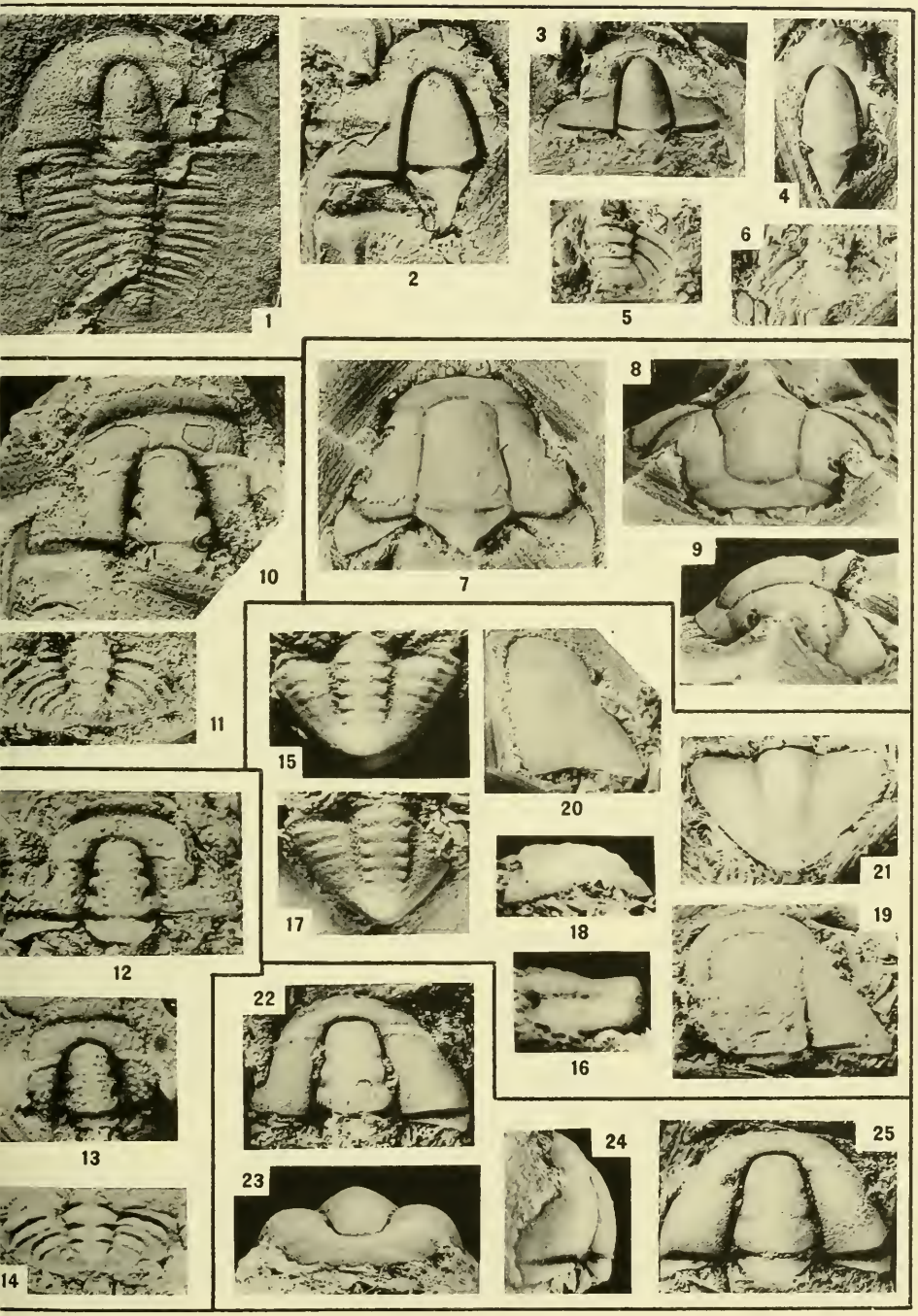

21


25


26

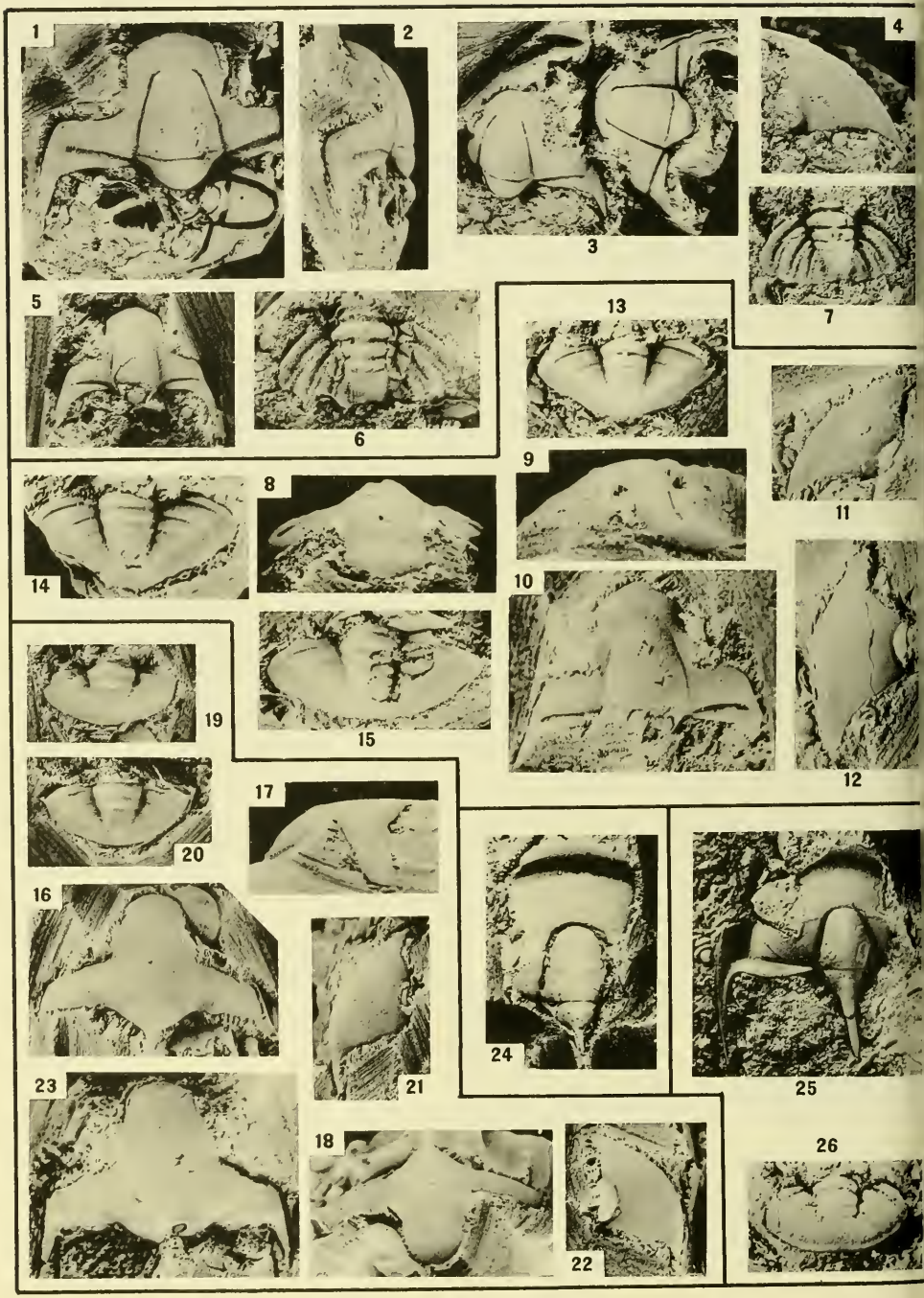
TRILOBITES OF THE CEDARIA ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



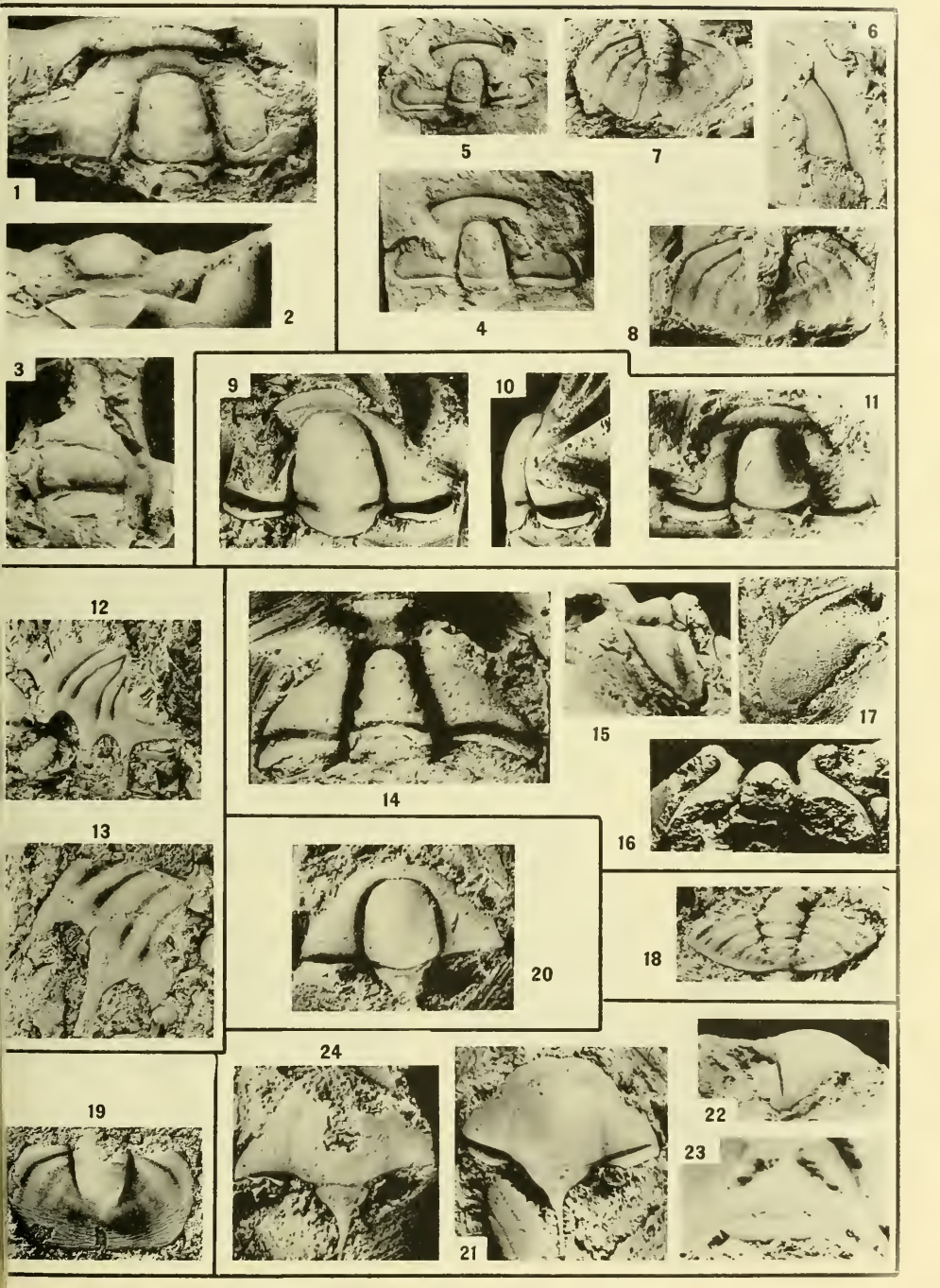
TRILOBITES OF THE CEDARIA ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



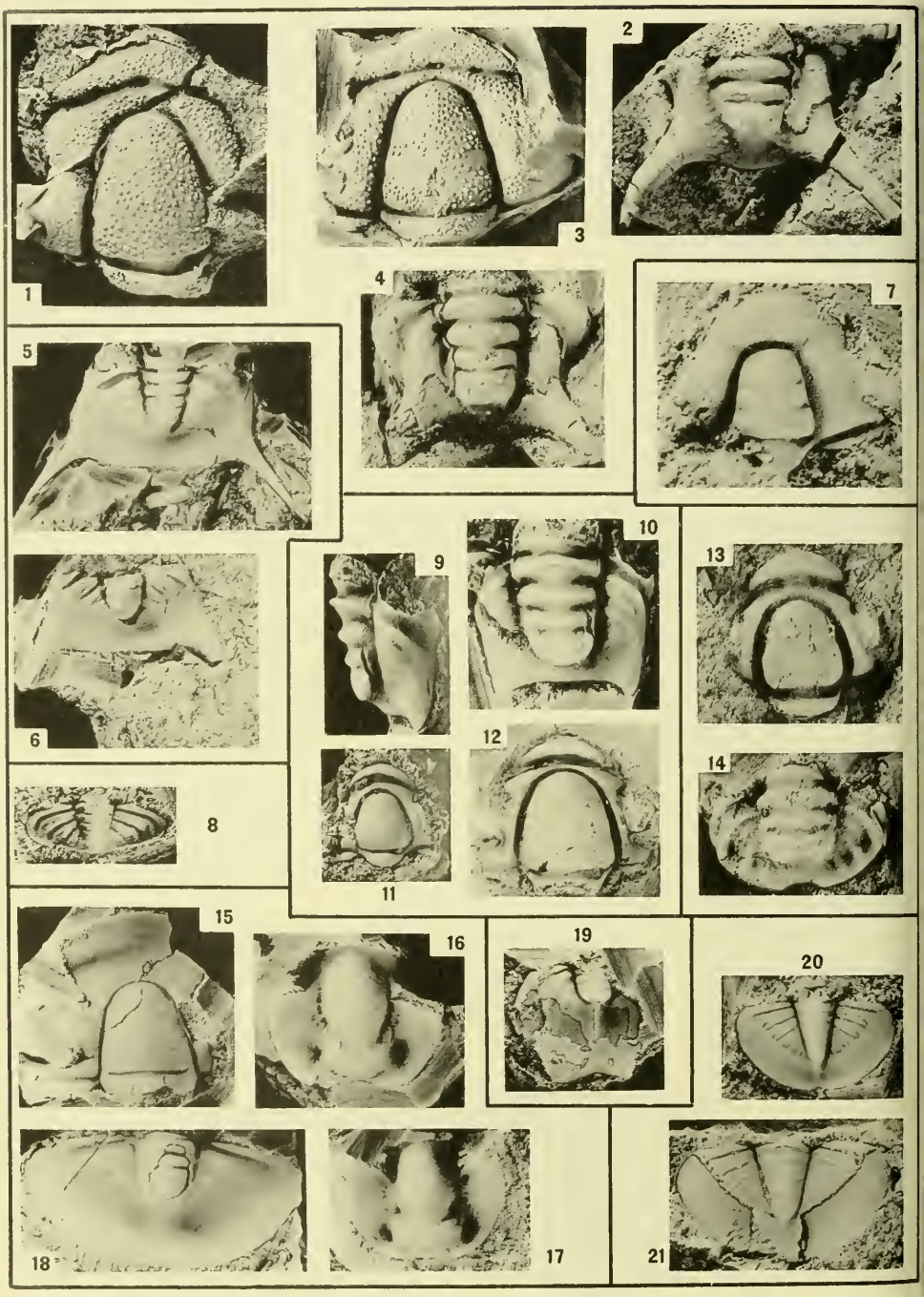
TRILOBITES OF THE CEDARIA ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



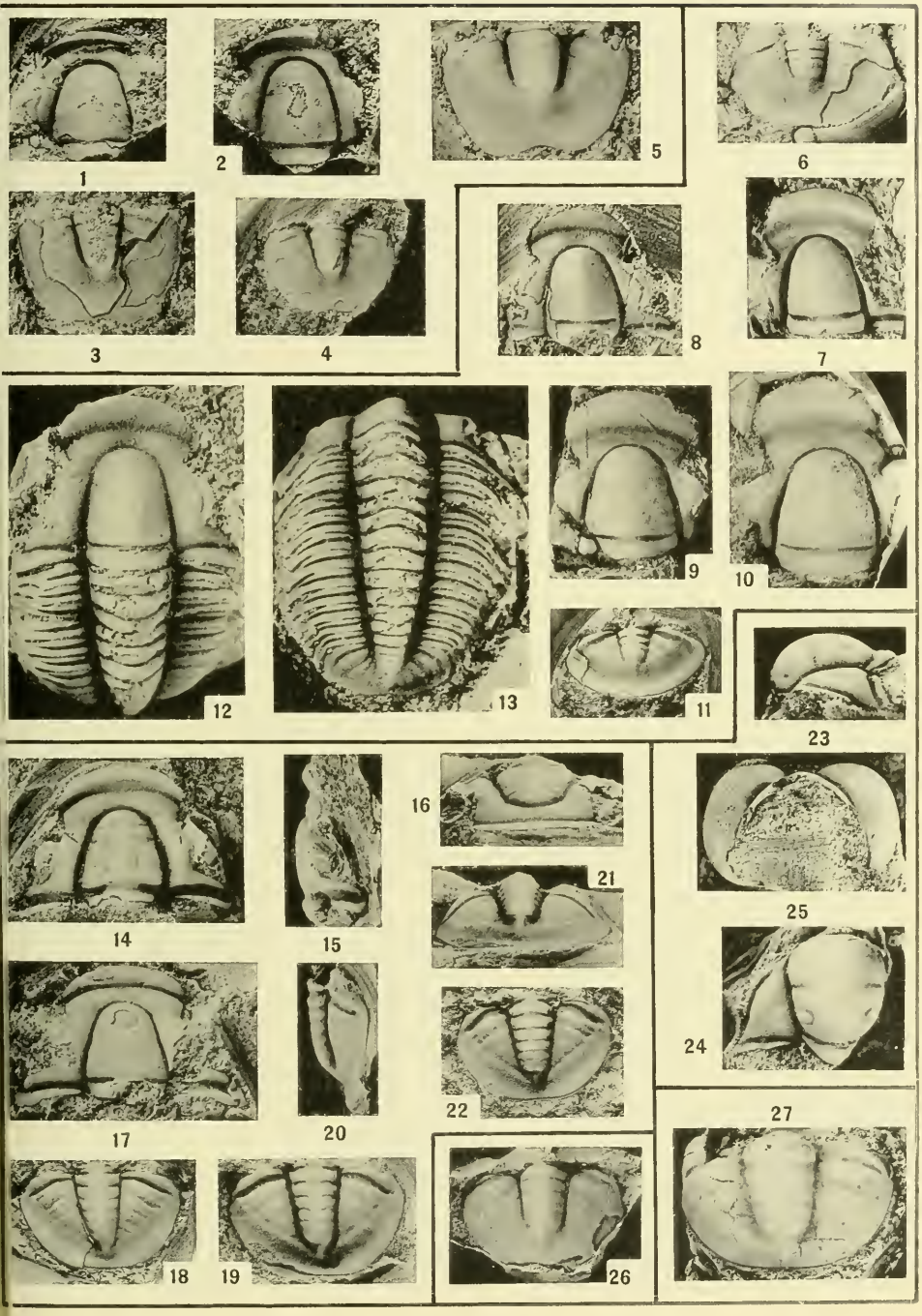
TRILOBITES OF THE CEDARIA AND CREPICEPHALUS ZONES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



TRILOBITES OF THE CREPICEPHALUS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

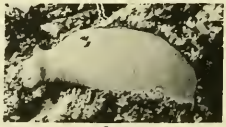


TRILOBITES OF THE CREPICEPHALUS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)


1


2


3


4


5


6

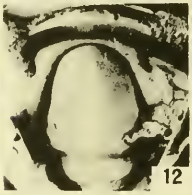

7


8


9

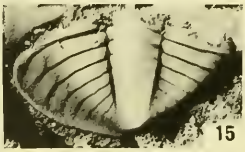

10

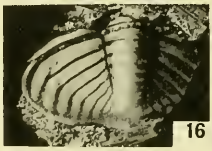

11


12

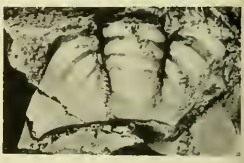

13


14


15


16


17

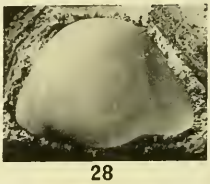

18


19


20


21


22

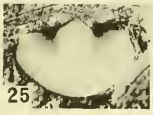

28


27


24


26


23

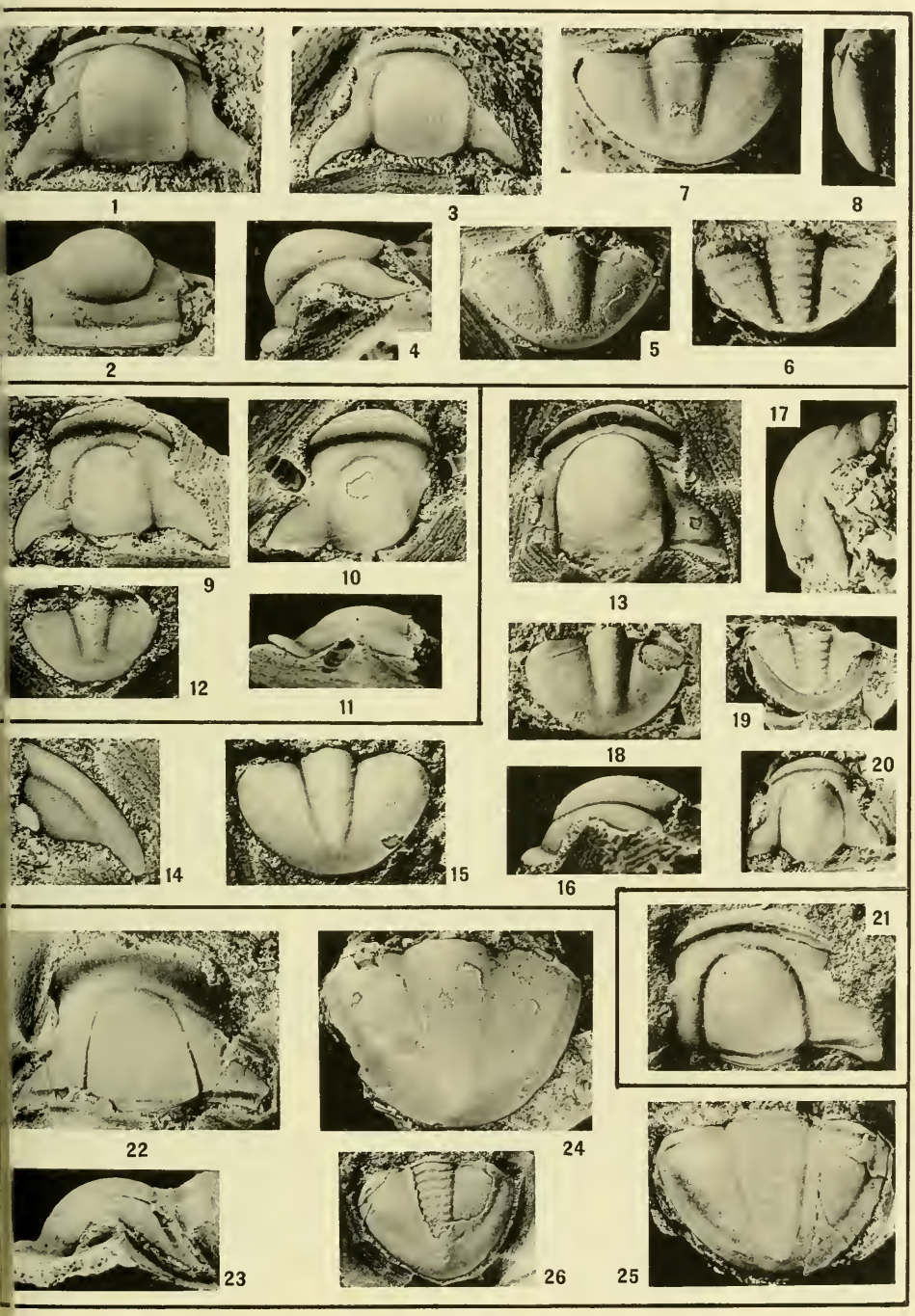

25


29


30

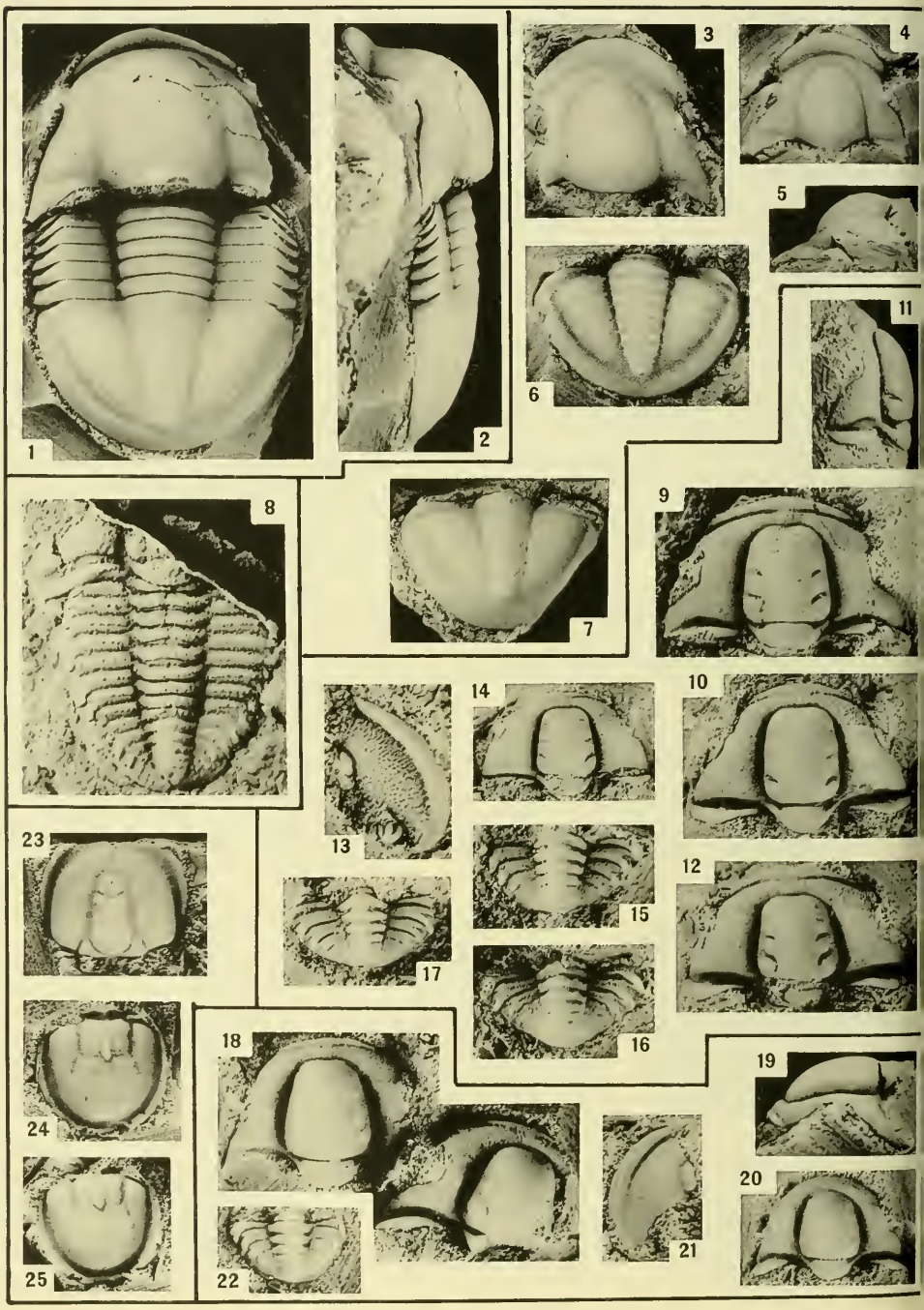
TRILOBITES OF THE CREPICEPHALUS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



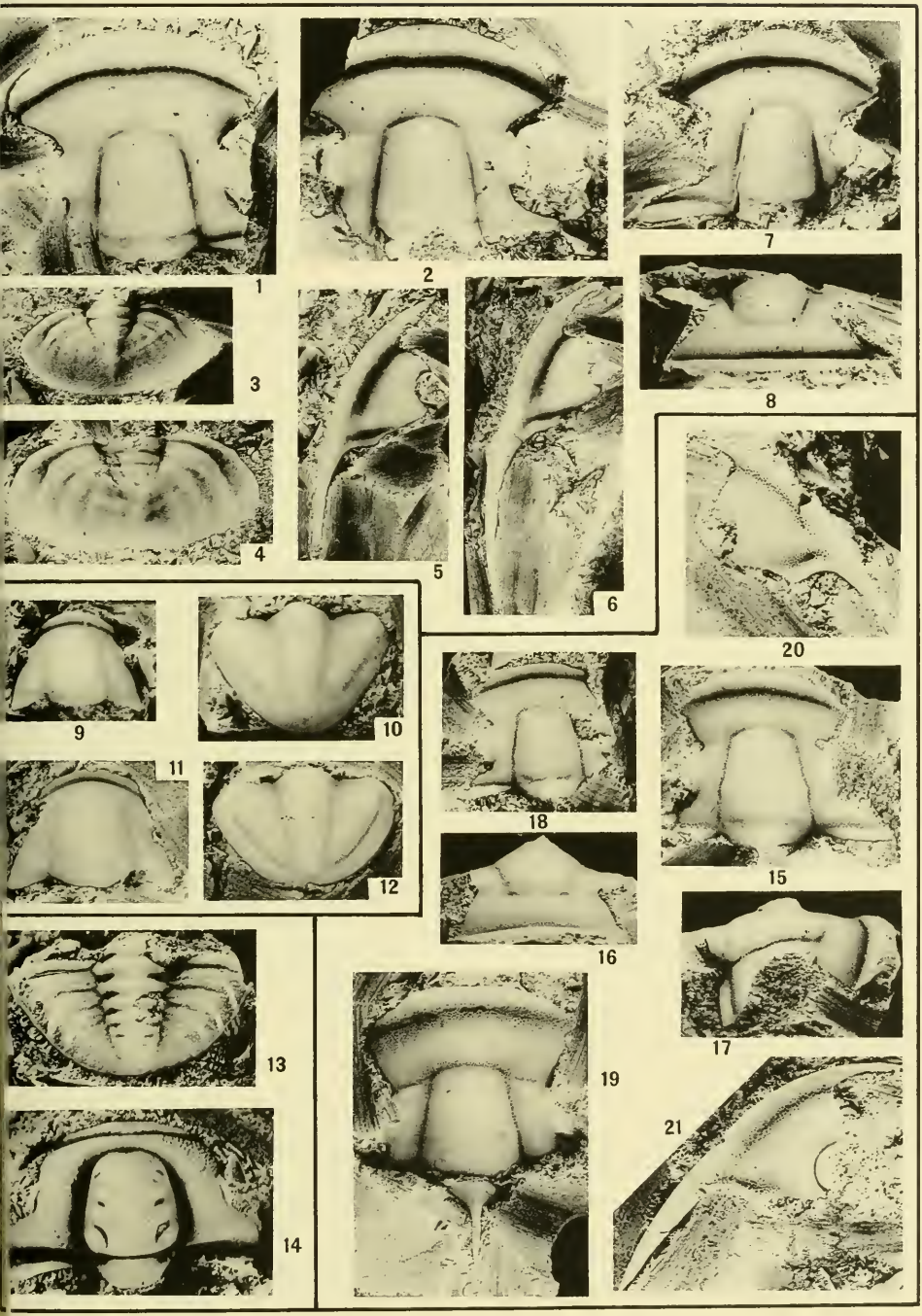
TRILOBITES OF THE CREPICEPHALUS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



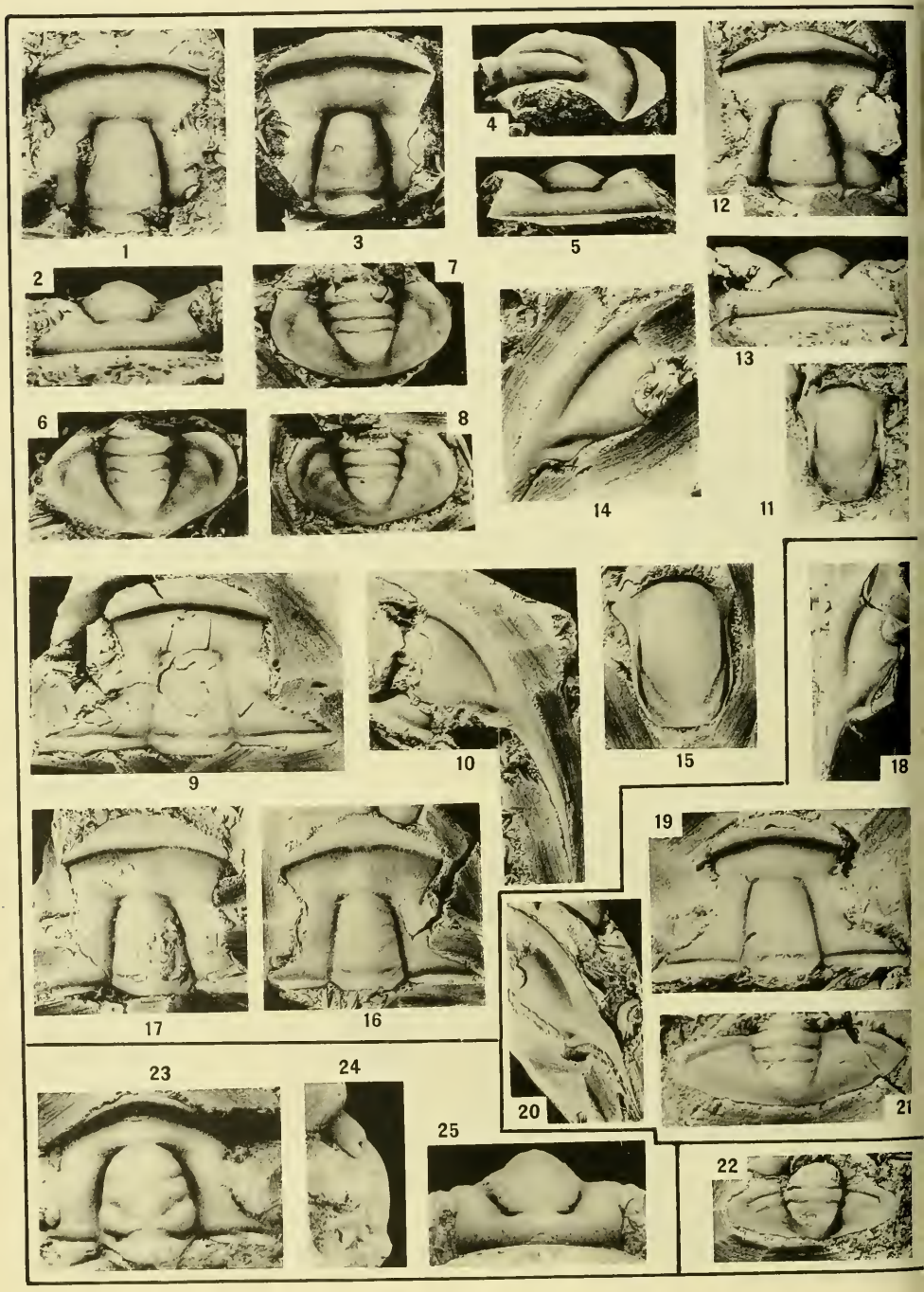
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



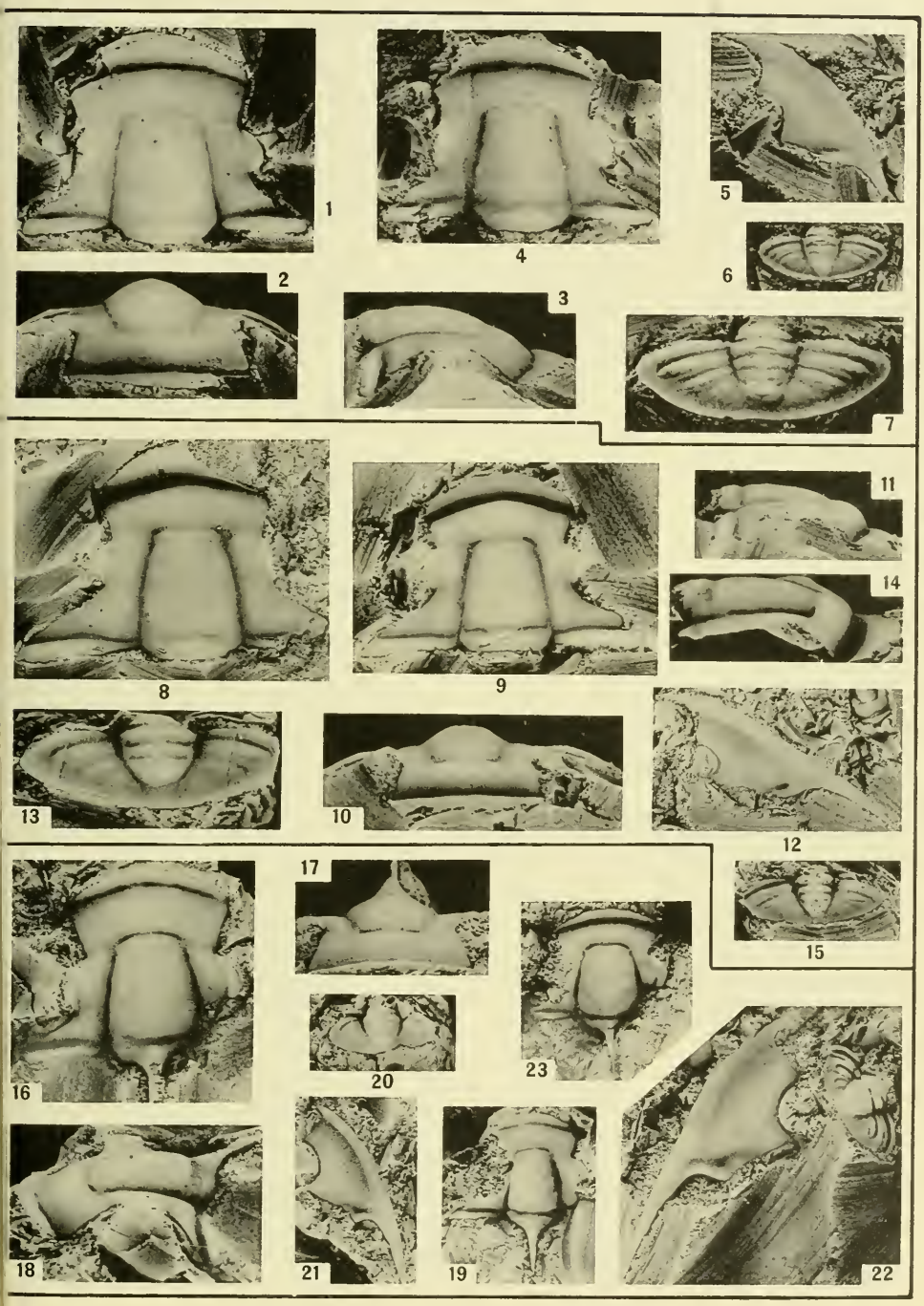
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



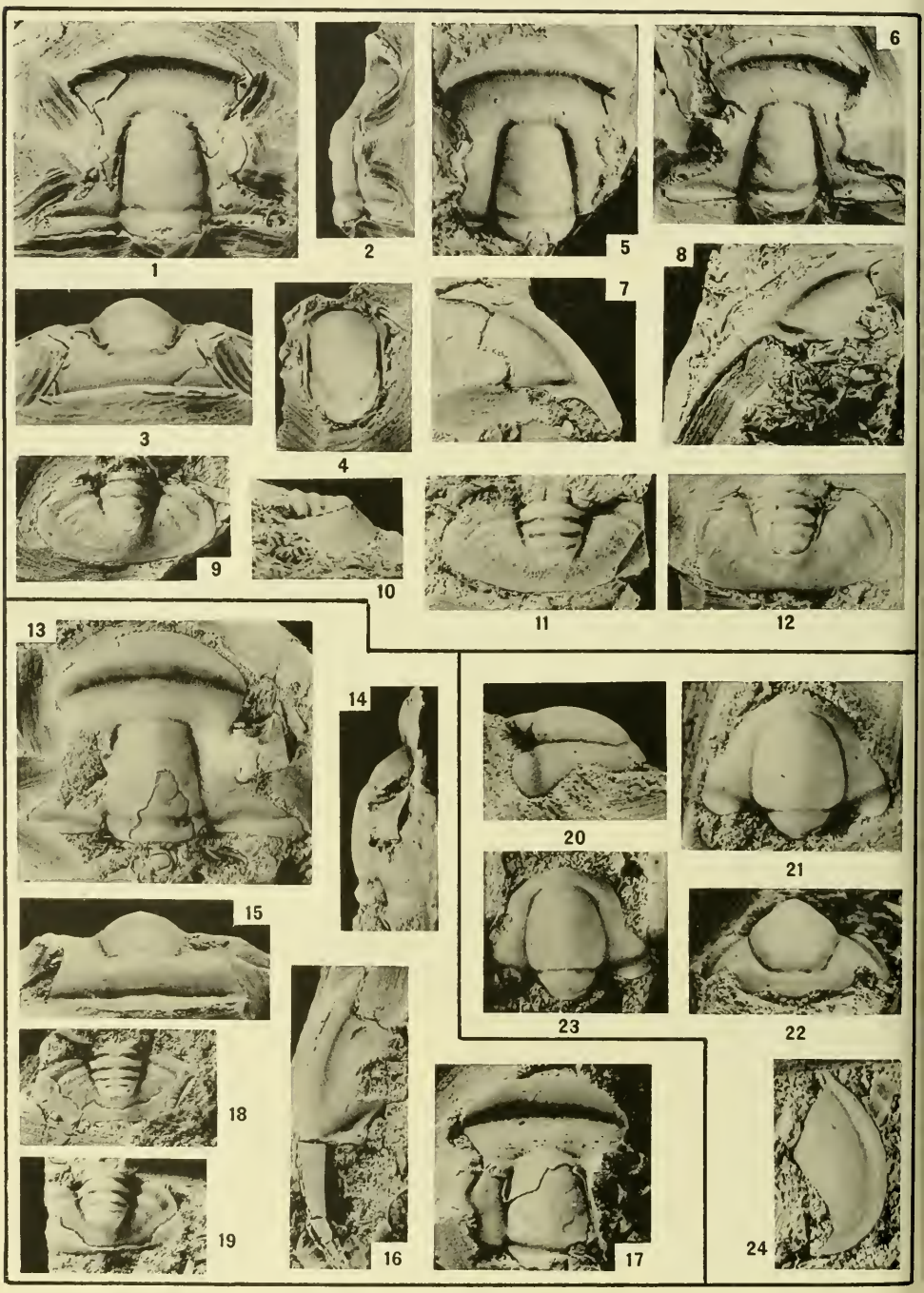
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



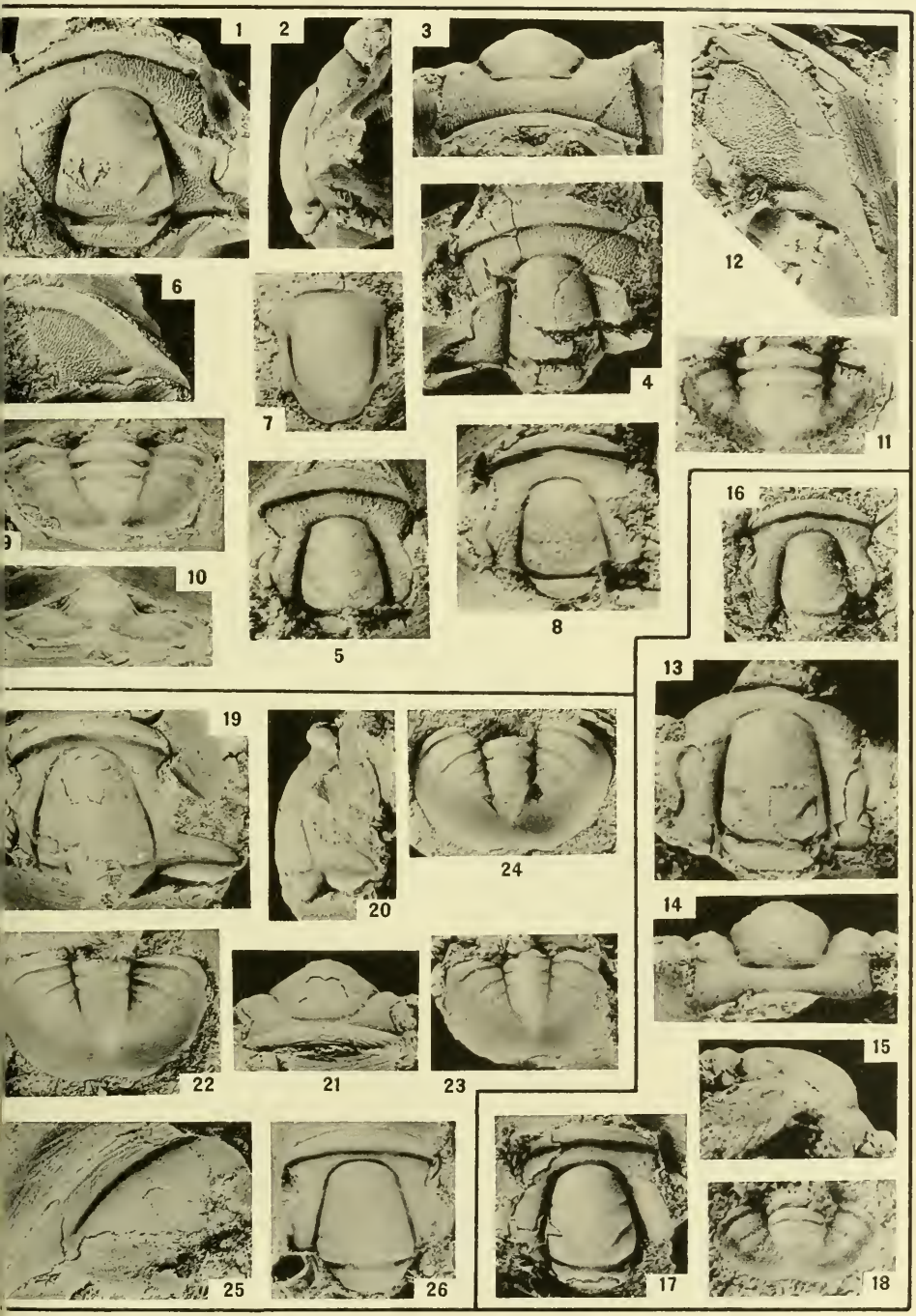
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



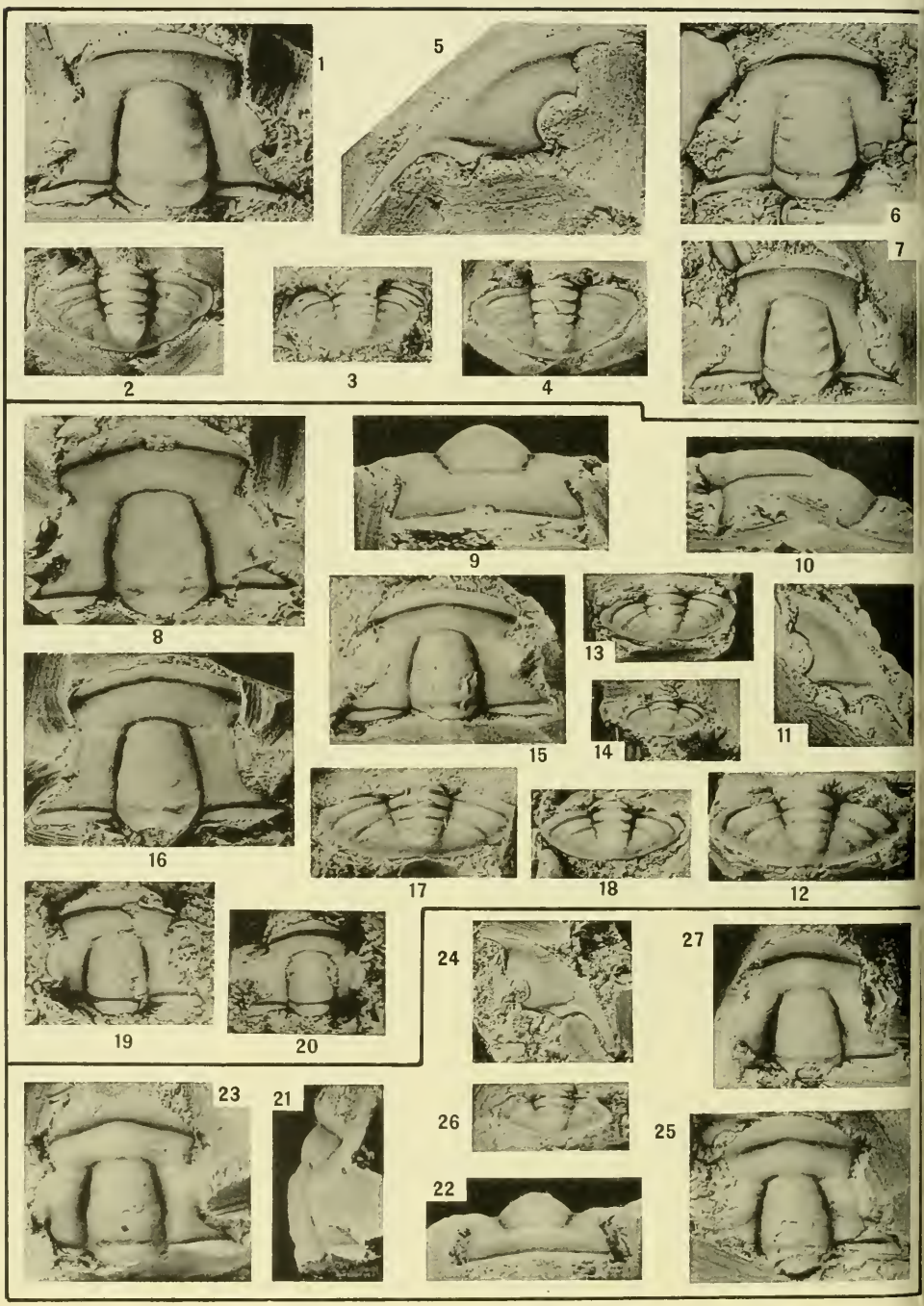
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



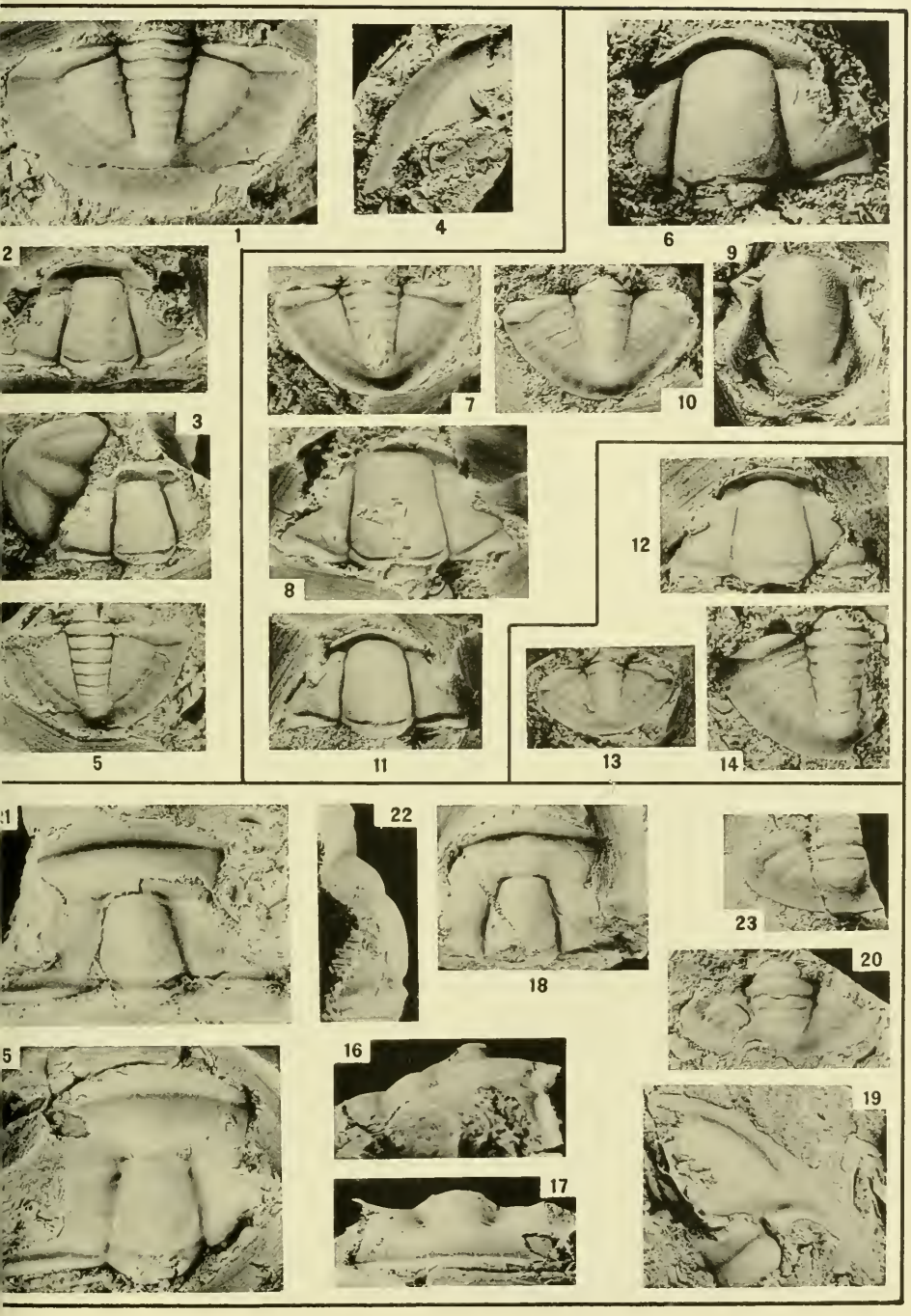
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



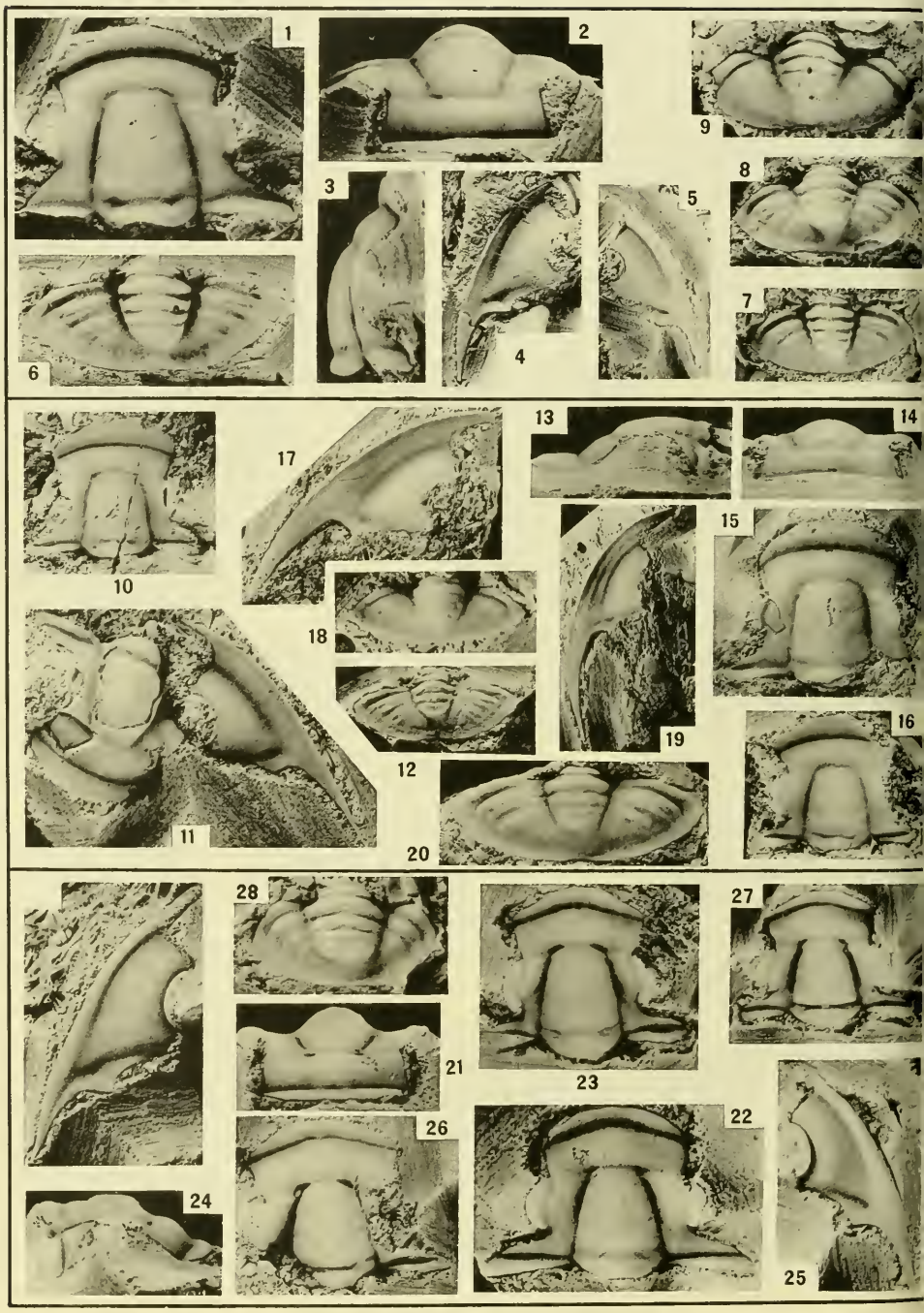
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



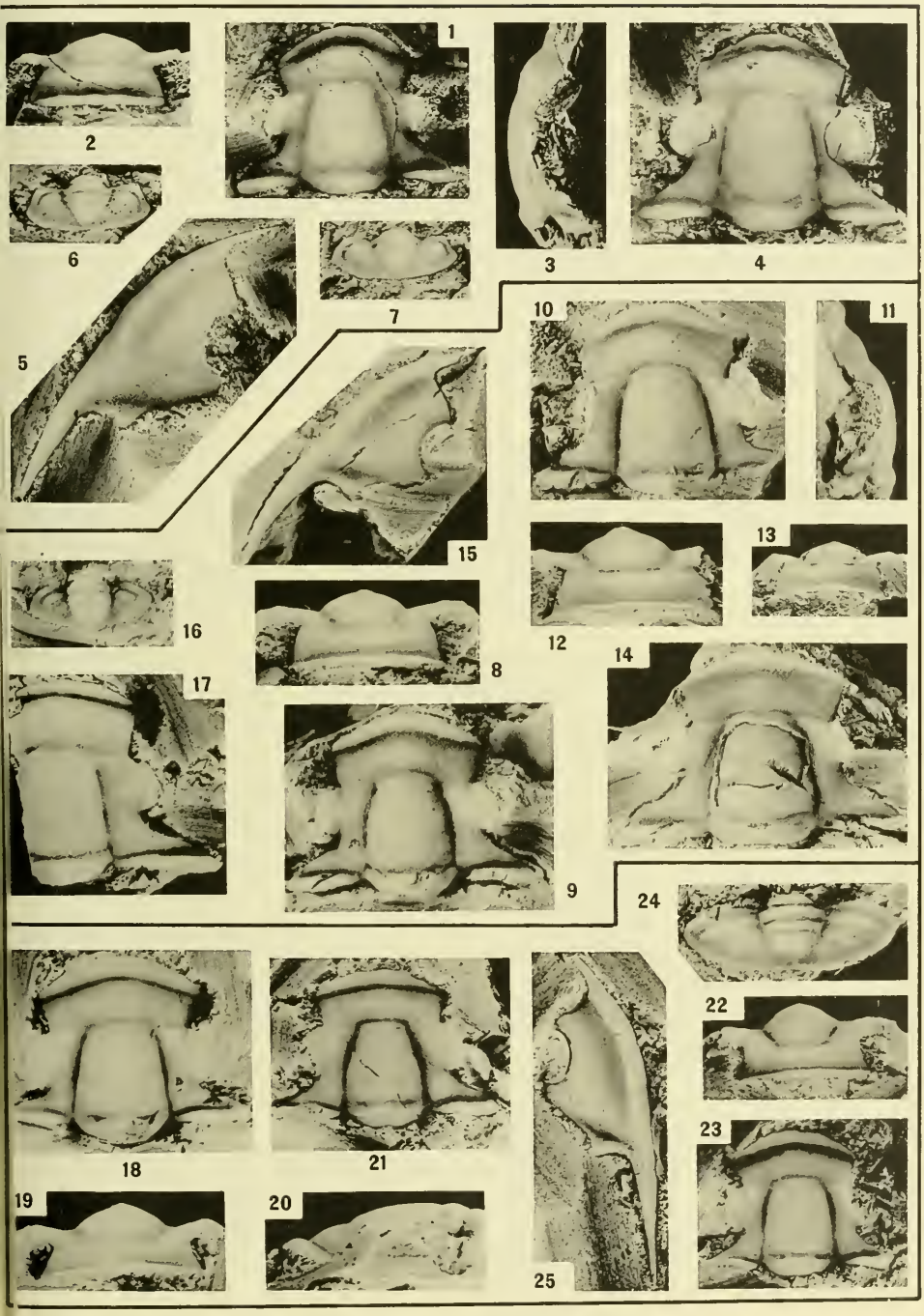
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



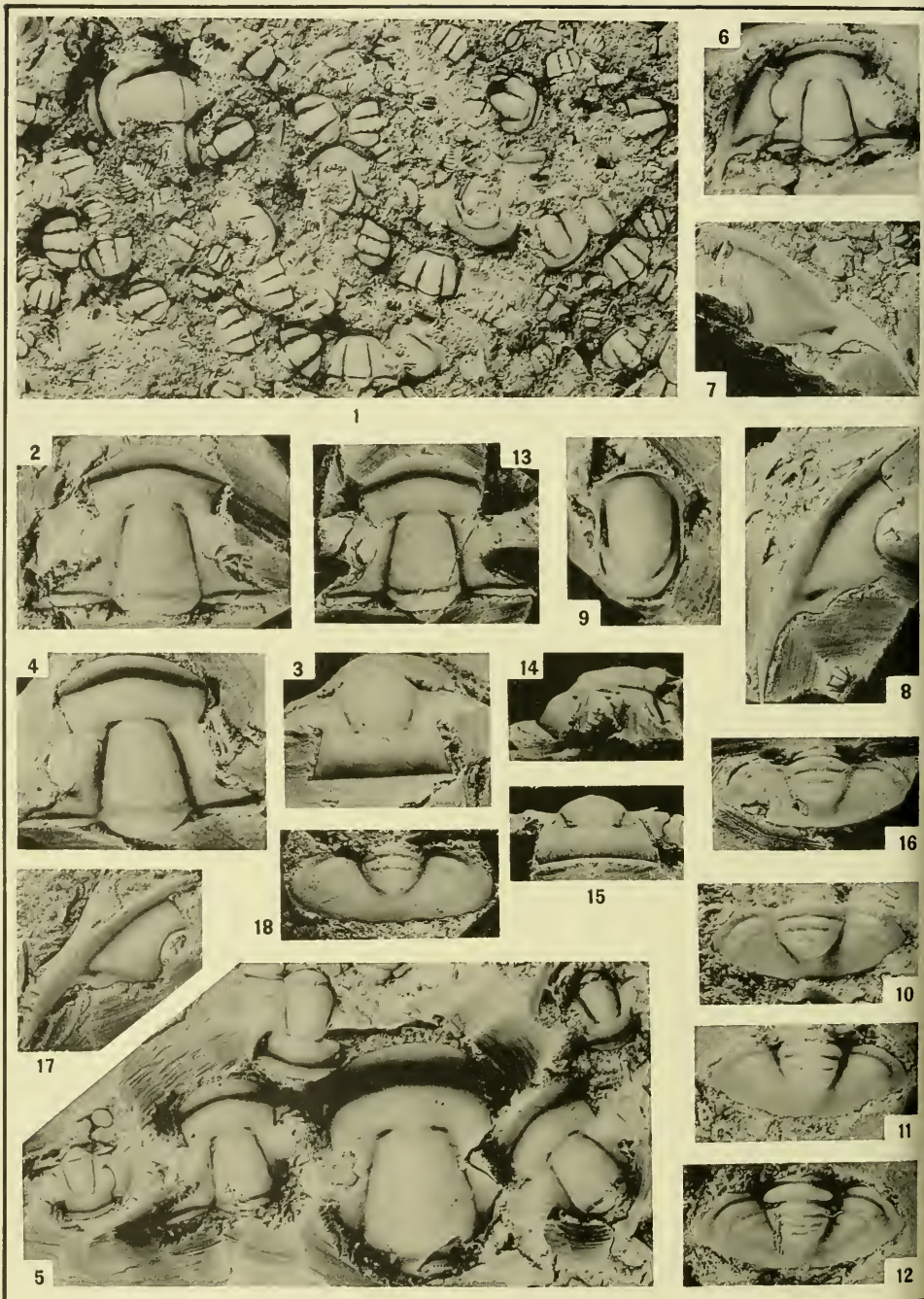
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



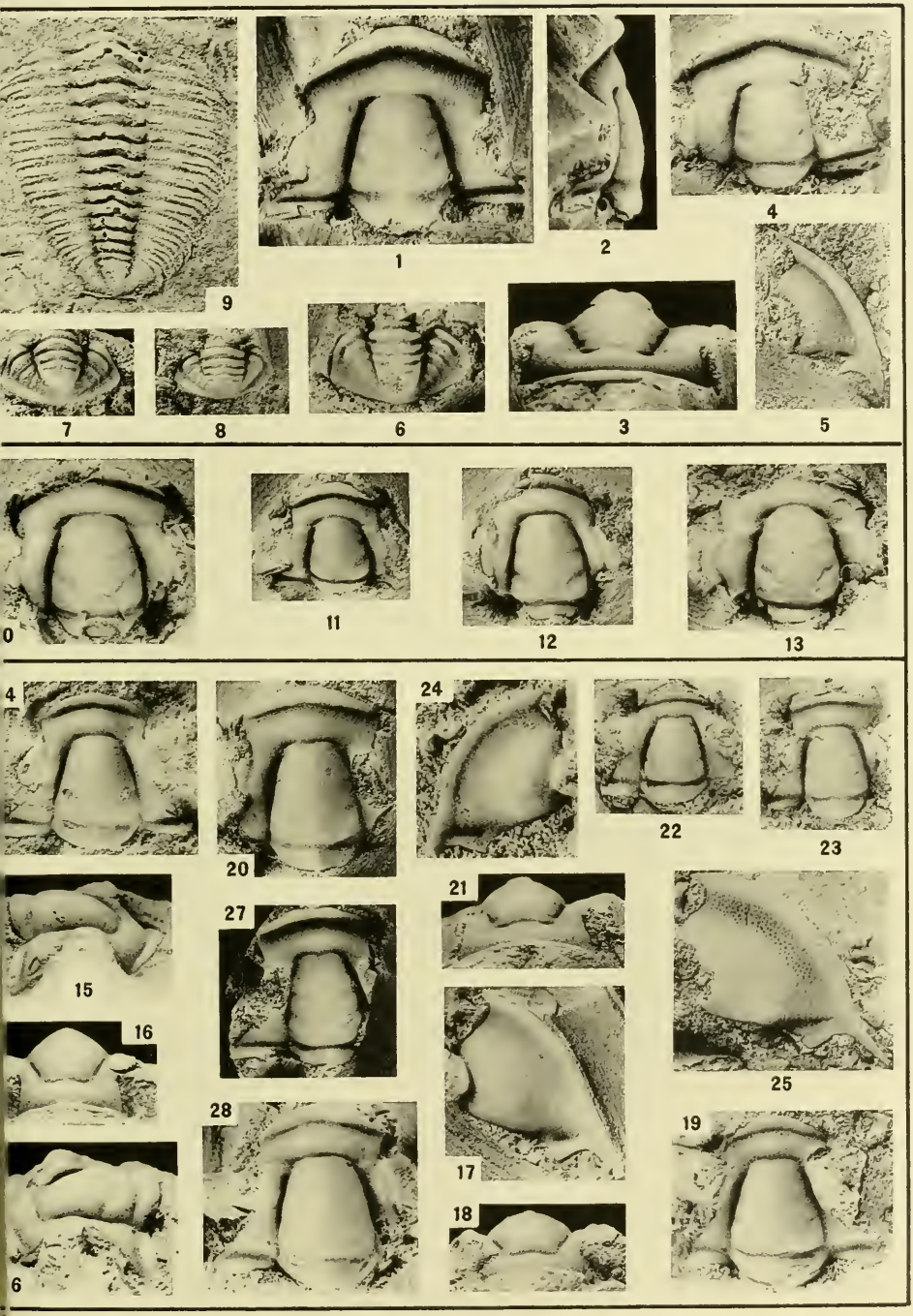
TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



TRILOBITES OF THE APHELASPIS ZONE.

(SEE EXPLANATION OF PLATES AT END OF TEXT.)