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A Late Cambrian (Sunwaptan) Silicified Trilobite Fauna from Nevada

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Systematic Paleontology

A LATE CAMBRIAN (SUNWAPTAN) SILICIFIED TRILOBITE FAUNA FROM NEVADA

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ABSTRACT

At Barton Canyon, Cherry Creek Range, east-central Nevada, a two-meter interval of the Bullwhacker Member of the Late Steptoean–Sunwaptan Windfall Formation has yielded abundant silicified sclerites. This Late Sunwaptan (Late Cambrian) assemblage, assigned to the informal *Bowmania lassieae* Fauna, is correlative with the *Prosaukia pyrene* Subzone of Texas, and with the uppermost *Illaenurus* Fauna of southern Alberta. At least 15 species are present, and these represent 14 genera; *Cherrycreekia* and *Glaberaspis* are new. New species are *Prosaukia oldyelleri, Sunwaptia plutoi, Euptychaspis dougali, Eurekia rintintini, Bowmania lassieae, Cherrycreekia benjii,* and *Glaberaspis scoobydooi.*

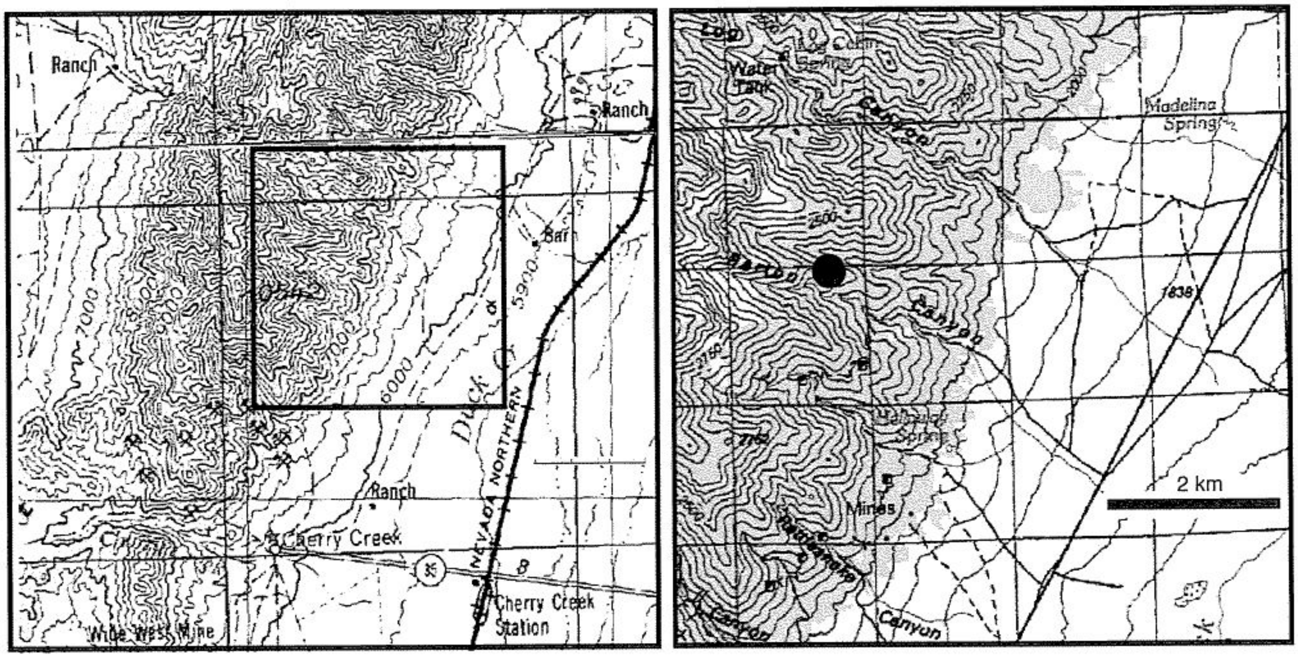
INTRODUCTION

North American silicified trilobites of Ordovician age were studied intensively in the 1950s by Evitt (1951), Ross (1951), Hintze (1953), Whittington and Evitt (1954) and Whittington (1956, 1959), and the morphologic and ontogenetic information provided by this work contributed greatly to the understanding of the phylogenetic relationships of post-Cambrian groups. In contrast, silicified faunas are virtually unknown in the Cambrian (see Ludvigsen, 1982, for an important exception) and their phylogenetic potential is largely untapped. Here we document a new silicified fauna from a Late Cambrian (Sunwaptan) sequence in the Cherry Creek Range of east-central Nevada. Although it lacks early ontogenetic stages, the fauna provides new insight into the morphology of a variety of genera. The fauna is also of significance because, although the trilobites of the underlying Steptoean stage have received considerable attention (Palmer, 1960, 1962, 1965), Sunwaptan trilobites of the Great Basin are essentially undocumented (see Taylor, 1976, for an exception).

The fauna was collected from a two-meter interval of the upper Bullwhacker Member of the Windfall Formation (Text-fig. 1) on the eastern side of the Cherry Creek Range, about 10 km north of the town of Cherry Creek (Text-fig. 2). The measured section runs along the crest of the ridge that forms the north side of Barton Canyon. Here, the upper Bullwhacker is composed of thin-bedded, fossiliferous calcareous sandstones and sandy bioclastic grainstones, with minor oolitic pack- and grainstones, intrarudites and thrombolitic microbial buildups (Text-fig. 3). The fauna includes 15 species, six of which are new.

ACKNOWLEDGMENTS

This a joint study; the order of authorship is alphabetical and does not indicate seniority. Support by the National Science Foundation through grant EAR-9973065 is gratefully acknowledged. We thank Pete Palmer for suggesting the Cherry Creek section as a locality with potential for recovery of silicified faunas, and Brian Chatterton and Bruce Lieberman for helpful reviews.

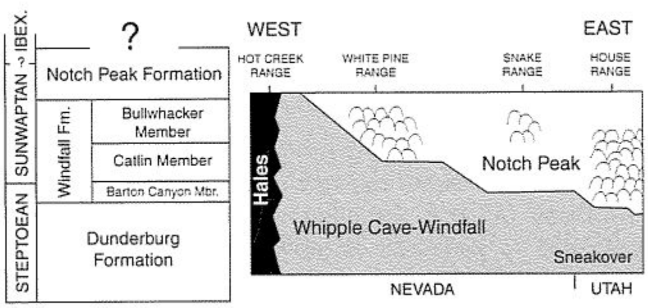


Text-figure 1.—A. Steptoean–Early Ibexian lithostratigraphy, Cherry Creek Range. B. Correlation of lithostratigraphic units immediately to the south of the study area, along an east-west transect from the House Range (west-central Utah) to the Hot Creek Range (central Nevada) (modified from Osleger and Read, 1993).

STRATIGRAPHIC AND ENVIRONMENTAL SETTING

STRATIGRAPHY

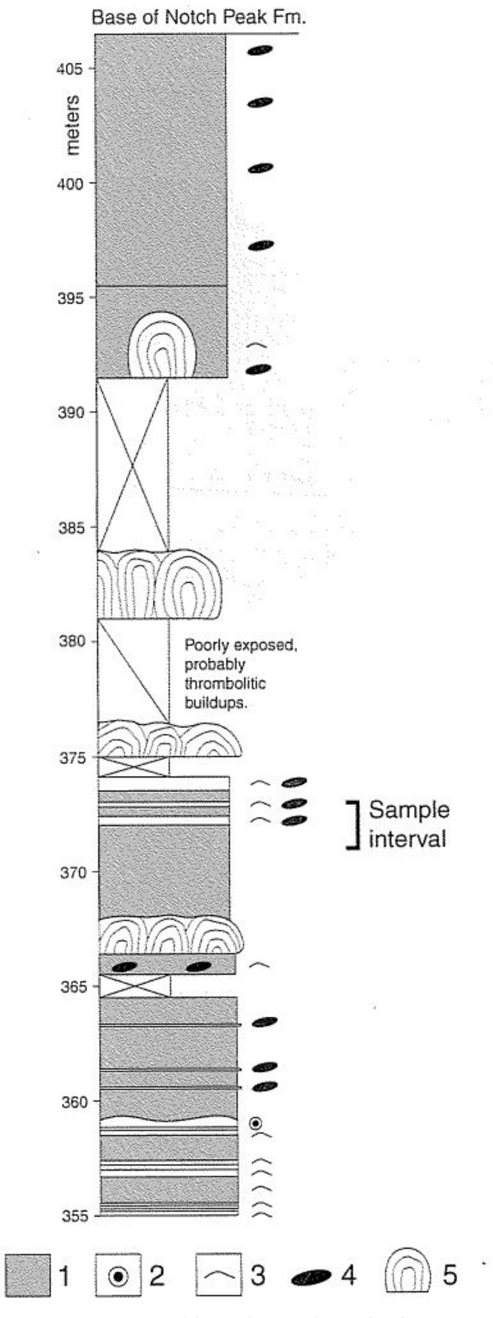
The Windfall Formation (Nolan *et al.*, 1956) was established in the Eureka Mining District of east-central Nevada for a sequence of carbonates that overlies the shales and interbedded carbonates of the Dunderberg Formation. The formation has also been recognized to the east and northeast of Eureka, in the Cherry Creek, northern Egan, and northern Schell Creek ranges (Palmer, 1971). Nolan *et al.* (1956) divided the Windfall into, in ascending order, the Catlin and Bullwhacker members. In the type area, the Catlin is composed of two distinct lithologies. The lower nine meters consists of thick-bedded, light-colored lime mudstones, and this is succeeded by about 75 meters of thin-bedded cherty carbonates. Farther to the east, in the northern Schell Creek Range, Young (1960) assigned the lower, light-colored carbonates to the Barton Canyon Limestone (named for, and well exposed at, the sample locality of this study), effectively restricting the Catlin to the overlying cherty carbonates. Subsequent workers (*e.g.*, Palmer, 1965, 1971) have followed Young in separating the Barton Canyon from the Catlin, and the three-fold division of the Windfall Formation is used herein (Text-fig. 1A).



Text-figure 2.—Locality Map, showing the measured section along the ridge at the north side of Barton Canyon, Cherry Creek Range.

The upper boundary of the Windfall Formation in the Cherry Creek Range is placed immediately below the base of a massive, cliff-forming unit that is composed of stacked thrombolitic and stromatolitic microbial buildups (Text-fig. 4). In previous work, Adair (1961) placed this buildup-bearing interval at the base of the "Pogonip Group." More recently, Osleger and Read (1993) interpreted a correlative interval of buildups farther to the south, in the White Pine Range, as a tongue of the Notch Peak Formation. In its type area of the southern House Range, Utah, the Notch Peak includes a thick interval of buildups (Hintze, 1973; Hintze *et al.*, 1988), and Osleger and Read's interpretation is followed herein.

The Barton Canyon Limestone yields faunas of the *Elvinia* Zone, with the base of the *Irvingella major* Zone (basal Sunwaptan) lying about 10 cm below the top of the member (Palmer, 1965; Adrain and Westrop,



Text-figure 3.—Stratigraphic column through the upper Bullwhacker Member, Barton Canyon, Cherry Creek Range, showing the interval that yielded the trilobite faunas described herein. Scale in meters above the base of the Catlin Member. The entire Bullwhacker is about 270 m in thickness at this locality. 1, sandy bioclastic limestone and calcareous sandstone; 2, wave-rippled oolitic grainstone; 3, bioclastic rudstone; 4, intraclastic rudstone; 5, thrombolitic microbial buildups.

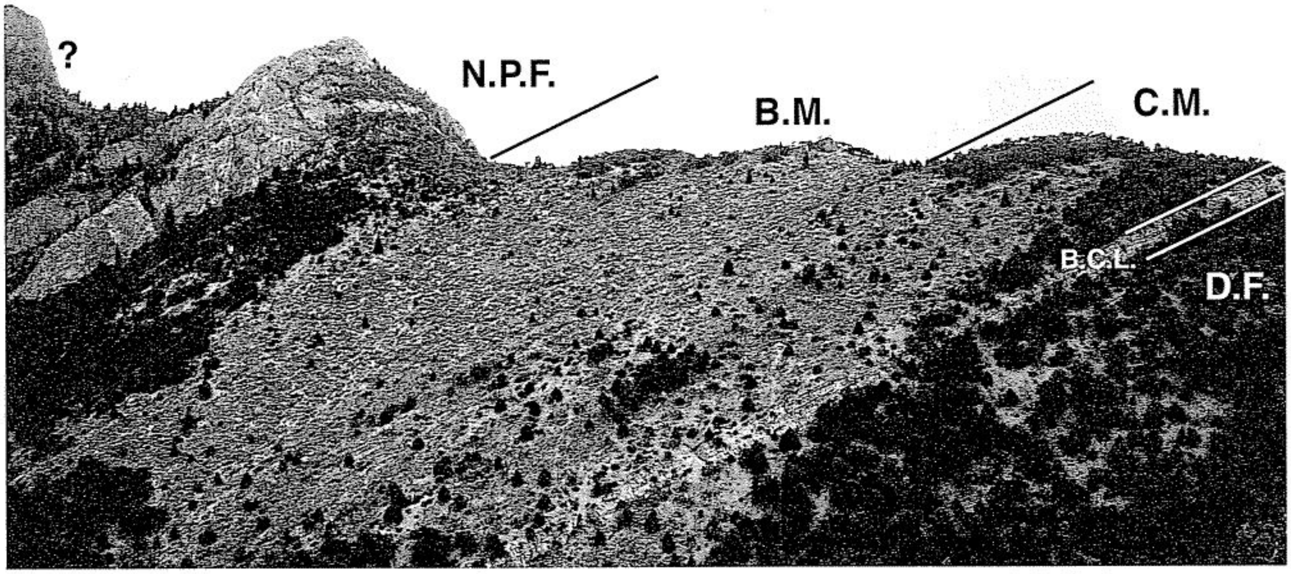
unpublished data). The basal few centimeters of the Catlin Member contains a fauna that includes *Elvinia roemeri* (Shumard, 1861), and this is followed by a 15-m interval with undescribed species of *Loganellus* Devine, 1863, *Wujiajiania*? Lu and Lin, 1980, and *Drumaspis* Resser, 1942 (Adrain and Westrop, unpublished data). The remainder of the Catlin is unfossiliferous, but the faunas of the lower 100 m of the Bullwhacker resemble the deep subtidal assemblages of the Rabbitkettle Formation of northwestern Canada (Ludvigsen, 1982; Westrop, 1995), and include *Idiomesus* Raymond, 1924, *Yukonaspis* Kobayashi, 1936a, *Tatonaspis* Kobayashi, 1935, *Parabriscoia* Kobayashi, 1935, *Hungaia* Walcott, 1914, *Elkanaspis* Ludvigsen, 1982, *Naustia* Ludvigsen, 1982 and *Eurekia* Walcott, 1916. The upper Bullwhacker includes the fauna described herein, and its age and correlation are discussed below.

The base of the Notch Peak Formation is a 50-cm-thick bed of sandy, cross-bedded bioclastic rudstone that provides the foundation for the overlying microbial buildups. The trilobite fauna of this rudstone includes *Eurekia longifrons* Westrop, 1986b and *Meniscocoryphe platycephala* (Kobayashi, 1935), and demonstrates that the Windfall–Notch Peak boundary correlates with the *Saukiella junia* Subzone of Oklahoma (Stitt, 1971, 1977) and Texas (Longacre, 1970), and the *Proricephalus wilcoxensis* Fauna of Alberta (Westrop, 1986b).

The buildup-bearing interval assigned to the Notch Peak Formation is overlain by a thick interval of largely unstudied carbonates. The lower 25 m consist mostly of bioturbated lime mudstones, with chert horizons appearing about 20 m above the top of the buildups. A silicified trilobite fauna was recovered 24.15 m above the top of the buildups, and this contains *Apoplanias* Lochman, 1964, *Symphysurina* Ulrich, *in* Walcott, 1924, and *Parakoldinioidia stitti* Fortey, 1983. It likely correlates with the upper *Missisquoia* or lower *Symphysurina* zones (*e.g.,* Stitt, 1977), an interval which lies near the top of the Notch Peak Formation in west-central Utah (Hintze *et al.,* 1988).

SEDIMENTARY FACIES

The thin-bedded, cherty lime mudstones and shales of the Catlin Member record a sharp deepening following the deposition of the shallow subtidal limestones of the Barton Canyon Limestone (see Brady and Rowell, 1976, for interpretation of the Barton Canyon Limestone and correlatives). The contact between the Catlin and the Bullwhacker Member is not exposed, and the latter is at least 270 m thick. The lower 100 m of the Bullwhacker consists of thin-bedded, unbioturbated lime mudstones with thin, dolomitic partings, and closely resembles the deep shelf facies of the Rabbitkettle Formation of northwest Canada (*e.g.,* Ludvigsen, 1982, fig. 12D; Westrop, 1995, text-fig. 3). In higher parts of the Bullwhacker, lime mudstones are extensively bioturbated and dolomite-mottled, sug-



Text-figure 4.—Skyline along ridge immediately to the north of the measured section, showing topographic expression of the Windfall and Notch Peak formations. D.F., Dunderburg Formation; B.C.L., Barton Canyon Limestone; C.M., Catlin Member; B.M., Bullwhacker Member; N.P.F., Notch Peak Formation; ?, unstudied cliff-forming carbonates of the "Pogonip Group." Stratigraphic thickness from the base of the Catlin Member to the top of the lower, resistant cliff formed by the Notch Peak buildup complex is 514.5 m.

gesting shallower, more oxygenated, subtidal conditions. In the upper 60 m of the Bullwhacker (Text-fig. 3), bioturbated lime mudstones are minor components of a succession that includes sandy bioclastic grainstones and calcareous sandstones. Shallow subtidal conditions (above storm wave base) are indicated by intraclastic rudstones ("flat pebble conglomerates") and pebbly intraclastic grainstones. Wave-rippled oolitic grainstones and thrombolitic buildups (1.5–3 m in thickness) also point to shallow-water conditions.

The Bullwhacker Member may be interpreted as recording upward-shoaling from deep subtidal conditions, culminating with the appearance of the thick, microbial buildup complex recorded by the Notch Peak Formation. The appearance of quartz sand and silt in the upper Bullwhacker (about 20 m below the fauna described herein) may be of more than local significance. Osleger (1995; Osleger and Read, 1993) suggested that a sequence boundary could be recognized within the lower *Saukia* Zone throughout southern Laurentia (Virginia–Tennessee, Oklahoma, Texas and west-central Utah). The biostratigraphic control presented by Osleger (1995) is limited, but the calcareous sandstones and sandy carbonates of the Bullwhacker may be an expression of the same sea-level fall.

AGE AND CORRELATION OF THE FAUNA

The assemblage described here is assigned to an informal biostratigraphic unit, the *Bowmania lassieae* n. sp. Fauna. Several species occur in other parts of North America, including *Illaenurus montanensis* Kobayashi, 1935, *Cherrycreekia benjii* n. sp., and *Corbinia implumis* Winston and Nicholls, 1967. At Wilcox Peak, southern Alberta (Westrop, 1986b, text-fig. 31), *I. montanensis* and *C. benjii* have been recorded from the upper part of the *Illaenurus* Zone, where they are separated by less than two meters of strata. *Proricephalus scapane* (Longacre, 1970) occurs with *C. benjii* in Alberta and is also present in the *Prosaukia pyrene* Subzone of the Wilberns Formation, central Texas (Longacre, 1970).

Corbinia implumis is known from two figured specimens (Winston and Nicholls, 1967, pl. 9, fig. 3; Longacre, 1970, pl. 3, fig. 13) from Texas that, according to boundaries defined by Longacre (1970, pp. 11–12), occur in the *P. pyrene* Subzone. In Alberta, this species extends from the upper *Illaenurus* Zone into the overlying *Proricephalus wilcoxensis* Fauna (Westrop, 1986b).

Although the biostratigraphic data support a correlation with the upper *Illaenurus* Zone of Alberta and the *Prosaukia pyrene* Subzone of Texas, we have not assigned the fauna from the silty and sandy carbonates of the upper Bullwhacker to either of these units. Quantitative analyses of Late Sunwaptan trilobite abundance and distribution (Ludvigsen and Westrop, 1983a; Westrop, 1986b, 1995, 1996) have demonstrated profound facies control, especially in carbonate environments. Assemblages track lithofacies changes (*e.g.*, Westrop, 1996, fig. 9), and this provides unequivocal evidence for the existence of environmentally controlled trilobite biofacies. Ludvigsen and Westrop (1983a; see also Ludvigsen *et al.*, 1986) advocated the use of separate zonations for different facies belts, and argued that correlation between zonations is best achieved through occurrences of relatively rare, widespread species. In contrast, Loch *et al.* (1993) ignored the complexities of facies control, and attempted to force all shallow-water facies into a single "standard" zonation based on the succession in southern Oklahoma and central Texas. They noted that the first occurrences of *Calvinella tenuisculpta* Walcott, 1914, a species that occurs at the base of the *Saukiella serotina* Subzone in Oklahoma, and *Stenopilus glaber* (Westrop, 1986b) are within three meters of each other in Alberta. From this, they concluded that the *Stenopilus glaber* Fauna of the latter region and the *Saukiella serotina* Subzone were equivalent. *Calvinella tennuisculpta* is, however, very rare in the Mistaya Formation (nine cranidia from three collections represent less than two percent of the trilobites recovered from the *S. glaber* Fauna; Westrop, 1984), so that it is unlikely that the first appearance in Alberta is synchronous with that in Oklahoma. As noted by Loch *et al.* (1993), *C. tenuisculpta* and *S. glaber* make their first occurrence in the same collection in a section at Mt. Murchison. They fail to mention, however, that this is the *only* collection from the Mistaya Formation at that locality, and is separated from the closest underlying sample by more than 100 meters (Westrop, 1986b, fig. 24). As such, it says nothing about the order of appearance of these species. Similarly, their (Loch *et al.*, 1993, p. 503) observation that the eponymous species is absent from the *S. glaber* Zone at Chaba Creek is irrelevant because the single collection from that locality contains only four trilobite sclerites (Westrop, 1984). Finally, the species that can be used to assign their section at Mt. Wilson to the *Saukiella serotina* Subzone are either poorly preserved, very rare (e.g., *Euptychaspis kirki* Kobayashi, 1935, is represented by only one cranidium; Loch *et al.*, 1993, Appendix 1) or misidentified (the larger of the two cranidia assigned to "*Briscoia*" *llanoensis* Winston and Nicholls, 1967, by Loch *et al.* [1993, fig. 6.18] shows a clearly defined anterior border and short preglabellar field that is not present on material from the type area in Texas [Winston and Nicholls, 1967, pl. 10, figs. 1, 3, 5]). Thus, although an approximate correlation between Alberta and Oklahoma-Texas is possible (Westrop, 1986b), use of a common zonal nomenclature implies a degree of accuracy that is not supported by the available data.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

Our approach to systematic treatment of fossils is essentially that laid out by Smith (1994), and our species concept corresponds to what he defined as "phena." Morphological terminology follows Whittington (1997). Specimens are reposited in the Paleontology Repository, Department of Geoscience, University of Iowa, with specimen numbers prefixed SUI. Trilobites were photographed using a Leitz Aristophot macrophotography system and Kodak Technical Pan film. Negatives were scanned using a Polaroid negative scanner to produce digital images, which were manipulated using Adobe Photoshop.

Class **TRILOBITA** Walch, 1771

Family **DIKELOCEPHALIDAE** Miller, 1889

Discussion.—The problematic nature of many dikelocephalid genera has been discussed often over the last 25 years (*e.g.* Taylor, *in* Taylor and Halley, 1974; Ludvigsen and Westrop, 1983b; Westrop, 1986b) but little progress has been made. The large number of taxa involved and their broad geographic distribution (*e.g.*, Shergold, 1975; Ergaliev, 1980; Peng, 1984, 1992) make revision of the Dikelocephalidae a daunting task that is well beyond the scope of this study.

Genus **DIKELOCEPHALUS** Owen, 1852

Type species.—*Dikelocephalus minnesotensis* Owen, 1852, p. 574.

Discussion.—The presence of a pair of posterolateral pygidial spines has generally been considered to be a diagnostic character of *Dikelocephalus* Owen (*e.g.*, Westrop, 1986b; Hughes, 1994). Apart from the absence of marginal spines, pygidia of several species currently assigned to Briscoia Walcott, 1924, (*e.g.*, Westrop, 1986b, pl. 2, figs. 3, 4) differ little from those of Dikelocephalus. It is also clear that the holaspid ontogenetic development of the frontal area in cranidia of Briscoia, in which the distinction between the preglabellar field and anterior border is lost (*e.g.*, Westrop, 1986b, pl. 2, figs. 1, 5, 6, 7) is similar to that of *Dikelocephalus*. Indeed, as noted by Westrop (1986b, p. 29), only the more anteriorly positioned palpebral lobe separates cranidia of *Briscoia* from *Dikelocephalus*, but similarly positioned palpebral lobes occur in a variety of other dikelocephalid genera (*e.g.*, Longacre, 1970, pl. 4, figs. 16, 17; Taylor and Halley, 1974, pl. 2, fig. 2; Westrop, 1986b, pl. 4, figs. 1, 10). Thus, even if well-developed pygidial spines and posteriorly positioned palpebral lobes are apomorphies of *Dikelocephalus*, recognition of the genus may create paraphyly in *Briscoia*.

Resolution of this problem must await a comprehensive revision of the Dikelocephalidae.

Dikelocephalus minnesotensis Owen, 1852
Plate 1, figures 1–26

Dikelocephalus minnesotensis Owen, 1852, p. 574, pl. 1, figs. 1, 2 (only), pl. 1a, figs. 3, 6; Hughes, 1994, p. 53, pls. 1–8, pl. 10, figs. 14, 15, pl. 11 (see for complete synonymy); Stitt and Straatman, 1997, p. 86.

Figured material.—One cranidium (SUI 99042), two pygidia (SUI 99048, 99051), one hypostome (SUI 99043), four librigenae (SUI 99045–99047) and two thoracic segments (SUI 99049, 99050).

Discussion.—Hughes (1994), in his analysis of phenotypic variation in the type area of the Upper Mississippi Valley, advocated a broad species concept for *Dikelocephalus minnesotensis*. At least one other species, *D. freebergensis* Feniak (*in* Bell *et al.,* 1952; Hughes, 1994, pl. 9, figs. 3–5, 17–19), may be represented in the Sunwaptan of the Upper Mississippi Valley (see Hughes, 1994, p. 57). It differs from *D. minnesotensis* in such pygidial features as longer, stouter marginal spines and a more transverse posterior pygidial margin.

Pygidia from the Bullwhacker Member (Pl. 1, figs. 13, 18, 19, 22–26) possess a fourth axial ring that is poorly differentiated from the terminal piece and fall within the range of variation of specimens of *D. minnesotensis* illustrated by Hughes. The pygidial doublure (Pl. 1, fig. 26) is very broad, and has a prominent medial notch beneath the terminal piece of the axis. In contrast, the doublure of *Prosaukia oldyelleri* n. sp. (Pl. 3, figs. 1, 18) is narrower, with an anterior margin that is bluntly rounded medially and extends forward only as far as the end of the postaxial ridge. A doublure similar to that of *P. oldyelleri* is also present in pygidia of *Calvinella palpebra* Ludvigsen (1982, fig. 58J) and, judging from the position of the faint paradoublural furrow or inflexion on the pleural field, in *Hoytaspis speciosa* (Walcott) (Ludvigsen and Westrop, 1983b, pl. 15, figs. 11–13), *P. corrugata* Rasetti (1959, pl. 54, figs. 6, 7) and *P. stosei* (Walcott) (Rasetti, 1959, pl. 54, fig. 17).

The associated cranidium (Pl.1, figs. 1–4) is much smaller than any that have been illustrated previously. It has a shorter frontal area than most larger holaspids from the Upper Mississippi Valley (*e.g.,* Hughes, 1994, pl. 2, figs. 2, 3, pl. 3, figs. 1–6), although Hughes (1994, p. 26, figs. 18, 19) demonstrated substantial variability in frontal area length. A distinct anterior border and border furrow is present, and similar features can be seen on small cranidia from the Upper Mississippi Valley (*e.g.,* Labandeira and Hughes, 1994, fig. 1.3). In this respect, it resembles small holaspids of *Briscoia* (Westrop, 1986b, pl. 2, fig. 5). Finally, the palpebral lobe is relatively long (Pl. 1, fig. 1; equal to slightly more than half of glabellar length), and this is consistent with Hughes's (1994, p. 32, fig. 24) conclusion that palpebral lobe length is size-dependant.

The hypostome of *D. minnesotensis* (Pl. 1, figs. 5, 6, 8) can be identified with confidence because of the association with complete cephala in Wisconsin (Ulrich and Resser, 1930, pl. 10, fig. 2). The expansion of the flat lateral border opposite the median furrow is particularly distinctive. Hypostomal borders of other dikelocephalids are variable. Some are similar to, but narrower than, those of *Dikelocephalus* (*e.g.,* Shergold, 1991, pl. 4, figs. 7, 20), whereas others are convex and rim-like (*e.g.*, Ulrich and Resser, 1933, pl. 36, fig. 14). A comparable range in morphologies, from flat and somewhat expanded (Westrop, 1986b, pl. 7, fig. 9, pl. 8, fig. 16) to convex rims (Westrop, 1986b, pl. 8, fig. 4), is seen among species of such outgroups as the ptychaspidid *Ptychaspis* Hall, 1863, so that character polarities are uncertain.

Genus **PROSAUKIA** Ulrich and Resser, 1933

Type species.—*Dikelocephalus misa* Hall, 1863, p. 144.

Discussion.—As discussed by Ludvigsen and Westrop (1983b, p. 30) and Westrop (1986b, p. 32), *Prosaukia* and *Saukiella* Ulrich and Resser, 1933, are to some extent gradational and could prove to be synonyms. Part of the problem stems from the fact that *Saukiella* currently includes two groups of species that differ in the structure of the frontal area. The type species, *Saukiella pepinensis* (Owen, 1852) (Ulrich and Resser, 1933, pl. 32, figs. 1–4, pl. 33, fig. 22; Longacre, 1970, pl. 5, figs. 10, 11), and *S. junia* (Walcott, 1914) (Winston and Nicholls, 1967, pl. 9, figs. 8, 10, 12, 14; Longacre, 1970, pl. 5, figs. 13–17, 19, 20) both possess long frontal areas in which the preglabellar field is barely developed. In contrast, *S. pyrene* (Walcott, 1914) (Ulrich and Resser, 1933, pl. 34, pl. 35, fig. 1; Longacre, 1970, pl. 5, figs. 1–7), *S. fallax* (Walcott, 1914) (Longacre, 1970, pl. 5, figs. 1, 3) and *S. serotina* Longacre (1970, pl. 6, figs. 1–3) are characterized by short, subequally divided frontal areas that are comparable to those of *Prosaukia* (*e.g.,* Longacre, 1970, pl. 4, figs. 19–21; Ludvigsen and Westrop, 1983b, pl. 11, figs. 1–8; Westrop, 1986b, pl. 4, figs. 8–11, 13). Indeed, of the criteria suggested by Longacre (1970, p. 49), only the confluent border furrows of the librigenae separate *S. pyrene* (*e.g.,* Ulrich and Resser, 1933 pl. 34, pl. 35, figs. 2, 3, pl. 36, figs. 7–9) from *Prosaukia hartti* (Walcott, 1879) which has border furrows that do not meet (Ludvigsen and Westrop, 1983b, pl. 11, fig. 10). Character polarities, however, are uncertain because both states occur in outgroups to the Dikelocephalidae (for examples of isolated border furrows similar to those of *P. hartti,* see Ludvigsen, 1982, fig. 58N, fig. 59S, T; Westrop, 1986b, pl. 7, fig. 5, pl. 8, fig. 5; confluent border furrows occur in *Keithiella depressa* [Rasetti, 1944], see Ludvigsen and Westrop, 1983b, pl. 16, fig. 8). Among dikelocephalid genera, confluent border furrows are present in *Calvinella* (Walcott, 1914) (Ulrich and Resser, 1933, pl. 37, figs. 22, 24, 27, 28, 31, 32; Ludvigsen, 1982, fig. 58F) and *Tellerina* Ulrich and Resser (1933, pl. 44, figs. 4, 19), whereas isolated furrows occur in *Parabriscoia* (Palmer, 1968, pl. 15, fig. 1). Thus, librigenal border morphology is ambiguous and does not demonstrate monophyly of *Saukiella.*

As a tentative first step toward a revision of the dikelocephalid genera, we suggest restriction of *Saukiella* to *S. pepinenis* and *S. junia,* with frontal area proportions (long frontal area with very short preglabellar field) as a potential apomorphy. *Saukiella pyrene, S. fallax,* and *S. serotina* are transferred to *Prosaukia,* and the diagnosis of Ludvigsen and Westrop (1983b) is followed herein.

Prosaukia oldyelleri, new species
Plate 2, figures 1–39, Plate 3, figures 1–41

Diagnosis.—A species of *Prosaukia* with small marginal spines on anteriormost pleura of pygidium. Anterior end of palpebral lobe reaches glabella, so that palpebral furrow joins axial furrow. Short, narrow frontal area has subtriangular anterior border.

Description.—Strongly convex subrectangular glabella occupies about 85 percent of cranidial length and slightly less than 60 percent of cranidial width across palpebral lobes. Axial and preglabellar furrows are finely etched grooves, and are bowed outward at S1 and S2 lobes, especially in larger cranidia; glabella is weakly constricted opposite anterior ends of palpebral lobes. Longitudinal profile of glabella is gently convex between posterior margin and anterior tips of palpebral lobes, but curves steeply downward anteriorly. Occipital furrow is narrow (sag.), roughly transverse groove. S1 furrows are curved gently backward and connected across glabella, although become somewhat shallower medially. S2 furrows also curved backward although are well defined only near axial furrows; may be connected across glabella in some individuals. Frontal area is short and narrow, with maximum width equal to about 70 percent of cranidial width across palpebral lobes; unequally divided into short preglabellar field and longer, convex, subtriangular anterior border by shallow, forwardly curved border furrow. Long, flat, strongly curved palpebral lobes are centered slightly in front of anterior tips of S1 furrows and extend from occipital furrow to mid-point of frontal glabellar lobe; separated posteriorly from glabella by narrow strips of fixigenae but abut glabella anteriorly. Palpebral furrow is finely etched groove that merges with axial furrow anteriorly; palpebral lobe may be subequally divided by barely perceptible furrow that parallels palpebral furrow. Posterior branches of facial sutures diverge sharply backward. Anterior branches moderately divergent near palpebral lobe, curving gradually inward to become nearly parallel at anterior border furrow before converging abruptly inward along anterior cranidial margin. Posterior fixigenae narrow, strap-like; in anterior view, flexed downward at about 30 degrees. Posterior border furrow very shallow, finely etched groove. Glabella, interocular fixigenae and anterior border have sculpture of terrace ridges; palpebral lobes and preglabellar field are smooth. Occipital ring may carry minute occipital spine.

Librigenae separated by median suture. Long, slender genal spine curves gently inward; equal to about 275 percent of length of librigenal field. Moderately inflated librigenal field separated from convex posterior and lateral border by shallow, confluent border furrows. Eye socle consists of two wire-like bands separated by finely etched longitudinal furrow. Inner edge of doublure lies beneath lateral border furrow but diverges posteriorly from posterior border furrow, so that doublure narrows laterally away from genal angle. Genal spine, borders, doublure and librigenal field carry sculpture of terrace ridges.

Pygidium subelliptical in outline, with length about 66 percent of maximum width; pair of minute marginal spines located slightly anterior of posterior tip of axis. Convex axis accounts for about half of pygidial height in lateral view, and about 40 percent of pygidial width at anteriormost axial ring; tapers backward and occupies slightly more than 75 percent of pygidial length; post-axial ridge terminates close to pygidial border. Axial furrows are shallow grooves. Four subequal axial rings and rounded terminal piece separated by subtransverse axial ring furrows; semielliptical articulating half-ring equal to about 75 percent of length of anteriormost axial ring. Pleural field nearly flat at axial furrow but flexed downward, becoming nearly flat at pygidial margin. Inner edge of doublure underlies point of downward flexure of pleural field and does not reach posterior end of axis. Pleural and interpleural furrows well defined and curve outward and backward to terminate just short of pygidial margin; degree of curvature decreases in successive furrows so that posteriormost are nearly straight. Apart from anteriormost, convex anterior and posterior pleural bands subequal in length. Pleural field and doublure carry fine terrace ridges that roughly parallel pygidial margin; axis also with terrace ridges.

Holotype.—A cranidium (SUI 99054; Pl. 2, figs. 3, 4, 7, 11) from the Bullwhacker Member, Windfall Formation, Barton Canyon, Cherry Creek Range, Nevada.

Figured material.—Eleven cranidia (SUI 99052–99062), four librigenae (SUI 99063, 99064, 99080, 99081), and 14 pygidia (SUI 99065–99079).

Etymology.—Named for Old Yeller.

Discussion.— *Prosaukia oldyelleri* n. sp. is unusual in possessing palpebral lobes whose anterior tips abut the glabella. The typical dikelocephalid condition has the anterior end of the palpebral lobe separated from the glabella by a strip of fixigena of variable width (*e.g., Prosaukia* [Rasetti, 1959, pl. 54, figs. 4, 5, 9, 16, 22; Longacre, 1970, pl. 4, figs. 19–21; Taylor and Halley, 1974, pl. 2, figs. 15–17; Ludvigsen and Westrop, 1983b, pl. 10, figs. 1, 3; Westrop, 1986b, pl. 4, figs. 8–11]; *Calvinella* Walcott, 1914 [Nelson, 1951, pl. 110, fig. 21; Longacre, 1970, pl. 4, figs. 16, 17; Taylor and Halley, 1974, pl. 2, figs. 2, 3]; *Saukia* Walcott, 1914 [Westrop, 1986b, pl. 3, figs. 8, 9, 11]; *Hoytaspis* Ludvigsen and Westrop [1983b, pl. 14, fig. 1, 8]; *Saukiella* Ulrich and Resser, 1933 [Longacre, 1970, pl. 5, figs. 10, 12, 17]; *Stigmaspis* Nelson, 1951 [Westrop, 1986b, pl. 4, figs. 1, 3–5]; *Tellerina* Ulrich and Resser, 1933 [Nelson, 1951, pl. 112, figs. 5, 12]; *Briscoia* Walcott, 1924 [Walcott, 1925, pl. 20, fig. 1; Westrop, 1986b, pl. 2, figs. 1, 5–7, 10]; *Parabriscoia* Kobayashi, 1935 [Palmer, 1968, pl. 15, figs. 2, 5; Westrop, 1995, pl. 1, figs. 28]; *Elkia* Walcott, 1924 [Walcott, 1925, pl. 18, figs. 1, 2]; *Dikelocephalus* Owen, 1952 [Hughes, 1994, pl. 2, figs. 1–3, 6, 7]; *Lophosaukia* Shergold, 1972 [Shergold, 1975, pl. 18, fig. 1; Peng, 1992, fig. 24B]; *Mictosaukia* Shergold, 1975 [Robison and Pantoja-Alor, 1968, pl. 104, figs. 13, 18; Shergold, 1975, pl. 24, fig. 10; Peng, 1992, fig. 24H]; *Anderssonella* Kobayashi, 1936b [Shergold, 1975, pl. 20, fig. 4]; *Galerosaukia* Shergold [1975, pl. 22, fig. 9]; *Caznaia* Shergold [1975, pl. 25, fig. 1]; *Platysaukia* Kobayashi, 1960 [Shergold, 1991, pl. 3, fig. 8]; *Eosaukia* Lu, 1954 [Shergold, 1991, pl. 5, fig. 21]). Although the anterior branches of the facial sutures are sharply divergent, the position of the palpebral lobes of *P. oldyelleri* results in a relatively narrow frontal area that also differs from typical dikelocephalids. Only *Osceolia osceola* (Hall, 1863) (Nelson, 1951, pl. 110, fig. 9) and at least some specimens of *Prosaukia pyrene* (Walcott, 1914) (*e.g.,* Ulrich and Resser, 1933, pl. 34, pl. 35, fig. 1; Nelson, 1951, pl. 110, fig. 4) have palpebral lobes in a position that is similar to *P. oldyelleri. Osceolia osceola,* however, is differentiated readily by a much longer frontal area on the cranidium and a pygidium (Nelson, 1951, pl. 110, fig. 10) that lacks interpleural furrows and has very long, stout marginal spines on the anteriormost pleura. *Prosaukia pyrene* has less strongly divergent anterior branches of the facial sutures, and an arcuate anterior border that results in an evenly rounded anterior cranidial margin.

The minute marginal spines on the anteriormost pleura and associated embayment of the lateral margin separate pygidia of *P. oldyelleri* from those of all previously described members of *Prosaukia,* although similarly sized spines could perhaps be overlooked or destroyed in preparation of "crackout" pygidia of other species. The only other spinose species is *P. spinula* Taylor (*in* Taylor and Halley, 1974, pl. 2, figs. 18, 20), but in that species, a single median spine is present.

Apart from the absence of marginal spines, pygidia of *P. pyrene* (Longacre, 1970, pl. 5, fig. 8) are very similar to those of *P. oldyelleri.* The type species, *P. misa* (Hall, 1863) (Westrop, 1986b, pl. 4, fig. 14), possesses pygidia that differ from those of *P. oldyelleri* and *P. pyrene* in having an axis composed of three, rather than four, axial rings plus terminal piece, whereas *P. hartti* (Walcott, 1879) (Ludvigsen and Westrop, 1983b, pl. 11, fig. 12) has five rings and a terminal piece.

The thoracic segment illustrated on Plate 17 (figs. 41, 46, 50) probably belongs to a dikelocephalid trilobite. We hesitate to assign it to *P. oldyelleri* because the coarse granules on the pleural bands and along the posterior margin of the axial ring are not present on any of the sclerites that can be confidently attributed to this species.

Family **PTYCHASPIDIDAE** Raymond, 1924

Subfamily **PTYCHASPIDINAE** Raymond, 1924

Discussion.—The genera of the Ptychaspidinae are in need of revision. Among North American representatives of the subfamily, monophyly of *Idiomesus* Raymond, 1924, is supported by substantial eye reduction or loss. *Keithia* Raymond, 1924, is defined by an expanded, bulb-shaped glabella that partly or completely overhangs the anterior border. *Proricephalus* Westrop, 1986a, (and its probable synonym *Plectrella* Ludvigsen and Westrop, *in* Ludvigsen *et al.,* 1989) can be diagnosed on the structure of the frontal area. The status of *Ptychaspis* Hall, 1863, and *Keithiella* Rasetti, 1944, is less certain. These genera have been separated by the expression of the anterior border and border furrow (*e.g.,* Longacre, 1970; Westrop, 1986b; Ludvigsen *et al.,* 1989). *Keithiella* possesses a convex anterior border and firmly impressed anterior border furrow, whereas *Ptychaspis* is characterized by an undifferentiated frontal area. By comparison with outgroups in the Dikelocephaloidea (*e.g.,* Westrop, 1986b, pl. 5, figs. 1, 2, 6), the condition in *Keithiella* is most likely plesiomorphic. The frontal area morphology of *Ptychaspis* is, however, shared with *Idiomesus*. Thus, it is possible that both *Ptychaspis* and *Keithiella* are paraphyletic. Any phylogenetic analysis will need to consider Australian and Chinese representatives of the subfamily, including *Asioptychaspis* Kobayashi, 1933 (regarded as a synomym of *Ptychaspis* by Shergold, 1991), *Changia* Sun, 1924, and *Quadraticephalus* Sun, 1924.

Genus **IDIOMESUS** Raymond, 1924

Type species.—*Idiomesus tantillus* Raymond, 1924, p. 397.

Idiomesus levisensis (Rasetti, 1944)

Plate 4, figures 1–20, 22, 23

Stigmametopus levisensis Rasetti, 1944, p. 257, pl. 37, figs. 8, 9.
Idiomesus levisensis (Rasetti). Taylor, 1976, p. 686, pl. 3, figs. 12, 13 (see for complete synonymy); Ludvigsen and Westrop, 1986, p. 305, pl. 20, figs. 5, 6D (see for synonymy); Ludvigsen, Westrop and Kindle, 1989, p. 32, pl. 20, figs. 8–13; Westrop, 1995, p. 24, pl. 7, fig. 24.

Figured material.—Six cranidia (SUI 99082–99088) and three librigenae (SUI 92089–92091).

Discussion.—The spindle-shaped glabella with S2 and S3 lateral glabellar furrows is characteristic of *Idiomesus levisensis* (Rasetti) (see Taylor, 1976, p. 686; Ludvigsen and Westrop, 1986). The librigena, illustrated here for the first time (Pl. 4, figs. 19, 20, 22, 23), carries a long, gently curved genal spine that contrasts with the minute spine of *I. tantillus* Raymond (Ludvigsen, 1982, fig. 54R)

Subfamily **MACRONODINAE** Westrop, 1986a

Genus **SUNWAPTIA** Westrop, 1986a

Type species.—*Sunwaptia carinata* Westrop, 1986a, p. 218.

Discussion.—Pygidial morphology offers potential synapomorphies for the Macronodinae (Adrain and Westrop, 2001, fig. 8), so that the discovery of the pygidium of *Sunwaptia* (Pl. 5, figs. 21–32) is of phylogenetic significance. As in *Macronoda* (Lochman, 1964, pl. 14, figs. 14, 18, 19, 21, 22; Westrop, 1986b, pl. 11, figs. 6, 7; Loch *et al.*, 1993, fig. 6.24), it is subtriangular in outline, with a long axis and narrow pleural fields. Moreover, *Sunwaptia* and *Macronoda* possess pits in the border furrow, and this character is an unequivocal synapomorphy. *Sunwaptia* differs in that the pits are overlain by swollen protuberances that extend inward from the border. The two genera also differ in the segmentation of the pygidial axis. The axis of *Sunwaptia plutoi* n. sp. has three or four axial rings, with a long terminal piece that occupies at least one-third of axial length. In contrast, pygidia of *Macronoda* have multisegmented axes, with up to at least 14 poorly defined axial rings (Loch *et al.*, 1993, p. 512).

Sunwaptia plutoi, new species

Plate 4, figures 21, 24–26, Plate 5, figures 1–32

Diagnosis.—A species of *Sunwaptia* in which fixigenal ridge is poorly defined or absent. Palpebral lobe relatively small. Anterior cranidial arch weak.

Description.—Cranidium subsemielliptical in outline, with length equal to 60 percent maximum width; posterior margin curved backward, so that posterior tips of fixigenae extend back well beyond occipital ring. Glabella strongly convex and accounts for about 75 percent of cranidial height in anterior view; bulb shaped in outline, and occupies about 90 percent of cranidial length and nearly 50 percent of cranidial width across palpebral lobes. Longitudinal profile horizontal between posterior margin and S1 furrow, becoming arched strongly upward at frontal lobe before curving almost vertically downward at anterior. Axial and preglabellar furrows moderately impressed grooves. Occipital furrow deeply incised, transverse; occipital ring equal to about 15 percent of glabellar length and with posterior margin bowed gently backward. S1 firmly impressed transverse groove; L1 transverse band, roughly equal in length to occipital ring. Frontal lobe suboval in outline and strongly inflated, with maximum height in lateral view equal to 150–175 percent of height of L1; maximum width opposite palpebral ridge and equal to 130–145 percent of width of L1. Anterior border furrows shallow, diverging forward from anterior corners of glabella to anterior corners of cranidium; anterior border nearly flat medially but arched strongly downward in anterior view in all but smallest cranidium (Pl. 5, fig. 9). Palpebral lobe ill-defined inflated area at abaxial end of conspicuous, gently curved, wall-like palpebral ridge; located in front of mid-length of anterior glabellar lobe. Anterior branches of facial suture run forward and inward from palpebral lobe; posterior branches diverge gradually backward before curving slightly inward near posterior corner of cranidium. Posterior fixigena broad, maximum width equal to about 300 percent of interocular fixigena; slopes steeply upward from axial furrow, creating broad, arcuate, depressed area from palpebral ridge to S1 furrow; reaches maximum convexity behind palpebral lobe before flexing downward to lateral cranidial margin. Some individuals show low fixigenal ridge extending for short distance posterolaterally from palpebral lobe (Pl. 4, figs. 25, 26). Posterior border furrow deeply incised, slot-like, and curves gently backward from axial furrow; posterior border convex, curving gently backward and expanding distally, so that length is less than length of occipital ring at axial furrow but is subequal at posterior corner. Well-preserved cranidia (Pl. 5, figs. 1, 4, 5) with coarse tubercles along crest of glabella, becoming finer along the sides; larger tubercles perforated by large pore. Near axial furrow, glabella mostly smooth, as is adjacent portion of posterior fixigena. Outer parts of posterior fixigena with closely spaced fine tubercles and scattered coarser tubercles.

Librigena with short, broad-based, subtriangular genal spine. Librigenal field broad and moderately inflated. Lateral border furrow moderately impressed, running parallel to border posteriorly, then diverges from border, curving backward and inward as shallow paradoublural furrow; posteriorly, border furrow ill defined, marked by change in slope. Lateral border convex, best defined anteriorly, and merges with rim-like posterior border at tip of genal spine. Outer edge of weakly convex doublure follows anterior border and paradoublural furrows. Sculpture of very fine terrace ridges on doublure; remainder of librigena smooth.

Pygidium subtriangular in outline, with length slight less than 70 percent of maximum width. Axis long, extending back to border and narrow, accounting for about 25 percent of maximum pygidial width; parallel sided to gently tapered anteriorly but with terminal piece expanded posteriorly, and strongly convex, standing well above pleural fields. Four axial rings and long terminal piece separated by firmly impressed, forwardly curved ring furrows; successive rings decrease slightly in length, so that posteriormost about 75 percent length of anteriormost; terminal piece accounts for about 40 percent of axis length. Articulating half-ring short, equal to 25 percent of length of adjacent axial ring, with very gently curved anterior margin; articulating furrow also gently curved and firmly impressed. Pleural field triangular in outline and flexed downward from axis; crossed by three pairs of firmly impressed, oblique pleural furrows; interpleural furrows barely perceptible on broad pleural bands. Border narrow, convex rim; border furrow with four pairs pits that are overlain by swollen protuberances that extend inward from the border. Doublure narrow, convex, so that border is subcircular in cross-section. Dorsal surface of pygidium smooth except for coarse terrace ridges on border.

Holotype.—A cranidium (SUI 99092; Pl. 4, figs. 21, 24–26) from the Bullwhacker Member, Windfall Formation, Barton Canyon, Cherry Creek Range.

Figured material.—Six cranidia (SUI 99092–99097), three librigenae (SUI 99098–99100), and four pygidia (SUI 99101–99104).

Etymology.—Named for Pluto Pup.

Discussion.—*Sunwaptia plutoi* n. sp. is very similar to the type species, *Sunwaptia carinata* Westrop (1986a, figs. 4A–E; 1986b, pl. 11, figs. 9–13), from the Mistaya Formation of Alberta, but clearly differs in that the fixigenal ridge extending from the palpebral lobe to the posterior border furrow is poorly defined, extending for only a short distance from palpebral lobe (*e.g.*, Pl. 4, figs. 25, 26), or absent (*e.g.*, Pl. 5, figs. 10, 14, 17). Other differences in *S. plutoi* include a somewhat longer L1 glabellar lobe, a less pronounced anterior arch, and a smaller palpebral lobe. The smallest cranidium (Pl. 5, figs. 8, 9) has a transverse, rather than arched, anterior margin, and appears to have a faint anterior border furrow and rim-like border.

Subfamily **EUPTYCHASPIDINAE** Hupé, 1953

Discussion.—Ingroup relationships of both the Euptychaspidinae and Macronodinae have been discussed recently by Adrain and Westrop (2001). As currently conceived, the Euptychaspidinae is confined to the Upper Sunwaptan (*sensu* Ludvigsen and Westrop, 1985) of North America, although Briggs *et al.* (1988) and Edgecombe (1992) suggested that *Curiaspis* Sdzuy, 1955, from the Leimitz Shale of Germany, might be an Ordovician ptychaspidid. Among the Ptychaspididae, glabellar structure of *Curiaspis* (Sdzuy, 1955, p. 7, figs. 11–16) is most similar to *Euptychaspis*, sharing transglabellar S1 and S2 furrows and a rounded anterior lobe. It has comparable palpebral lobes, but lacks the ridge-like extensions of the border on the occipital ring, which carries a conventional spine. Unlike *Euptychaspis* (and any other dikelocephaloidean), *Curiaspis* is proparian, with a short, slender genal spine. The relationship between *Curiaspis* and the euptychaspidines is uncertain, although discovery of the pygidium may clarifiy the affinities of this genus.

Calvipelta Westrop, 1986b, a small, effaced, blind trilobite from the Late Sunwaptan of Alberta, may prove to be a euptychaspidine. The poorly defined, parallel-sided glabella shares features with *Euptychaspis* (Pl. 6, figs. 1, 2, 4, 8; see also Ludvigsen, 1982, fig. 58K–M, Q, V, W). Although not connected across the glabella, distinct S1 and S2 lateral furrows are present, and the frontal lobe may be slightly expanded (Westrop, 1986b, pl. 41, figs. 33–35). In addition, the posterior border is curved backward to merge with the occipital ring. This resembles the structure of the occipital ring in *Euptychaspis*, in which the posterior border is extended backward as ridge (Pl. 6, figs. 1, 2, 4, 8; see also Ludvigsen, 1982, fig. 58K–M). The external surface of the pygidial exoskeleton appears to have been entirely effaced (Westrop, 1986b, pl. 41, fig. 36), but internal molds show that the axial, axial ring and pleural furrows were expressed on the ventral surface. The axis is similar in width to that of *Euptychaspis* (*e.g.,* Pl. 6, fig. 39), but the pleural field is broader. The pleural field is, however, more closely comparable to that of *Larifugula leonensis* (Winston and Nicholls, 1967) (Ludvigsen, 1982, fig. 67R), which was assigned to the Euptychaspidinae by Adrain and Westrop (2001).

Genus **EUPTYCHASPIS** Ulrich *in* Bridge, 1931

Type species.—Euptychaspis typicalis Ulrich *in* Bridge, 1931, p. 218.

Discussion.—Euptychaspis has to this point consisted of three named species: *E. typicalis,* the type species, *E. kirki* Kobayashi, 1935, and *E. jugalis* Winston and Nicholls, 1967. *Euptychaspis frontalis* Longacre, 1970, has been assigned to *Kathleenella* Ludvigsen, 1982. The holotype of *Euptychaspis trematocus* Hu, 1973, appears to be a shumardiid, and the pygidium associated by Hu (1973, pl. 2, fig. 14) appears to represent a missisquoiid.

Euptychaspis typicalis is known in its type occurrence in the Eminence Dolomite of Missouri from a tiny, retouched photograph (Ulrich in Bridge, 1931, pl. 19, fig. 7) of a dolomitic internal mold of cranidium lacking its occipital spine and posterior fixigenae, along with two stylized line drawings (Ulrich in Bridge, 1931, pl. 19, figs. 5, 6). The types have never been revised, and no other material from the Eminence Dolomite has ever been figured. Documentation of the types of *Euptychaspis kirki* is equally poor. The two incomplete, poorly preserved cranidia (Kobayashi, 1935, pl. 10, figs 4, 5) from the Windfall Formation in the Eureka mining district, Nevada, have never been revised, and no other material from this unit has ever been illustrated. *Euptychaspis jugalis* is known from a tiny stereopair photograph of a single incomplete cranidium (Winston and Nicholls, 1967, pl. 9, fig. 13) from the San Saba Member of the Wilberns Formation, Texas. Longacre (1970, pl. 3, fig. 18) figured another stereopair of a large cranidium from the type area but it is so poorly preserved that it is far from clear that it is actually conspecific with Winston and Nicholls' holotype.

Taken together, the type material of the species assigned to *Euptychaspis* provide a woefully inadequate basis for comparison. Nevertheless, the names *E. typicalis* and *E. kirki* have been used for many occurrences of *Euptychaspis,* in widely separated regions of Laurentia, and both species have come to be regarded as biostratigraphically important. Material has been assigned to *Euptychaspis typicalis* from Texas (Dake and Bridge, 1932; Winston and Nicholls, 1967; Longacre, 1970), Maryland (Rasetti, 1959), Oklahoma (Stitt, 1971), New York State (Taylor and Halley, 1974), the Mackenzie Mountains (Ludvigsen, 1982), and the southern Canadian Rocky Mountains (Westrop, 1986b). Similarly, *Euptychaspis kirki* has been reported from Texas (Winston and Nicholls, 1967; Longacre, 1970), Oklahoma (Stitt, 1971), and the Mackenzie Mountains (Westrop, 1995). The species have also been used to support the trilobite biostratigraphy of potential Cambrian-Ordovician boundary stratotype sections in western Utah (*e.g.,* Miller *et al.,* 1982; see also Hintze *et al.,* 1988; Loch *et al.,* 1999), though no specimens have ever been figured.

Close examination of the range of intra-sample variation in these reports suggests that pervasive morphological differences exist between some samples from different regions, and that in the case of both *E. typicalis* and *E. kirki,* a plexus of related species has been confused as a single species, largely on the basis of inadequate documentation. We will deal with the species regarded as *Euptychaspis kirki* in a forthcoming work. Here we document an unequivocal new species that would have been assigned under previous practice to the broad wastebasket of *E. typicalis.* The status of other occurrences assigned to *E. typicalis* is discussed below.

Euptychaspis dougali, new species

Plate 6, figures 1–44

Diagnosis.—S1 only weakly impressed medially in most specimens; S2 restricted to notches adjacent to the axial furrows, not impressed medially and not forming a single transverse furrow; L1 and L2 lacking sharp, scarp-like anterior and posterior margins; eye ridge not discernible dorsally or ventrally; interocular fixigenae broad; genal spine very long; pygidium with three axial rings.

Description.—Cranidium subpentagonal in outline, with length (excluding occipital spine) equal to about 60 percent of width at posterior; strongly convex with height opposite palpebral lobes equal to about half of cranidial length (excluding occipital ring). Glabella parallel sided, well rounded anteriorly, strongly convex and raised well above adjacent fixigenae at L1 lobe; occupies about 80 percent of cranidial length (excluding occipital ring) and 40 percent of cranidial width between the palpebral lobes. In front of occipital ring, longitudinal profile of glabella curves steadily downward so that anterior part of anterior lobe weakly raised above surrounding fixigenae. Axial and preglabellar furrows narrow but well-defined grooves. Composite occipital ring includes slender, steeply inclined occipital spine equal to about 60 percent of preoccipital glabellar length; ring and spine enclosed by raised rims that are extensions of posterior border and that join beneath posterior tip of spine. Occipital furrow finely etched groove, transverse or bowed gently forward. S1 furrow transglabellar (Pl. 6, fig. 4, 22), deepest at axial furrow but shallow medially. S2 lateral furrow well incised, narrow (tr.), extending inward for about 15 percent of glabellar width, and not connected across glabella. L1 lobe convex, subtransverse band and slightly wider (tr.) than occipital ring. L2 lobe subequal in length and width to L1. Frontal lobe weakly inflated, well rounded anteriorly, and accounts for about 50 percent of preoccipital glabellar length. Frontal area slopes forward to terminate at minute triangular border that is little more than expanded sculptural ridge. Palpebral area of fixigenae nearly flat. Palpebral lobe semielliptical, upturned flap, length about one-third of preoccipital glabellar length; palpebral furrow finely etched groove. Anterior branches of facial suture initially gently convergent before swinging sharply inward along anterior cranidial margin; posterior branches diverge gradually backward. Convex posterior border slightly shorter (exsag.) than L1 lobe and separated from fixigena by firmly impressed border furrow. Doublure beneath border short near axial furrow but increases in length (exsag.) distally. Frontal area with coarse, irregular sculptural ridges that are roughly parallel to cranidial margin. With exception of smooth cranidial furrows, posterior border and ridge along occipital spine, remainder of cranidium has sculpture of irregular, coarse anastomosing ridges. Sculpture not expressed on ventral surface (Pl. 6, fig. 3).

Librigenae with long genal spine narrowing backward and gently curved distally; length somewhat more than twice length of genal field. Genal field convex, accounting for more than half of height of librigena in lateral view, with distinct eye socle overlain by visual surface of eye. Posteriorly, librigenal field merges with broad, anterior end of carinate ridge extending along entire length of genal spine. Lateral border furrow is broad shallow groove; lateral border convex and steeply downsloping. Posterior border furrow firmly impressed and does not join lateral border; extends along inner edge of genal spine as narrow, weakly concave band that lacks sculpture. Narrow, tubular doublure beneath borders and raised above adjacent doublure of genal spine. Genal field, borders and spine with coarse, weakly anastomosing sculptural ridges that run roughly parallel to margin; border furrows and doublure smooth.

Pygidium elliptical in outline with length about 60 percent of maximum width; strongly convex, with height in posterior view equal to about half of pygidial width. Posterior margin with narrow, upward medial embayment. Axis and very narrow pleural field enclosed by narrow, rim-like ridges that extend backward and inward from anterior pygidial margin to join behind axis. Convex axis tapers gently backward and occupies about 65 percent of pygidial length; width at anterior axial ring equal to slightly less than 40 percent of maximum pygidial width. Three axial rings subequal in length and separated by finely etched, transverse ring furrows. Forwardly curved articulating half ring bounded posteriorly by transverse, finely etched articulating furrow. Pleural field with firmly impressed pleural furrow at anterior; remaining pleural and interpleural furrows shallow to barely perceptible. Broad posterior border slopes steeply downward from ridges bounding axis and pleural field. Border carries sculpture of anastomosing terrace ridges whereas axis has coarser anastomising ridges; pleural fields and pygidial furrows smooth.

Holotype.—A cranidium (SUI 99105; Pl. 6, figs. 1, 5, 11, 12, 22) from the Bullwhacker Member, Windfall Formation, Barton Canyon, Cherry Creek Range.

Figured material.—Seven cranidia (SUI 99105–99110, 99115, 99119), seven librigena (SUI 99111–99114, 99116–99118, 99122, 99123), and two pygidia (SUI 99120, 99121).

Etymology.—After Dougal, of the Magic Roundabout.

Discussion.—The most striking feature of *Euptychaspis dougali* is the presence of S2 furrows that are not connected across the glabella. A transglabellar S2 furrow is clearly present in Ulrich's photographed type specimen of *Euptychaspis typicalis* (Ulrich *in* Bridge, 1931, pl. 19, fig. 7). Moreover, in all reasonably well-known cranidia that have been assigned to *E. typicalis* (Rasetti, 1959, pl. 52, figs. 11–13; Winston and Nicholls, 1967, pl. 9, fig. 17; Longacre, 1970, pl. 4, fig. 9; Stitt, 1971, pl. 6, fig. 19; Taylor in Taylor and Halley, 1974, pl. 2, figs 4–6; Ludvigsen, 1982, fig. 58K, Q, V; Westrop, 1986b, pl. 10, figs 22, 23), both S1 and S2 are transglabellar and expressed in the central body of the glabella as distinct, unsculptured, transverse trenches. Both L1 and L2 are convex, transverse bands that extend across the glabella and whose anterior and posterior margins are sharply defined at a vertical, scarp-like break in slope. Opposite the notch-like S2 of *E. dougali,* the glabellar sculpture of coarse, anastomosing ridges extends without interruption across the central area of the glabella. S1 is generally more weakly developed in *E. dougali* than in any cranidia assigned to *E. typicalis.* Although this furrow is clearly transverse (confirmed by the presence of a furrow in ventral view, Pl. 6, figs. 3, 22), it is much deeper and notch-like near the axial furrow and very shallow to nearly indistinct (*e.g.*, Pl. 6, fig. 2) medially. In several specimens, the glabellar sculpture runs medially across S1 essentially without interruption. This glabellar morphology is unique within the genus, and it alone serves to differentiate *E. dougali* from all other occurrences of *Euptychaspis*. The species differs in detail in other ways from various taxa assigned to *E. typicalis,* and to clarify these contrasts it is necessary to evaluate each of these occurrences:

The type material of *E. typicalis* is totally inadequate and cannot be meaningfully compared with other taxa. *Euptychaspis typicalis* should be restricted to its type specimens, until such time as it is revised on the basis of new and better material.

Occurrences in Texas (Winston and Nicholls, 1967; Longacre, 1970) and Oklahoma (Stitt, 1971) are so poorly documented that they, too, cannot be meaningfully compared with other taxa. Until such time as they are adequately described, with more cranidia, knowledge of librigena and pygidia, etc., they should be regarded as *Euptychaspis* cf. *typicalis*. For the same reasons, two cranidia from Maryland (Rasetti, 1959) should also be placed in open nomenclature.

We regard occurrences of *Euptychaspis* from the Whitehall Formation of New York (Taylor *in* Taylor and Halley, 1974) and the Rabbitkettle Formation of northwest Canada (Ludvigsen, 1982) as each representing a distinct species, but we are reluctant to formally name them in the present state of knowledge. The Whitehall material is known from three cranidia, a librigena, and a pygidium (Taylor and Halley, pl. 2, figs. 4–11). It differs from what little is known of *E. typicalis* most prominently in the fact that its L1 is substantially wider than its L2 (this also distinguishes it from all other material assigned to *E. typicalis*). Further, its anterior glabellar bulb is wider and more inflated than in any other material assigned to *E. typicalis*. It has a prominent eye ridge, not visible on Ulrich's photograph of *E. typicalis* or on any other specimens that have been assigned to the species. Finally, it has very small, subsemicircular palpebral lobes. Additional comparisons are made with other taxa below.

The species from the Rabbitkettle Formation is known from three cranidia, two librigenae, and a pygidium, all silicified (Ludvigsen, 1982, fig. 58K–W). It differs from the Whitehall species in the possession of an L1 that is subequal in width to L2, a considerably less laterally inflated anterior glabellar lobe, longer (exsag.) palpebral lobes, librigena with a much shorter genal spine, a pygidium with two as opposed to three clearly developed axial rings, and in the absence of distinct eye ridges. Caution must obviously be exercised in pygidial comparisons, as each species is represented by only one specimen. However, work in progress on silicified faunas of the Notch Peak Formation of western Utah indicates that in large pygidial samples of *Eupytchaspis,* there is no intrasample variation in axial ring number. Indeed, there is no documented example of variation in this feature in any species of *Euptychaspis*. The two cranidia from the Mistaya Formation of the southern Canadian Rocky Mountains illustrated by Westrop (1986b) are comparable in all available details to the Rabbitkettle material (including the presence of fine anastomosing sculpture at the base of the occipital spine) and may well prove conspecific.

Euptychaspis dougali shares with the Whitehall species a pygidium with three distinct axial rings and a very similar librigena with a long genal spine. In addition to its glabellar autapomorphies, *E. dougali* differs in that its L1 is subequal to, or even narrower than, its L2, its anterior glabellar bulb is less inflated, it lacks eye ridges, it lacks a very sharp break in slope of the frontal area (demarcated in the Whitehall species by a prominent, transverse sculptural ridge), and it has longer, larger palpebral lobes with a much less prominent palpebral furrow. *E. dougali* can be differentiated from the Rabbitkettle species (in addition to its glabellar autapomorphies) in the possession of a more transverse versus more rounded anterior cranidial margin in dorsal view (this could be affected by distortion of the Rabbitkettle specimens), relatively wider interocular fixigena, less well impressed palpebral furrow, much longer genal spine, and a pygidium with three versus two axial rings. The pygidium of *E. dougali* has a prominent median notch in its posterior margin (Pl. 6, fig. 44) that is not present in the Rabbitkettle specimen (Ludvigsen, 1982, fig. 58S), but this apparent difference could be influenced by photographic orientations and should be confirmed on the basis of additional specimens.

Family **ILLAENURIDAE** Vogdes, 1890

Genus **ILLAENURUS** Hall, 1863

Type species.—*Illaenurus quadratus* Hall, 1863, p. 176.

Illaenurus montanensis Kobayashi, 1935
Plate 7, figures 1–37, Plate 8, figures 1–35

Illaenurus montanensis Kobayashi, 1935, p. 48, pl. 10, figs. 1, 2; Westrop, 1986b p. 70, pl. 34, figs. 13–15 (see for complete synonymy).

Diagnosis.—A species of *Illaenurus* with divergent anterior branches of facial sutures; in large individuals, width at anterior end of cranidium exceeds width across palpebral lobes.

Discussion.—As revised by Westrop (1986b, pp. 69–71), *Illaenurus* falls into two stratigraphically segregated groups of species that differ in cranidial length. A lower group, comprising *I. priscus* Resser, 1942, (Westrop, 1986b, pl. 34, figs.1–5) and *I. holcus* Westrop (1986b, pl. 34, figs. 6–10), is characterized by relatively short cranidia. The stratigraphically higher species, *I. quadratus* Hall, 1863, (Westrop, 1986b, pl. 33, figs. 1–7) and *I. montanensis* Kobayashi, 1935, (Westrop, 1986b, pl. 34, figs. 13–15) have longer cranidia. The material illustrated here conforms to the current concept of *Illaenurus montanensis* by possession of strongly divergent, anterior branches of the facial sutures. Like cranidia from Alberta (Westrop, 1986b, pl. 34, fig. 14), width at the anterior end of the cranidium of large individuals of *I. montanensis* from Nevada exceeds width across the palpebral lobes. Cranidia from Alberta possess punctae along the axial furrows and frontal area that are absent from cranidia illustrated herein. *Illaenurus quadratus* is characterized by subparallel to weakly divergent anterior branches of the sutures and, consequently, the anterior portion of the cranidium is relatively narrower.

Sclerites other than the cranidium have not been illustrated previously. Small librigenae (Pl. 8, figs. 5, 12, 14–16) have long, gently curved genal spines and conspicuous, convex lateral borders. During ontogeny, this spine is reduced to a small, thorn-like structure (Pl. 8, figs. 1, 2, 4, 6) and is lost almost completely in the largest individuals (Pl. 8, fig. 13). The lateral border is lost posteriorly, but is retained as a rim anteriorly (*e.g.,* Pl. 8, figs. 1, 2, 10). The doublure is narrow, and at least one specimen (Pl. 8, figs. 1, 7) suggests that a functional rostral suture was present. In contrast, *I. priscus* Resser (Westrop, 1986b, pl. 33, figs. 14, 15) appears to have had yoked checks.

The pygidium of *I. montanensis* has not been described previously. It is subelliptical in outline, with length slightly less than 40 percent of maximum width, and is moderately convex, with height along midline (posterior view) a little less than 25 percent of pygidial width; anterior corners have well-defined articulating facets. The lateral profile is evenly curved upward. The axis is weakly convex and differentiated from the pleural field in posterior view only by a change in slope. The axial ring furrows are completely effaced. The pleural field is effaced except for one pair of pleural furrows at anterior. The doublure occupies about 33 percent of pygidial length and maintains a roughly even width; the anterior margin is weakly undulose. The external surface of the pygidium is smooth except for terrace ridges near, and parallel to, the posterior margin.

Figured material.—Thirteen cranidia (SUI 99124–99137), eleven librigenae (SUI 99138–99149), one thoracic segment (SUI 99154), and five pygidia (SUI 99150–99153, 99155).

Family **CATILLICEPHALIDAE** Raymond, 1937

Genus **TRIARTHROPSIS** Ulrich, *in* Bridge, 1931

Type species.—*Triarthropsis nitida* Ulrich, *in* Bridge, 1931, p. 214.

Triarthropsis limbata Rasetti, 1959

Plate 9, figures 1–25, 28, 32, 33

Triarthropsis limbata Rasetti, 1959, p. 382, pl. 52, figs. 1–8; Ludvigsen, 1982, p. 74, fig. 57U (see for complete synonymy).

Figured material.—Seven cranidia (SUI 99156–99161, 99170) and seven librigenae (SUI 99162–99169).

Discussion.—Wide fixigenae and, on several specimens, a poorly defined anterior border furrow, are shared with *Triathropsis limbata* Rasetti (1959, pl. 52, figs. 1–8). Rasetti's types are variable in glabellar outline but tend to have a somewhat more tapered anterior lobe than the cranidia illustrated herein. Rasetti (1959, p. 382) described faint median furrows on the anterior lobes of his specimens, although they are not evident in his photographs. *Triarthropsis nitida* Ulrich (*in* Bridge, 1931, pl. 19, figs 3, 4; Rasetti, 1959, pl. 55, figs. 6–13; Westrop, 1986b, pl. 39, figs. 8–13) has narrower fixigenae and lacks an anterior border and border furrow. In addition, specimens from Pennsylvania (*e.g.,* Rasetti, 1959, pl. 55, fig. 12) and Alberta (*e.g.,* Westrop, 1986b, pl. 39, figs. 8, 10, 12) have paired tubercles on the fixigenae and glabella.

Triarthropsis marginata (Rasetti, 1945, pl. 60, figs, 9–13; Ludvigsen *et al.,* 1989, pl. 35, figs. 17–19), *T.* cf. *marginata* (Westrop, 1986b, pl. 39, figs. 6, 7) and *T. casca* Ludvigsen and Westrop (*in* Ludvigsen *et al.,* 1989, pl. 35, figs. 20–27) all differ from *T. limbata* in having much shorter frontal areas and palpebral lobes that are located close to the glabella. The poorly known *T. princetonensis* Kobayashi, 1935, (Winston and Nicholls, 1967, pl. 11, fig. 26) differs from *T. limbata* on the basis of the subrectangular glabella that is poorly differentiated from a short anterior border, and palpebral lobes that are centered opposite the S2 glabellar furrow, rather than the L2 lateral lobe.

Librigenae (Pl. 9, figs. 12–25) include some specimens that are yoked. They possess long genal spines and convex lateral borders that carry sculpture of coarse terrace ridges. The librigenal field is narrow and also carries terrace ridges. Similar librigenae have been attributed to *T. nitida* Ulrich (Rasetti, 1959, pl. 55, fig. 9; Westrop, 1986b, pl. 39, fig. 13), and those of *Peracheilus spinosus* (Rasetti, 1945) (Ludvigsen *et al.,* 1989, pl. 34, fig. 17) differ in having a shorter, more slender genal spine and a more convex librigenal field. *Theodenisia gibba* (Rasetti, 1944) (Ludvigsen *et al.,* 1989, pl. 32, fig. 10) has a librigena with sculpture of coarse terrace ridges and a stout genal spine, but the lateral border is not differentiated from the librigenal field.

Triarthropsis sp. 1

Plate 9, figures 26, 27, ?29, 30, 31, 34–38

Figured material.—Three cranidia (SUI 99171–99173) and three librigenae (SUI 99174–99176).

Discussion.—A few cranidia differ from *Triarthropsis limbata* (Pl. 9, figs. 1–11) in having a shorter frontal area and narrower preocular fixigenae. In these respects, they resemble cranidia of T. *marginata* (Rasetti, 1945, pl. 60, figs, 9–13; Ludvigsen *et al.,* 1989, pl. 35, figs. 17–19), *T.* cf. *marginata* (Westrop, 1986b, pl. 39, figs. 6, 7), *T. casca* Ludvigsen and Westrop (*in* Ludvigsen *et al.,* 1989, pl. 35, figs. 20–27) and *T. princetonensis* Kobayashi, 1935, (Winston and Nicholls, 1967, pl. 11, fig. 26). All of these differ from *T.* sp. 1, however, in having smaller palpebral lobes that are located very close to the glabella. In addition, the palpebral lobes of *T. princetonensis* are located farther forward on the cranidium and the anterior end of the glabella is poorly differentiated from the frontal area. Librigenae of *T.* sp. 1 (Pl. 9, figs. 34, 35, 37, 38) are similar to those of *T. limbata* (Pl. 9, figs. 12–25), differing in possessing a much longer posterior segment of the the facial suture that corresponds to a wider posterior fixigena (Pl. 9, fig. 26, 27). Also, the border furrow of *T.* sp. 1 is shallower than on similarly sized librigenae of *T. limbata.*

Family **EUREKIIDAE** Hupé, 1953

Discussion.—Ludvigsen and Westrop (*in* Ludvigsen *et al.,* 1989) suggested that the Eurekiidae could be assigned to the Remopleuridoidea. Although some characters (*e.g.,* size and position of the palpebral lobes) lend support to this view, new information on the structure of the thorax (Pl. 11, figs. 30–35, Pl. 12, figs. 1–5) suggests that eurekiids are not remopleuridoideans. Thoracic segments of *Eurekia* are strongly arched with a well-defined fulcrum and wide inner portion of the pleura; articulation is fulcrate. In contrast, remopleuridoideans have a fulcrum close to the axial furrow and, consequently, very narrow inner portion of the pleura (Whittington, 1997); articulation includes well-developed fulcral processes and sockets (Chatterton and Ludvigsen, 1976, pl. 1, figs. 16–19, 23, 25–29, 31, 49). The Eurekiidae are regarded herein as of uncertain affinities.

Although the broader relationships of the Eurekiidae are uncertain, they may be related to such Early Sunwaptan genera as *Monocheilus* Resser, 1937, and *Stigmacephalus* Resser, 1937. Westrop (1986b) considered such a relationship unlikely, but there are striking similarities in glabellar furrow morphology and size and position of the palpebral lobes between small cranidia of *Monocheilos* (*e.g.,* Westrop, 1986b, pl. 15, figs. 7, 8) and eurekiids. Restudy of the poorly known *Maladia* Walcott, 1924, generally regarded as an early member of the Eurekiidae (*e.g.,* Longacre, 1970), may be helpful in evaluating eurekiid relationships.

Genus **EUREKIA** Walcott, 1916

Type species.—*Ptychoparia* (*Euloma*)? *dissimilis* Walcott, 1884, p. 409 (see Taylor, 1978).

Eurekia rintintini, new species

Plate 10, figures 1–32, Plate 11, figures 1–35, Plate 12, figures 1–29

Diagnosis.—A species of *Eurekia* with sculpture of closely spaced, irregular, star-shaped tubercles over external surface of cranidium, librigenal field, thoracic pleurae, and axis and pleural field of pygidium. Cranidium with distinct preglabellar field that is subequal in length to anterior border. Large pygidium with five pairs of long, widely spaced, tapered marginal spines.

Description.—Cranidium (excluding posterior fixigenae) subrectangular in outline, with width between the palpebral lobes equal to cranidal length; maximum width across posterior fixigenae slightly more than 150 percent of width between palpebral lobes. Convex glabella raised well above level of palpebral lobes and occupies a little more than 80 percent of cranidial length; width is 55 percent cranidial width across palpebral lobes. Occipital ring raised above rest of glabella in lateral view; longitudinal profile of preoccipital glabella curved, with curvature increasing sharply in front of palpebral lobes. Glabellar outline subrectangular; rounded anteriorly. Axial furrows firmly impressed and bowed gently outward, so that maximum glabella width is at S1 furrow or L2 lobe. Occipital furrow well-incised groove, subtransverse medially but deflected forward near axial furrows; occipital ring occupies slightly less than 25 percent of glabellar length. Firmly impressed S1 furrow curves backward and inward from axial furrow. L1 lobe subcircular in outline and slightly shorter than occipital ring; width equal to about 25 percent of glabellar length. S2 furrow as deep as, but less strongly curved than, S1 furrow. L2 lobe equal in length to occipital ring. Frontal lobe accounts for about 27 percent of glabellar length. Frontal area subequally divided into downsloping preglabellar field and upturned, triangular anterior border that is strongly arched in anterior view (Pl. 10, fig. 4); anterior border furrow may be transverse (Pl. 10, figs. 1, 22), forwardly curved (Pl. 10, fig. 16) or bowed gently backward (Pl. 10, fig. 3). Interocular fixigenae narrow, roughly equal in width to palpebral lobe, and upwardly sloping. Palpebral lobe flat to gently upsloping, arcuate band centered opposite L2 lobe; extends from midpoint of L1 to posterior end of frontal lobe. Palpebral furrow finely etched groove. Anterior branches of facial suture weakly convergent, nearly straight before swinging abruptly inward along anterior cranidial margin. Posterior branches diverge at almost 90 degrees to axial furrow, then curve almost straight back. Posterior fixigenae narrow, nearly transverse bands flexed downward at about 45 degrees; bisected by firmly impressed posterior border furrow; posterior border expands abaxially, so that distal width is twice width at axial furrow. Cranidial furrows, inner half of palpebral lobe and preglabellar field lack sculpture; glabella, fixigenae, and anterior border carry sculpture of closely spaced, irregular, star-shaped tubercles; outer part of palpebral lobe has network of anastomosting ridges that produce an irregularly punctate appearance.

Hypostome shield shaped in outline with width about 75 percent of length; posterior margin well rounded and anterior margin bowed gently forward. Convex, subelliptical median body divided unequally by barely perceptible median furrow into crescentic posterior lobe and roughly oval anterior lobe; latter accounts for about 60 percent of median body length. Lateral and posterior borders narrow, convex rims separated from median body by finely etched border furrows; width of posterior border about 50 percent width of lateral border. Anterior border wall-like, directed ventrally well below level of adjacent portions of lateral borders. Anterior wings triangular in outline, flexed dorsally at about 30 degrees; width about 30 percent of hypostome length. Posterior wings narrow, vertically directed prongs with tips curved gently forward. Sculpture of terrace ridges confined to borders and anterior wings.

Librigenae separated by median suture and carry small, thorn-like genal spine. Librigenal field tall, accounting for about 75 percent of librigenal field in lateral view, and slopes steeply downward from eye socle. Socle consists of two bands separated by shallow longitudinal furrow; upper band slightly narrower than lower band. Convex, tube-like border separated from librigenal field by broad, shallow border furrow; inner edge of doublure lies beneath border furrow; panderian notch present near posterior end of doublure. Librigenal field with sculpture of closely spaced, irregular, star-shaped tubercles and coarse, longitudinal ridges on border; doublure with fine terrace ridges.

Thorax of at least 11 segments; tapers gradually backward, so that width at posterior is about 67 percent width at anterior. Axis occupies about 35 percent of segment width in dorsal view; strongly arched, accounting for about 45 percent of segment height in anterior view. Axial furrows shallow, ill-defined grooves. Subelliptical articulating half-ring depressed slightly below rest of ring; firmly impressed articulating furrow transverse medially but curved forward near axial furrows. Pleura with well-defined fulcrum. Inner portion of pleura horizontal; outer portion slopes steeply downward from fulcrum to terminate at short, blunt spine. Well-incised, narrow, nearly transverse pleural furrow divides pleura into subequal anterior and posterior pleural bands; outer portion of anterior band with narrow, subtriangular facet. Facet and articulating half-ring smooth; pleural spine with terrace ridges. Sculpture of closely spaced, irregular, star-shaped tubercles on remainder of segment.

Pygidium subelliptical in outline, with length (excluding marginal spines) slightly more than 50 percent of width; triangular facet at anterior corner. Five pairs of tubular marginal spines that decrease in size posteriorly; posteriormost pair about 33 percent of length of anteriormost. Spines become longer, more slender, distinctly tapered, more pointed, and more widely spaced during holaspid ontogeny (compare Pl. 12, figs. 7, 8, 11, 15, 16 and Pl. 12, figs. 19–21, 23–27). Axis strongly convex, raised well above pleural field, and accounts for about 65 percent of pygidial height in posterior view; in dorsal view, occupies slightly less than 90 percent of pygidial length and about 33 percent of maximum pygidal width; tapers gradually backward, with width at anterior ring about 150 percent of width at terminal piece. Axial furrows broad, clearly defined grooves. Three axial rings and rounded terminal piece; anteriormost ring with conspicuous, semielliptical articulating half-ring and deep, transverse articulating furrow. Rings decrease in length posteriorly, so that first ring is almost twice length of third; terminal piece accounts for about 20 percent of axial length. Two anterior ring furrows firmly impressed, but third furrow shallower. Pleural fields convex, downsloping. Narrow, slot-like pleural and interpleural furrows become shallower and indistinct toward rear; only two pairs usually evident. Subequal anterior and posterior pleural bands usually evident only opposite first axial ring. Doublure narrow, with anterior edge extending to posterior end of axis. Pleural field and axis with sculpture of irregular tubercles; marginal spines carry terrace ridges.

Holotype.—A cranidium (SUI 99178; Pl. 10, figs. 2, 5, 8, 9) from the Bullwhacker Member, Windfall Formation, Barton Canyon, Cherry Creek Range.

Figured material.—Twelve cranidia (SUI 99177–99187, 99193), seven hypostomes (SUI 99188–99192, 99195, 99196), five librigenae (SUI 99194, 99197–99200), one thoracopygon (SUI 99203), two isolated thoracic segments (SUI 99201, 99202), and eight pygidia (SUI 99204–99211).

Etymology.—Named for Rin Tin Tin.

Discussion.—Irregular, star-shaped turbercles similar to those of *Eurekia rintintini* n. sp. are scattered over external surfaces of *Eurekia* sp. 1 from the Rabbitkettle Formation of the Mackenzie Mountains (Westrop, 1995, pl. 6, fig. 1), although their true morphology cannot be determined on internal molds. *Eurekia* sp. 1 differs from *E. rintintini* in lacking a preglabellar field.

Eurekia longifrons Westrop (1986b, pl. 6, figs. 1–5), from the Mistaya Formation of Alberta, is the only other species with a distinct preglabellar field. This feature is relatively longer than that of *E. rintintini,* and is equal to roughly twice the length of the anterior border. *Eurekia longifrons* also possesses conventional, rounded tubercles on the cranidium and has narrower, less strongly curved palpebral lobes than *E. rintintini.* Pygidia of these two species possess similar marginal spines, but can be differentiated on the basis of sculpture. The type species of *Eurekia, E. dissimilis* (Walcott, 1884) (Taylor, 1978, text-fig. 1) from the Windfall Formation of Nevada, is much more strongly convex than *E. rintintini,* so that the anterior third of the glabella slopes steeply downward and partly overhangs the anterior border. *Eurekia ulrichi* (Rasetti, 1945) (Ludvigsen, 1982, fig. 61A–Q), from northern and eastern Canada, has a finely tuberculate sculpture and lacks a preglabellar field. The pygidium of this species has shorter, less tapered marginal spines than *E. rintintini,* and has faint pleural and axial ring furrows posteriorly. The hypostome attributed to *E. ulrichi* is very similar to that of *E. rintintini,* and corroborates the assignment. *Eurekia eos* (Hall, 1863) (Taylor, 1978, pl. 1, figs. 1–17, pl. 2, figs. 1–17), a species that has been reported widely over North America, and *E. bacata* Ludvigsen (1982, fig. 62A–J), from the Rabbitkettle Formation of the Mackenzie Mountains, both differ from *E. rintintini* in lacking a preglabellar field. In addition, the pygidia are differentiated readily from *E. rintintini. Eurekia eos* has short, closely spaced, bluntly ended marginal spines (see also Westrop, 1986b, pl. 6, fig. 11), whereas *E. bacata* has a broad axis that overhangs the posterior pygidial axis. Finally, *Eurekia plectocanthus* Loch (*in* Loch *et al.,* 1993, fig. 6.2, 3, 5–7), from the Survey Peak Formation, Alberta, is based upon inadequate material and is probably best restricted to the types. It appears to have possessed an anteriorly rounded glabella that is quite different from the subquadrate glabella of *E. rintintini.*

Genus **CORBINIA** Walcott, 1924

Type species.—*Corbinia horatio* Walcott, 1924, p. 55.

Corbinia implumis Winston and Nicholls, 1967
Plate 13, figures 1–28

Corbinia implumis Winston and Nicholls, 1967, p. 86, pl. 9, fig. 3; Westrop, 1986b, p. 78, pl. 6, figs. 6, 7 (see for complete synonymy).

Bayfieldia binodosa (Hall). Stitt and Straatman, 1997, fig. 9.17 (only).

Diagnosis.—A species of *Corbinia* with coarsely granulose sculpture on cranidium; pygidium with sculpture restricted to terrace ridges on or near marginal spines. Only anterior axial ring and pleural furrows impressed firmly; remaining furrows shallow to barely perceptible. Terminal piece of axis has pair of gently rounded protuberances. Bluntly rounded marginal spines are closely spaced.

Description.—Cranidium (excluding posterior fixigenae) subrectangular in outline, with width across palpebral lobes equal to about 95 percent of length; width across palpebral lobes 67 percent of width across posterior fixigenae. Glabella tapers forward, gently rounded anteriorly and slightly constricted at L1; occupies about 85 percent of cranidial length and 60–70 percent (lower values in smaller cranidia) of cranidial width between palpebral lobes; strongly convex and raised well above palpebral lobes in anterior view. Lateral profile of glabella curved, with occipital ring barely raised above level of L1; degree of curvature increases in front of palpebral lobes. Axial and preglabellar furrows narrow, but clearly defined, grooves. Occipital furrow firmly impressed, transverse medially but curved forward near axial furrow; bifurcates distally, so that occipital ring is composite with small, gently inflated antero-lateral lobe. Occipital ring occupies about 17 percent of cranidial length. S1 and S2 lateral furrows are barely perceptible on even small cranidia (Pl. 13, figs. 3, 4) and not expressed on ventral surfaces (Pl. 13, fig. 11). Short frontal area with distinct preglabellar field equal to 20–30 percent of anterior border length; border furrow may be transverse or bowed gently backward, so that outline of border may be subtriangular (Pl. 13, fig. 3) to transversely subelliptical. Border gently upturned in lateral view and moderately arched in anterior view. Palpebral lobes flat to weakly upturned, arcuate bands centered opposite L2; length decreases somewhat through holaspid ontogeny from 45 percent of glabellar length in smaller cranidia to 36 percent in large specimens. Palpebral furrow finely etched groove. Interocular fixigenae narrow, equal in width to palpebral lobe; anterior and posterior tips of palpebral lobes separated from glabella by very narrow strips of fixigenae. Anterior branches of facial sutures very weakly divergent before swinging inward along anterior cranidial margin. Posterior branches initially weakly divergent before diverging abruptly along nearly transverse path; swing backward at anterior tips of posterior fixigenae and are subparallel near posterior margin of cranidium. Posterior fixigenae narrow, nearly transverse bands flexed downward at about 45 degrees; bisected by firmly impressed posterior border furrow (shallower in largest cranidum); posterior border expands abaxially, so that distal width is twice width at axial furrow. Most small cranidia with sculpture of closely spaced, fine tubercles over entire surface; on largest cranidium (Pl. 13, fig. 1), tubercles subdued, more widely scattered, and confined to glabella.

Fixigenae separated by median suture and with very short, sharply pointed genal spine. Eye socle simple, arcuate band. Tall librigenal field slopes steeply downward from socle to broad, shallow anterior border furrow. Anterior border convex, tubular; outer edge of doublure lies beneath border furrow and is deflected by panderian notch near posterior margin of librigena. Sculpture of closely spaced, fine tubercles on librigenal field; coarse, longitudinal ridges on border.

Pygidium subelliptical in outline with length slightly less than half of width; narrow, triangular facet at anterior corner. Five pairs of short, bluntly pointed, closely spaced marginal spines that become progressively more curved inward and reduced slightly in size toward rear; posteriormost pair expressed only as rounded protuberances. Axis convex, gently tapered and long, occupying almost entire pygidial length; width at anterior ring about 35 percent of maximum pygidial width. Axis strongly convex, occupying about 75 percent of pygidial height in posterior view. Two axial rings and long terminal piece that carries pair of ill-defined, rounded protuberances at posterior; terminal piece occupies 40 percent of axis length. Anteriormost ring includes conspicuous, semielliptical articulating half-ring and firmly impressed articulating furrow. Two transverse axial ring furrows; posteriormost very shallow and barely perceptible on some specimens. Pleural field flexed steeply downward, becoming flatter near margin. Two pairs of pleural furrows expressed as narrow grooves on most specimens; interpleural furrows weak. Subequal anterior and posterior pleural bands well defined opposite anteriormost axial ring, but indistinct on remainder of pleural field. Medially, outer edge of doublure reaches posterior end of axis; doublure expands abaxially, so that width at anterior corner of pygidium almost twice width behind axis. Surface smooth except for terrace ridges on and near marginal spines, doublure, and posterior tip of terminal piece.

Figured material.—Four cranidia (SUI 99212–99215), one librigena (SUI 99216), and three pygidia (SUI 99217–99219).

Discussion.—Westrop (1986b) restricted the type species of *Bayfieldia, B. tumifrons* Clark, 1924, to the incomplete holotype (Westrop, 1986b, pl. 6, fig. 8), and suggested that *Bayfieldia binodosa* (Hall, 1863) should be assigned to *Corbinia* Walcott, 1924. Pygidia (Hall, 1863, pl. 7, fig. 47) and cranidia (Clark, 1924, pl. 4, fig. 7; see Winston and Nicholls, 1967, p. 84 for discussion) of *C. binodosa* are preserved as sandstone internal molds and have never been illustrated photographically, so that this species is difficult to interpret. Cranidia of *C. implumis* Winston and Nicholls (1967, pl. 9, fig. 3) are coarsely granulose, whereas cranidia from Texas (Winston and Nicholls, 1967, pl. 9, fig. 1) that have been attributed to *C. binodosa* are smooth. Although Longacre (1970; see also Stitt, 1971) argued that *C. binodosa* and *C. implumis* were synonyms, Westrop (1986b) suggested that the distinction between them should be maintained. The material illustrated herein supports the latter view. Cranidia (Pl. 13, figs. 1–15) closely resemble the holotype of *C. implumis* (Winston and Nicholls, 1967, pl. 9, fig. 3), differing only in having an anterior border furrow that is less strongly curved backward posteriorly. The coarsely granulose sculpture is retained through a broad size range, although it is more subdued in the largest (Pl. 13, fig. 1, 15) and smallest (Pl. 13, figs. 4, 10) specimens. Pygidia of C. *implumis* have not been described previously but are quite distinct from those attributed to *C. binodosa,* including Hall's (1863, pl. 7, fig. 47) type. On the dorsal surface (Pl. 13, figs. 18, 19, 21, 24), pygidia of the former species have one well-defined anterior axial ring, and a second ring that is separated from the terminal piece by a faint ring furrow. Pleural furrows also become progressively effaced toward the rear. Expression of axial ring and pleural furrows is equally poor on ventral surfaces (Pl. 13, fig. 27) and, therefore, these features will be ill defined on internal molds. In contrast, Hall (1863, p. 160) noted the presence of three axial rings and a terminal piece in the axis of *C.*? *binodosa,* and described well-defined ribs on the pleural field. Pygidia attributed to this species by other workers (*e.g.,* Grant, 1965, pl. 15, fig. 18; Winston and Nicholls, 1967, pl. 9, fig. 2; Stitt, 1971, pl. 5, fig. 7) all possess three pairs of firmly impressed pleural furrows that define convex pleural bands. In addition, these pygidia are relatively narrower than those illustrated herein.

Pygidia of the type species of *Corbinia, C. horatio* Walcott, 1924 (Westrop and Ludvigsen, 1986, fig. 2.6–

2.8), are closely comparable to those of *C. implumis* in the degree of effacement. *Corbinia implumis* has rounded, closely spaced marginal spines, whereas those of *C. horatio* are widely spaced and sharply pointed. In addition, *C. horatio* lacks the pair of rounded protuberances that are present on the terminal piece of the axis of *C. implumis* (*e.g.,* Pl. 13, figs, 18, 24), and the pleural field carries granulose sculpture. Cranidia of *C. horatio* from Walcott's type lot (Westrop and Ludvigsen, 1986, fig. 2.1, 2.2, 2.5, 2.9) are mostly exfoliated, but demonstrate that the external surface of the fixigena, frontal area, and at least part of the glabella was smooth. This species is also unique in the very small size of the palpebral lobes (*e.g.,* Westrop and Ludvigsen, 1986, fig. 2.9; Westrop, 1986b, pl. 5, fig. 15). Our cranidia of *C. implumis* cover a broad size range and demonstrate that the relative length of the palpebral lobe was reduced during holaspid ontogeny. Only the largest cranidium (Pl. 13, fig. 1) has a palpebral lobe that approaches the size of that of *C. horatio.*

The cranidia of *C. implumis* show the bifurcating occipital furrow and inflated lateral portion of the occipital ring (*e.g.,* Pl. 13, fig. 3) that was included in the diagnosis of *Bayfieldia* by Longacre (1970, p. 36). However, the phylogenetic significance of this feature, which is poorly expressed in *C. horatio,* is unclear because it also occurs in "*Bayfieldia*" *simata* Winston and Nicholls, 1967, (especially "*B.*" *simata* "var. A" Winston and Nicholls, 1967, pl. 9, fig. 24 [regarded herein as a separate species]) and, apparently, *Maladia* Walcott, 1924 (Walcott, 1925, pl. 16, figs. 23, 24).

Family **ENTOMASPIDIDAE** Ulrich, *in* Bridge, 1931

Genus **HETEROCARYON** Raymond, 1937

Type species.—*Heterocaryon platystigma* Raymond, 1937, p. 1119.

Heterocaryon vargum Westrop, 1986b

Plate 14, figures 1–33

Heterocaryon vargum Westrop, 1986b, p. 80, pl. 40, figs. 4–6 (see for complete synonymy); Loch *et al.,* 1993, fig. 6.10.

Figured material.—Five cranidia (SUI 99220–99224), seven librigenae (SUI 99225–99230, 99232), and two pygidia (SUI 99231, 99233).

Discussion.—Cranidia from the Bullwhacker Member (Pl. 14, figs. 1–16) are closely comparable to silicified specimens from the Rabbitkettle Formation, northwest Canada (Ludvigsen, 1982, fig. 55A–F, H, L) assigned to *Heterocaryon vargum* Westrop, 1986b, a species known from two cranidia from the Mistaya Formation of the southern Canadian Rocky Mountains. Pygidia illustrated herein (Pl. 14, figs. 26, 27, 29–33) are somewhat longer than those from the Rabittkettle Formation, and have a weak medial indentation (Pl. 14, figs. 30, 33) in the ventral margin of the steeply sloping border. Ludvigsen (1982, fig. 55G) illustrated a single incomplete librigena. New material illustrated herein (Pl. 14, figs. 17–19) demonstrates that the species, like *Bowmania* (Pl. 16, figs 18, 21, 22; Ludvigsen, 1982, fig. 54F; Westrop, 1995, pl. 14, fig. 5), possessed yoked librigenae.

Genus **BOWMANIA** Walcott, 1924

Type species.—*Arethusina americana* Walcott, 1884, p. 62.

Discussion.—In his revision of the genus, Ludvigsen (1982, p. 69) included the presence of marginal cephalic spines on the librigenae in the diagnosis of *Bowmania. Bowmania lassieae* n. sp. from the Bullwhacker Member at Cherry Creek has a fringe of closely crowded, very short spines, and possession of a row of elongate spines can now be interpreted as a probable autapomorphy of the type species, *B. americana* (Walcott, 1884). Librigenae are unknown for other species currently assigned to the genus. Ludvigsen (1982, p. 72) noted that highly spinose librigenae occurred with cranidia of *Bowmania pennsylvanica* Rasetti, 1959, in the Frederick Limestone of Maryland. The types of *B. pennsylvanica,* however, are from the Conococheague Formation and lack librigenae; cranidia from the Frederick Limestone are poorly preserved and only "tentatively attributed to the species" (Rasetti, 1959, p. 396). Thus, the nature of the librigenae of *B. pennsylvanica* remains uncertain.

The dorsal pygidial margins of *B. americana* (Ludvigsen, 1982, figs, 53K, 54H–L; Westrop, 1995, pl. 14, figs. 7, 9, 11) and *B. bridgei* (Rasetti, 1952, pl. 117, fig. 13) have narrow, nearly continuous raised rims, composed of low, closely spaced subrectangular pleural spines, and Ludvigsen (1982, p. 69) included this trait (misconstured as a "pygidial border") in his diagnosis. In the pygidium of *B. lassieae* (Pl. 17, figs. 1–16, 18–20, 23, 25, 26, 28) the pleural spines are less crowded, and are similar to those of *Heterocaryon vargum* (see above) (Pl. 14, figs. 26, 29, 30–33).

Bowmania lassieae, new species

Plate 15, figures 1–30, Plate 16, figures 1–30, Plate 17, figures 1–16, 18–20, 23, 25, 26, 28

Diagnosis.—A species of *Bowmania* with a very subdued fringe of small spines along cephalic margin; occipital spine absent in all but smallest holaspids. Anterior cranidial border long, convex, with length roughly equal to occipital ring. Cranidial sculpture of closely spaced tubercles augmented by fine pits. Pygidial border formed by incompletely fused, square-tipped marginal spines.

Description.—Cranidium subtrapezoidal in outline, with forwardly curved anterior margin; length 80 percent of width across palpebral lobes, and maximum width across posterior fixigenae 125 percent of width at palpebral lobes. Posterior cranidial margin curved weakly (Pl. 15, fig. 1) to strongly (Pl. 15, fig. 2) backward, so that lateral tips of posterior fixigenae extend back slightly to well behind occipital ring. Glabella parallel sided and well rounded anteriorly, with length 67 percent of cranidal length and width 33 percent of cranidial width across palpebral lobes; strongly convex and stands well above level of fixigenae; in most specimens, accounts for about half of cranidial height in anterior view. Longitudinal profile of glabella weakly convex between occipital furrow and anterior tips of palpebral lobes, then sloping forward to become nearly vertical at preglabellar furrow. Axial and preglabellar furrows shallow grooves. Finely etched occipital furrow is transverse medially but curved forward near axial furrow. Occipital ring accounts for slightly more than 20 percent of glabellar length; may bear large median tubercle or, in smallest individuals, minute, thorn-like occipital spine. Firmly impressed S1 furrow short and oblique, terminating close to axial furrow; S2 similar but more transverse. L1 about twice length of L2 and occupies about 20 percent of glabellar length; frontal lobe accounts for nearly 40 percent of glabellar length. Long frontal area with inflated, steeply sloping preglabellar field and shorter, gently convex anterior border; border occupies 33–40 percent of frontal area length. Anterior border furrow well-incised groove and curved forward, roughly parallel to anterior cranidial margin. Small, semicircular, gently upsloping palpebral lobe centered opposite L2 or, less commonly, S2 and equal to about 25 percent of glabellar length; differentiated from broad, gently inflated interocular fixigenae by change in slope. Convex palpebral ridge curved gently forward and reaches glabella near mid-length of frontal lobe. Anterior branches of facial sutures weakly convergent before swinging inward along anterior cranidial margin. Posterior branches moderately divergent, but curve inward at posterior border furrow. Posterior fixigenae with firmly impressed posterior border furrow and convex posterior border; near axial furrow, border equal to about seven percent of cranidal length and increases somewhat in length distally. Surfaces of fixigenae and preglabellar field finely pitted and carry closely spaced tubercles that are perforated by median pores in large cranidia. Similar tubercles present on glabella, anterior and posterior border and palpebral ridges, and scattered fine tubercles on inner part of palpebral lobe.

Librigenae yoked anteriorly and carry long genal spines that curve gently outward and backward, and may be flexed upward distally; spine equal to 325 percent of length of librigenal field. Eye socle of two narrow bands separated by finely etched groove; upper band slightly smaller than lower band. Librigenal field tall, accounting for about 65 percent of librigenal height in lateral view, and slopes steeply downward from socle to borders. Lateral and posterior borders broad, shallow, confluent grooves. Lateral and posterior borders convex; doublure also convex and outer edge lies beneath border furrow. Librigenal field with pitted sculpture augmented with "pitted" tubercles similar to those on cranidium. Tubercles also present on lateral and posterior borders, and continue along proximal 33 percent of genal spine; remainder of genal spine finely granulose. Doublure carries fine terrace ridges.

Thoracic segment with very long, gently inclined axial spine; spine about 14 times length of rest of segment. Axis narrow, equal to slightly more than 20 percent of segment width, and convex, accounting for about 50 percent of segment height. Articulating half-ring slightly more than half of length of axial ring; articulating furrow transverse. Inner portion of pleura horizontal; outer portion flexed gently downward at fulcrum and teminates at slender spine. Pleural furrow transverse, finely etched groove and divides pleura into subequal anterior and posterior pleural bands. Pleurae and axial ring with sculpture of fine tubercles; tubercles present on proximal part of axial spine but grade into granulose scupture distally.

Pygidium subelliptical in outline, with length about 50 percent of maximum width. Axis long and narrow, occupying about 80 percent of pygidial length and 25 percent of maximum pygidial width; convex, standing well above pleural field and accounting for about 60 percent of pygidial height. Six axial rings and rounded terminal piece; anterior ring with semielliptical articulating half-ring, equal to about 50 percent of length of ring and transverse, finely etched articulating furrow. Ring furrows also transverse and finely etched. Pleural fields weakly arched in posterior view; flat near axis but flexed gently downward distally. At least four pairs of well-incised pleural furrows define subequal pleural bands. Anterior furrow nearly transverse before curving gently backward near border. Other furrows are increasingly oblique toward rear, and posteriormost does not reach border. Interpleural furrows finely etched and parallel to pleural furrows. Pygidial rim formed by closely crowded, square-tipped pleural spines. Border descends steeply from rim. Doublure extends inward medially to posterior edge of axis, but widens abaxially to become about 200 percent of medial width at anterior corners of pygidium. Sculpture of fine tubercles on axial rings and pleural bands; on some segments, sculpture is missing on some anterior pleural bands.

Holotype.—A cranidium (SUI 99234; Pl. 15, figs. 1, 4, 7, 12, 13) from the Bullwhacker Member, Windfall Formation, Barton Canyon, Cherry Creek Range.

Figured material.—Fifteen cranidia (SUI 99234–99248, 99250), four librigenae (SUI 99251, 99253–99255), one thoracic segment (SUI 99249), and nine pygidia (SUI 99256–99264).

Etymology.—Named for Lassie.

Discussion.—The type species of *Bowmania, B. americana* (Walcott, 1884) is known from a single cranidium from the Eureka mining district of Nevada. Specimens from various regions of Laurentia have been assigned to it, but more data from Nevada are required to properly evaluate the true range of variation of the species. Material from elsewhere (Ludvigsen, 1982, fig. 53K–S, fig. 54A–O; Westrop, 1995, pl. 14, figs. 1–14), is variable in sculpture, frontal area length, and glabellar proportions, but all cranidial morphs are characterized by the presence of an occipital spine and a shorter anterior border than *B. lassieae*; librigenae have fringe of long marginal spines (Ludvigsen, 1982, figs. 53P, 54F, G, M–O; Westrop, 1995, pl. 14, figs. 5, 12). The type lot of *B. pennsylvanica* Rasetti (1959, pl. 55, figs. 1–5) apparently varies somewhat in cranidial sculpture (Taylor *in* Taylor and Halley, 1974, p. 21), but all specimens are characterized by very short anterior borders. The cranidum identified as *B.* cf. *B. pennsylvanica* by Taylor (*in* Taylor and Halley, 1974, pl. 2, figs. 12–14) also has a short anterior border, and the preglabellar field descends steeply from the anterior end of the glabella. *Bowmania sagitta* Winston and Nicholls (1967, pl. 10, figs. 19, 20) has a medially pointed anterior margin, which gives the cranidium a subpentagonal outline.

The less crowded pygidial pleural spines separates the pygidium of *B. lassiae* (Pl. 17, figs. 1–16, 18–20, 23, 25, 26, 28) from all other species of the genus for which this sclerite is known (*e.g.,* Rasetti, 1952, pl. 117, fig. 13; Ludvigsen, 1982, figs, 53K, 54H–L; Westrop, 1995, pl. 14, figs. 7, 9, 11).

Family **PLETHOPELTIDAE** Raymond, 1925

Discussion.—The most recent evaluation of the Plethopeltidae was presented by Ludvigsen and Westrop (*in* Ludvigsen *et al.,* 1989, p. 56). Of the characters listed in their diagnosis, the terminations of the thoracic pleurae appear to be the most robust of the potential synapomorphies that define the group. *Plethopeltis* Raymond, 1913, has distinctive, square-tipped segments with ill-defined spines that appear to be continuations of the anterior pleural bands (Ludvigsen *et al.,* 1989, pl. 45, figs. 9–11, pl. 46, fig. 2, 3). Identical thoracic tips are present in *Leiocoryphe* Clark, 1924 (Ludvigsen *et al.,* 1989, pl. 48, fig. 11, pl. 49, figs. 7, 11, 12) and on all but the three anterior segments of *Stenopilus pronus* Raymond, 1924 (Stitt, 1976, pl. 2, fig. 1).

A wide range of pygidia have been attributed to species assigned to *Plethopeltis* (*e.g.,* Rasetti, 1959, pl. 53, figs. 3, 5, 7, 10, 13; Stitt, 1971, pl. 6, figs. 13, 14, 18, pl. 8, fig. 14; Westrop, 1986b, pl. 36, figs. 7, 10, 12, 13, pl. 37, figs. 6, 8–10, 14, 15; Ludvigsen *et al.,* 1989, pl. 45, figs. 2, 9, 10, pl. 46, figs. 12, 14, 18, 19), suggesting that the current classification captures only a fraction of the phylogenetic structure that might be retrieved from a detailed analysis of the Plethopeltidae. Recognition of *Plethometopus* Ulrich, in Bridge, 1931, and *Plethopeltis* as differently effaced grades, however, as advocated by Loch *et al.* (1993), does not address this issue and merely creates paraphyly in *Plethopeltis.* Further revision is needed, but is beyond the scope of this monograph.

CHERRYCREEKIA, new genus

Type species.—*Cherrycreekia benjii,* new species.

Diagnosis.—A genus of? Plethopeltidae with cranidial outline bluntly pointed at anterior. Librigenae with long, slender, outwardly curved genal spine. Pygidium with short axis reduced to single axial ring and terminating at conspicuous ridge that is directed steeply upward and backward. Pleural and interpleural furrows absent.

Etymology.—For the Cherry Creek Range.

Assigned species.—*Bynumiella*? *oklahomensis* Resser, 1942; *Cherrycreekia benjii* n. sp.

Discussion.— *Cherrycreekia* resembles several variably effaced, mostly small and probably polyphyletic Sunwaptan trilobites, including *Calvipelta* Westrop, 1986b and *Pugionicauda* Westrop, 1986b. Westrop (1986b) initially assigned them to the family Kingstoniidae but later (Westrop, 1992) argued that differences in the structure of the occipital ring cast doubt on a relationship with such genera as *Kingstonia* Walcott, 1924, and *Bynumia* Walcott, 1924. As discussed above, *Calvipelta* may prove to be an effaced euptychaspidine, but the affinities of *Pugionicauda* remain uncertain.

Cranidia from the Mistaya Formation, Alberta, (Westrop, 1986b, pl. 41, figs. 11–13) are clearly conspecific with those illustrated herein (Pl. 18, figs. 1–23, 29, 30). In discussing the affinities of this species, Westrop (1986b) made comparisons with *Acheilus* Clark, 1924, (see Ludvigsen, 1986), but noted that differences in the size and position of the palpebral lobes made an assignment to that genus questionable. Also, the glabella of *Acheilus* is subrectangular in outline (Ludvigsen *et al.,* 1989, pl. 37, figs. 6, 12), whereas *C. oklahomensis* (Resser, 1942) (Westrop, 1986b, pl. 41, fig. 8) has a glabella that is tapered anteriorly. Thus, while comparisons between effaced taxa are fraught with difficulty, the available information makes a close relationship between *Cherrycreekia* and *Acheilus* unlikely.

Cherrycreekia is most likely a member of the family Plethopeltidae. The new silicified material (Pl. 18, figs. 1–23) shows that the cranidial outline of *Cherrycreekia* is very similar to that of *Plethopeltis* (*e.g.,* see Ludvigsen, 1982, fig. 56T–V; Ludvigsen and Westrop, 1983b, pl. 19, figs. 1–5, 8, 9; Westrop, 1986b, pl. 36, figs. 1, 2, 14, 16, 17, 19, pl. 37, figs. 1–3, 11–13), and differs only in the bluntly pointed, rather than evenly rounded, anterior cranidial margin (*e.g.,* Pl. 18, fig. 16) and the less divergent posterior branches of the facial sutures. The long, slender, outwardly curved genal spines differ from the short, stout spines that are developed in *Plethopeltis* (*e.g.,* Ludvigsen and Westrop, 1983b, pl. 18, figs, 7, 8, 13, pl. 19, fig. 10; Westrop, 1986a, pl. 36, fig. 5; Ludvigsen *et al.,* 1989, pl. 45, fig. 11, pl. 46, fig. 1); other plethopeltid genera possess rounded genal angles (*e.g.,* Ludvigsen *et al.,* 1989, pl. 47, fig. 3, pl. 48, figs. 3, 9, pl. 49, fig. 22, pl. 50, figs. 1, 2).

Square-tipped thoracic segments (Pl. 17, figs. 48, 49) similar to those of *Plethopeltis* and *Leiocoryphe* (*e.g.,* Ludvigsen *et al.,* 1989, pl. 45, figs. 9–11, pl. 46, fig. 2, 3, pl. 48, fig. 11, pl. 49, figs. 7, 11, 12) may belong to *Cherrycreekia* and provide strong support for an assignment to the Plethopeltidae.

The pygidium of *Cherrycreekia* has a distinctive ridge at the posterior end of the short axial lobe that must have docked with the cephalic doublure during enrollment. Although a wide diversity of plethopeltid tails have been described (*e.g.,* Rasetti, 1959, pl. 3, figs. 3, 5, 7, 13, 18, 19, 20, 21, 28–30; Stitt, 1971, pl. 4, fig. 10, pl. 6, figs. 13, 14, 18, pl. 8, fig. 14; Westrop, 1986b, pl. 36, figs. 7, 10, 13, pl. 37, figs. 6, 8, 9, 14; Ludvigsen *et al.,* 1989, pl. 45, figs. 2, 9, pl. 46, figs. 3, 12, 14, 18, 19, pl. 47, figs. 5, 6, 8, 9, 11–14, pl. 48, figs. 5, 18–20. pl. 49, figs. 3, 7, 11, 12, 19), none possesses a comparable structure. Ridge-shaped structures that presumably functioned in enrollment also occur on pygidia of the euptychasidine, *Euptychaspis* (Pl. 6, figs. 37–39, 42–44; see also Taylor and Halley, 1974, pl. 2, fig. 11; Ludvigsen, 1982, fig. 58S–U; Westrop, 1995, pl. 7, fig. 21), but are much lower than in *Cherrycreekia.* In both genera, the down-sloping region of the pygidium outside of the ridge is unfurrowed, and carries a sculpture of anastomosing terrace ridges or coarser ridges. Despite these general similarities, we are confident the pygidium of *Cherrycreekia* is correctly assigned. Sclerites of *Cherrycreekia* do not occur in association with cranidia and librigenae of euptychaspidines. There are numerous differences in the structure of the cranidia and librigenae between *Euptychaspis* and *Cherrycreekia,* so that pygidial similarities are reasonably interpreted as homoplasious. It is also worth noting that several features of the pygidium of *Cherrycreekia* also occur in some plethopeltids, including the overall outline and the convex, down-sloping pleural field with sculpture of terrace ridges (*e.g.,* Rasetti, 1959, pl. 53, figs. 17–19).

Cherrycreekia benjii, new species

Plate 18, figures 1–30, Plate 19, figures 1–11, 17,
?Plate 17, figures 48, 49

Acheilus? cf. *oklahomensis* (Resser, 1942). Westrop, 1986b, p. 83, pl. 41, figs. 11–13 (only; fig. 10 = *Calvipelta spinosa*).

Diagnosis.—A species of *Cherrycreekia* with glabella effaced anteriorly and with long, slender occipital spine.

Description.—Cranidium subrectangular in outline, with bluntly pointed anterior margin; width across palpebral lobes slightly greater than preoccipital length. Long, slender occipital spine directed gently upward at about 10 degrees and equal to at least 50 percent of preoccipital cranidial length. Lateral cranidial profile gently convex between occipital furrow and anterior tips of palpebral lobes, then slopes evenly downward at about 45 degrees to anterior cranidial margin. Cranidial furrows largely effaced, with very shallow, subparallel axial furrows expressed only between posterior margin and anterior tips of palpebral lobes. Glabella moderately arched posteriorly, occupying about 60 percent of width between palpebral lobes, but undifferentiated from fixigena in front of palpebral lobes. Faint, transverse occipital furrow evident on most specimens; occipital ring subtriangular, length (excluding spine) equal to slightly more than 25 percent of preoccipital cranidial length. Palpebral lobes semielliptical flaps, horizontal or gently down sloping; differentiated from down-sloping interocular field centered slightly behind cranidial mid-length; length equal to about 75 percent of occipital ring length. Anterior branches of facial sutures initially subparallel, then curve smoothly inward to become nearly tranverse at midline; posterior branches diverge for short distance before becoming subparallel. Posterior fixigenae subtriangular in outline and flexed downward at about 45 degrees; posterior border furrow obsolete. External surface of cranidium smooth.

Librigena with long, stout, gently tapered, slightly advanced genal spine curved outward and backward; length about 160 percent length of remainder of librigena. Eye socle composed of two parallel bands separated by shallow, transverse groove; upper band somewhat smaller than lower band. Librigenal field slopes steeply downward almost to cranidial margin; lateral border very narrow rim separated from librigenal field by finely etched groove. Doublure narrow, gently convex and maintains even width. External surface of librigena smooth, except for coarse terrace ridges on border.

Pygidium subelliptical in outline, with length about 80 percent of maximum width; strongly convex, with distinct arch in posterior margin; lateral margins straight, oblique, and broad posterior margin well rounded. Axis very short, equal to about 25 percent of pygidial length, and bounded posteriorly by tall, wall-like ridge extending upward and backward to terminate well above level of axis; in posterior view, ridge has inverted v-shape. Single transverse axial ring and subequal articulating half-ring with gently curved anterior margin; articulating furrow shallow, nearly transverse groove. Pleural field unfurrowed and flexed steeply down to posterior margin; border and border furrow absent. Doublure narrow, gently convex and maintains even width along posterior margin; length equal to 10 percent of pygidial length. Pleural field with sculpture of anastomosing terrace ridges; ridge at end of axis may have small node at apex.

Holotype.—A cranidium (SUI 99276; Pl. 18, figs. 1, 2, 5, 10, 12) from the Bullwhacker Member, Windfall Formation, Barton Canyon, Cherry Creek Range.

Figured material.—Eight cranidia (SUI 99276–99282, 99286), three librigenae (SUI 99284, 99285, 99287), three pygidia (SUI 99288–99290) and, possibly, one thoracic segment (SUI 99268).

Etymology.—Named for Benji.

Discussion.— *Cherrycreekia oklahomensis* (Resser, 1942) (Westrop, 1986b, pl. 41, figs. 8, 9; see also Stitt, 1971, pl. 7, fig. 15) differs from *C. benjii* n. sp. in the absence of an occipital spine, and by possession of a more nasute anterior cranidial margin. *Cherrycreekia oklahomensis* is also less effaced, so that the glabella is outlined completely by axial and preglabellar furrows on both the dorsal surface of the exoskeleton (Stitt, 1971, pl. 7, fig. 15) and on internal molds (Westrop, 1986b, pl. 41, figs. 8, 9). Faint S1 lateral furrows and a more firmly impressed occipital furrow are present, as are palpebral ridges.

As discussed above, cranidia from the Mistaya Formation, Alberta, assigned by Westrop (1986b) to *Acheilus* cf. *oklahomensis* (Resser, 1942), are unquestionably conspecific with *C. benji.* Westrop (1986b, pl. 41, fig. 10) also attributed a small, exfoliated pygidium with a long axis to this species, but it most likely belongs to *Calvipelta spinosa* Westrop, 1986b, which occurs through the same stratigraphic interval (Westrop, 1986b, fig. 31).

GLABERASPIS, new genus

Type species.—*Glaberaspis scoobydooi,* new species.

Diagnosis.—A blind, isopygous genus of ?Plethopeltidae with semielliptical pygidium with long, narrow axis that consists of four axial rings and terminal piece. Convex cranidium with conspicuous occipital ring that is curved strongly backward. Where evident, glabella is forwardly tapered and subtriangular in outline.

Etymology.—From *glaber,* hairless, bald, smooth, and *aspis,* shield, in reference to the strongly effaced cranidium of this species.

Assigned species.—*Leiocoryphe occipitalis* Rasetti, 1944; *Leiocoryphe longiceps* Rasetti, 1963; *Bynumiella vescula* Stitt, 1971; *Glaberaspis scoobydooi* n. sp.

Discussion.—In their revision of the plethopeltid genera, Ludvigsen and Westrop (*in* Ludvigsen *et al.,* 1989) assigned *Leiocoryphe occipitalis* Rasetti and *L. longiceps* Rasetti only questionably to that genus in the absence of information of the pygidium. Cranidia of both of these species, and a related new species from the Bullwhacker Member, differ from those of *Leiocoryphe* in possessing conspicuous, backwardly curved occipital rings. The new species has a pygidium (Pl. 19, figs. 24–39) that differs markedly from all previously described plethopeltid pygidia, and provides the basis for the establishment of a new genus. The pygidium of *Glaberaspis scoobydooi* n. gen. and sp. is semielliptical in outline, with a long, well-defined axis that consists of four axial rings and a terminal piece. Cranidia and pygidia show a comparable size range, suggesting that it was isopygous. In contrast, *Leiocoryphe* is micropygous with an effaced lenticular pygidium whose axis is broad and convex (Ludvigsen *et al.,* 1989, pl. 48, fig. 11, pl. 49, figs. 3, 4, 7, 11, 12).

Although the dorsal surface of the cranidium of *Glaberaspis* is effaced, the ventral surface of the exoskeleton shows the barely perceptible outline of an anteriorly tapered, subtriangular glabella (Pl. 19, figs. 16, 19; the dark, triangular areas near the posterior margins of the cranidia are shadows created by flash photography). Taylor (1976) suggested that *Bynumiella vescula* Stitt (1971, pl. 7, figs. 16–18) should be assigned at least questionably to *Leiocoryphe.* The well-defined occipital ring and anteriorly tapered, subtriangular glabella, however, both suggest that this species is related to *G. scoobydooi*. Differences between these two species are discussed below.

Like *Leiocoryphe* and *Glaberaspis, Meniscocoryphe* Ludvigsen and Westrop (in Ludvigsen *et al.,* 1989) is blind, and possesses broad, short, transversely semielliptical pygidia. Although expressed only on the ventral surface of the exoskeleton, the long, narrow axis of *Mensicocoryphe* (*e.g.,* Ludvigsen *et al.,* 1989, pl. 49, fig. 19) appears to consist of at least four segments and, in this respect, resembles the pygidium of *Glaberaspis.* Pygidia of *Meniscocoryphe* (*e.g.,* Stitt, 1971, pl. 4, fig. 10; Westrop, 1986b, pl. 38, fig. 21; Ludvigsen *et al.,* 1989, pl. 49, figs. 19, pl. 50, fig. 3) encompass a similar size range as associated cranidia and it is possible that this genus, like *Glaberaspis,* was isopygous.

Both *Stenopilus* and *Plethopeltis* differ from *Glaberaspis* in possessing eyes. Cranidia of *Stenopilus* (*e.g.,* Ludvigsen *et al.,* 1989, pl. 47, figs. 1–4, 7, 16–22, pl. 48, figs. 1–3, 8, 9, 13–16) are comparable to *Glaberaspis* in the degree of effacement, but are more strongly arched longitudinally. The effaced pygidia of *Stenopilus* are typically short and possess broad, convex axes (*e.g.,* Ludvigsen *et al.,* 1989, pl. 47, figs. 5, 6, 9, 12–14, pl. 48, figs. 4–6, 12). The glabella of *Plethopeltis* is defined by axial furrows at least posteriorly and, where fully expressed, is very gently tapered and rounded anteriorly (*e.g.,* Ludvigsen and Westrop, 1983b, pl. 18, figs. 1–3, 9, 12, pl. 19, figs. 1, 6, 8, 11, 13). In late meraspids of *Plethopeltis hastatus* (Westrop, 1986b, pl. 38, fig. 14), however, the glabella is subtriangular in outline, and resembles *Glaberaspis* much more closely. Although most species of *Glaberaspis* possess posteriorly rounded occipital rings, *G.* cf. *G. occipitalis* from the Shallow Bay Formation (Ludvigsen *et al.,* 1989, pl. 49, figs. 17, 18) has a tapered, posteriorly pointed occipital ring and distinct occipital furrow that closely resembles those of some species of *Plethopeltis* (*e.g.,* Westrop, 1986b, pl. 36, figs, 8, 9, pl. 37, fig. 6; Ludvigsen *et al.,* 1989, pl. 46, figs. 6, 8, 13)

In the absence of information on the thoracic segments, assignment of *Glaberaspis* (and *Meniscocoryphe*) to the Plethopeltidae must be tentative. It is also worth making comparisons with *Clelandia* Cossman, a genus whose affinities are currently uncertain. Westrop (1986b) commented on the similarities between some species of this genus and *G. vescula.* The glabella of the type species, *C. typicalis* (Resser, 1942) (Westrop, 1986b, pl. 41, figs. 20–30) is strongly tapered and subtriangular in outline. Lateral glabellar furrows are effaced on the external surface of the exoskeleton but, as in *G. vescula* (*e.g.,* Stitt, 1971, pl. 7, figs., 17, 18), they are expressed on internal molds as ill-defined pits that are connected across the glabella by a shallow furrow (*e.g.,* Westrop, 1986b, pl. 41, figs. 23, 24). Pygidia of *Clelandia* are quite different from those of *Glaberaspis* or any other plethopeltid (Norford, 1969).

Glaberaspis scoobydooi, new species

Plate 19, figures 12–16, 18–39

Diagnosis.—A species of *Glaberaspis* with conspicuous, posteriorly rounded occipital rings that lacks an occipital furrow. Glabella is poorly defined on ventral surface of exoskelton.

Description.—Cranidium subelliptical in outline, with width between posterior corners of fixigenae 90–95 percent of length; strongly convex with highest point at posterior end of occipital ring; lateral profile gently curved upward and steeping in slope along anterior third of cranidium. All cranidial furrows completely effaced on dorsal surface; strongly tapered, subtriangular glabella outline barely perceptible on ventral surface. Occipital rings conspicuous, occupying about 30 percent of cranidial length and about 70 percent of maximum cranidial width; posterior margin curved strongly backward. Palpebral lobes absent. In dorsal view, sutures converge forward in smooth curve. In anterior view, each branch of the sutures appears gently curved upward, meeting on midline, so that anterior tip of cranidium is pointed (Pl. 19, fig. 20). External surface of cranidium is smooth.

Pygidium semielliptical in outline with length 67–80 percent of maximum width (lower proportions in smaller pygidia). In posterior view, axis and pleural fields weakly arched, with very weakly concave lateral margins descending steeply. Axis long, narrow, tapered gradually backward, and gently convex, occupying 33–43 percent of pygidial width at anterior (lower proportions in smaller pygidia), and nearly 95 percent of pygidial length in dorsal view. Axial furrows very shallow grooves. Axial rings and ring furrows ill defined on dorsal surfaces of larger pygidia; ventral surfaces of larger pygidia and dorsal surfaces of some small individuals show four axial rings and rounded terminal piece separated by nearly transverse axial furrows. Pleural field crossed by faint, oblique pleural furrows. Border in form of narrow rim at base of steeply descending flanks of pygidium. External surface of pygidium is smooth.

Holotype.—A cranidium (SUI 99291; Pl. 19, figs. 12, 14, 19, 20) from the Bullwhacker Member of the Windfall Formation, Barton Canyon, Cherry Creek Range.

Figured material.—Three cranidia (SUI 99291–99293) and five pygidia (SUI 99294–99298).

Etymology.—Named for Scooby-Doo.

Discussion.—The conspicuous, well-rounded occipital ring of *Glaberaspis scoobydooi* is shared with *G. occipitalis* (Rasetti, 1944), a species that has been reported from the south-central United States (*e.g.*, Bell and Ellinwood, 1962; Stitt, 1971) and eastern Canada (Rasetti, 1944; Ludvigsen *et al.,* 1989). However, all cranidia assigned previously to the latter species (Bell and Ellinwood, 1962, pl. 59, fig. 4; Stitt, 1971, pl. 4, fig. 13; Ludvigsen *et al.,* 1989, pl. 49, figs. 15, 16) possess a well-defined occipital furrow on both testate and exfoliated surfaces, whereas the furrow is absent on *G. scoobydooi.* In addition, the occipital ring is the most elevated portion of the cranidium of *G. scoobydooi* (Pl. 19, figs. 14, 18, 21), whereas stereopairs of *G. occipitalis* (*e.g.,* Stitt, 1971, pl. 4, fig. 13) indicate that the central portions of the cranidium are strongly convex and are elevated above the occipital ring. *Glaberaspis* cf. *G. occipitalis* from the Shallow Bay Formation of western Newfoundland (Ludvigsen *et al.,* 1989, pl. 49, figs. 17, 18) has a tapered, posteriorly pointed occipital ring and distinct occipital furrow, and probably represents an undescribed species. *Glaberaspis longiceps* (Rasetti, 1963, pl. 130, figs. 21–26) has a relatively narrower cranidium than *G. scoobydooi* and is much more convex, so that the anterior end slopes almost downward in lateral view. In addition, an occipital furrow is expressed on at least larger individuals (Rasetti, 1963, pl. 130, fig. 25).

Glaberaspis vescula (Stitt, 1971, pl. 7, figs. 16–18; see also Taylor, 1976, pl. 3, fig. 21) bears a superficial resemblance to *G. scoobydooi,* but shows an anteriorly tapered glabella on testate (Stitt, 1971, pl. 7, fig. 16) and exfoliated surfaces (Stitt, 1971, figs. 17, 18; Westrop, 1986b, pl. 41, fig. 31). Stitt (1971, p. 23) describes "very faint" palpebral lobes and furrows, although they are not evident in his photographs (1971, pl. 7, figs. 16–18). Examination of the holotype (OU 6519) and paratypes (OU 6520, OU 6521), housed at the Oklahoma Museum of Natural History, showed that these features are not present. The apparent deflection in the suture on the left side of the holotype (Stitt, 1971, pl. 7, fig. 16) is actually a broken surface, and the sutures form a smooth curve in lateral view. At least parts of the lateral cranidial margins of the paratypes have been damaged during preparation and do not show the true course of the facial sutures.

Family **UNCERTAIN**

GEN. AND SP. INDET.

Plate 17, figures 51–53

Figured material.—One cranidium (SUI 99275)

Discussion.—A single cranidium is characterized by a narrow, convex, gently tapered, anteriorly rounded glabella with three pairs of shallow lateral furrows. Palpebral lobes are long, extending from the occipital furrow to the S3 furrow, and are separated from narrow fixigenae by finely etched palpebral furrows. The short frontal area lacks an anterior border and border furrow.

The long palpebral lobes invite comparison with genera of the Dikelocephalidae or, perhaps, Eurekiidae. However, dikelocephalids typically possess conspicuous, transglabellar S1 furrows throughout the holaspid ontogeny (*e.g.,* Pl. 2, figs. 2, 13, 15, 34), whereas the cranidium described herein has weak lateral furrows only. Some eurekiids have lateral furrows that approach those of our cranidium (*e.g.,* Ludvigsen, 1982, fig. 61A–F), but those species with long palpebral lobes are characterized by very narrow interocular fixigenae (*e.g.,* Westrop, 1986b, pl. 6, fig. 15).

UNASSIGNED SCLERITES

Plate 17, figures 17, 21, 22, 24, 27, 29–47, 50

Discussion.—Thoracic segments with narrow pleurae and extremely long axial spines (Pl. 17, figs. 17, 21, 22, 24, 27, 29, 30, 34, 36) are presumably from the posterior part of a thorax. Similar segments occur at the end of the thoraces of articulated individuals of *Yukonaspis* from the lower Bullwhacker Member at Cherry Creek (Adrain and Westrop, unpublished data), although other sclerites of this genus have not been recovered from the samples described herein.

Hypostomes have been attributed to very few Sunwaptan trilobites. Eurekiid (Ludvigsen, 1982; Pl. 11, figs. 1–11), plethopeltid (Westrop, 1986b, pl. 36, fig. 3, pl. 37, fig. 16; Ludvigsen *et al.,* 1989, pl. 46, fig. 15) dikelocephalid (Pl. 1, figs. 5, 6, 8; Ulrich and Resser, 1933, pl. 26, fig. 6, pl. 31, fig. 2, pl. 35, fig. 5, pl. 36, fig. 13, pl. 37, fig. 3; Shergold, 1991, pl. 3, fig. 11, pl. 4, figs. 7, 14, 20) and ptychaspidid (Lochman and Hu, 1959, pl. 58, fig. 25; Westrop, 1986b, pl. 7, fig. 9, pl. 8, figs. 4, 16) hypostomes have been documented and, on this basis, the specimens illustrated herein are unlikely to belong to *Prosaukia, Euptychaspis, Sunwaptia, Corbinia, Cherrycreekia* or *Glaberaspis.*

The hypostomes are similar in outline, convexity and shape of the median body, expression of the median furrow and the morphology of the lateral and posterior borders. They differ in size and position of the anterior and posterior wings. On the basis of size, the larger specimens illustrated herein (Pl. 17, figs. 33, 35, 37, 40, 42, 45) might belong to *Illaenurus montanensis.*

A single pygidium (Pl. 17, figs. 31, 38, 43) is convex with a well-defined axis of three rings and a terminal piece, weakly furrowed pleural field, narrow posterior border and a well-defined median embayment of the posterior margin in posterior view. Only two genera, *Triarthropsis* and Gen. Uncertain, are potential candidates for this pygidium, as all others occur with pygidia that are assigned with confidence. Although a wide variety of pygidia have been attributed to catillicephalids (*e.g.*, Ludvigsen *et al.*, 1989, pl. 32, figs. 21, 22, 28, 29, pl. 34, figs. 13, 28, 29, pl. 35, fig. 7), the specimen illustrated herein is unlikely to belong to either species of *Triarthropsis* present in our collections. The pygidia associated with holotype of *T. limbata* Rasetti in Virginia (Rasetti, 1959, pl. 52, figs. 5–8) are quite different, with long, multi-segmented axes and pleural fields traversed by up to six pairs of firmly impressed pleural and interpleural furrows. The pygidia that occur with cranidia of *T. nitida* Ulrich (Rasetti, 1959, pl. 55, figs. 6–8) are comparable to those of *T. limbata* and are unlike our specimen.

As noted earlier, under the discussion of *Prosaukia oldyelleri,* dikelocephalid thoracic segments (Pl. 17, figs. 41, 46, 50) are left unassigned because they possess sculpture of coarse granules that is not matched in either of the species described herein. A librigena (Pl. 17, fig. 47) also belongs to a dikelocephalid trilobite but differs from those of *P. oldyelleri* (Pl. 2, figs. 35, 37–39; Pl. 3, figs. 33, 41) in having a shorter, more slender and rapidly tapering genal spine.

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7, 10. Left librigena, SUI 99044, external and internal views, ×12.	
9. Left librigena, SUI 99045, external view, ×10.	
11. Right librigena, SUI 99046, external view, ×12.	
12. Right librigena, SUI 99047, external view, ×10.	
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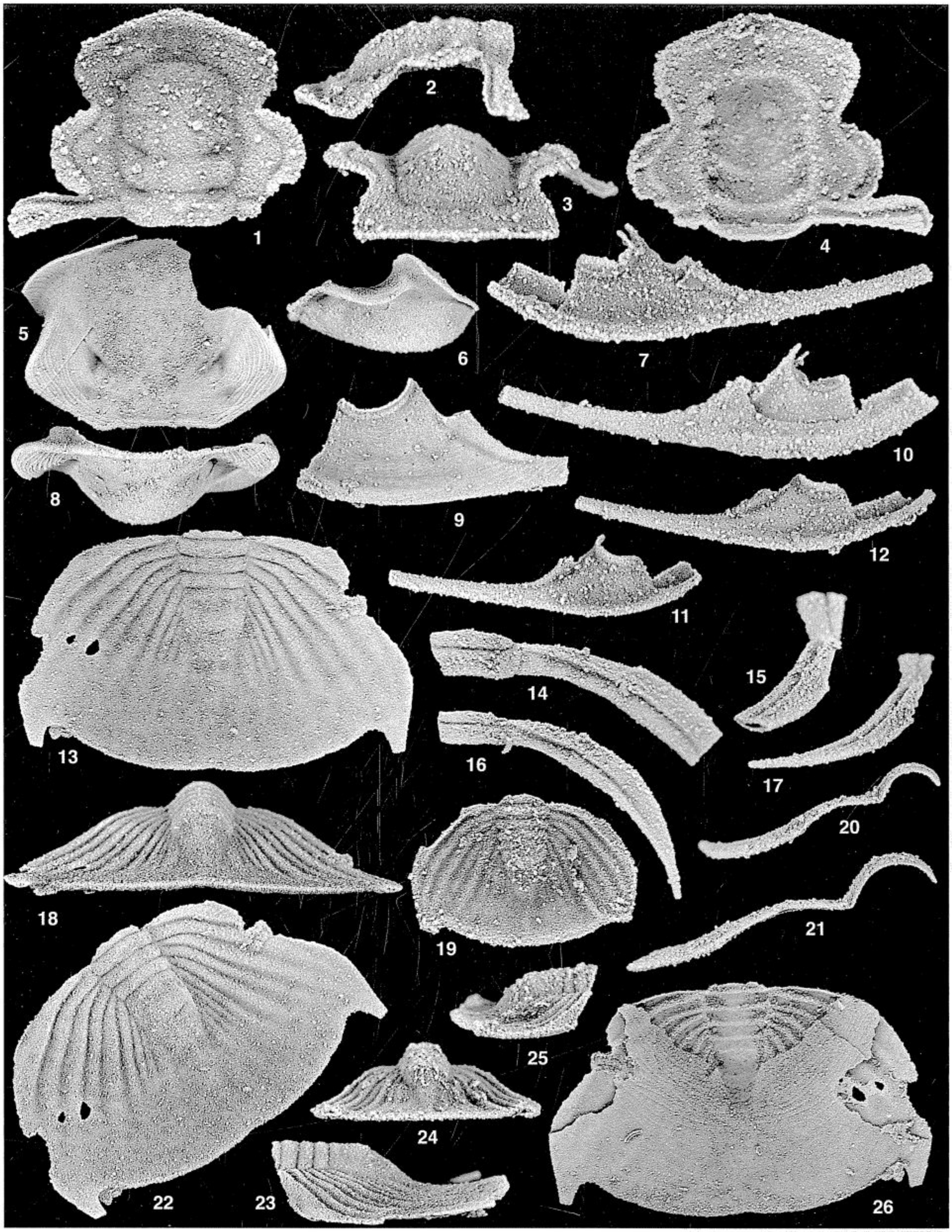
19, 24, 25. Pygidium, SUI 99051, dorsal, posterior, and right lateral views, ×10.	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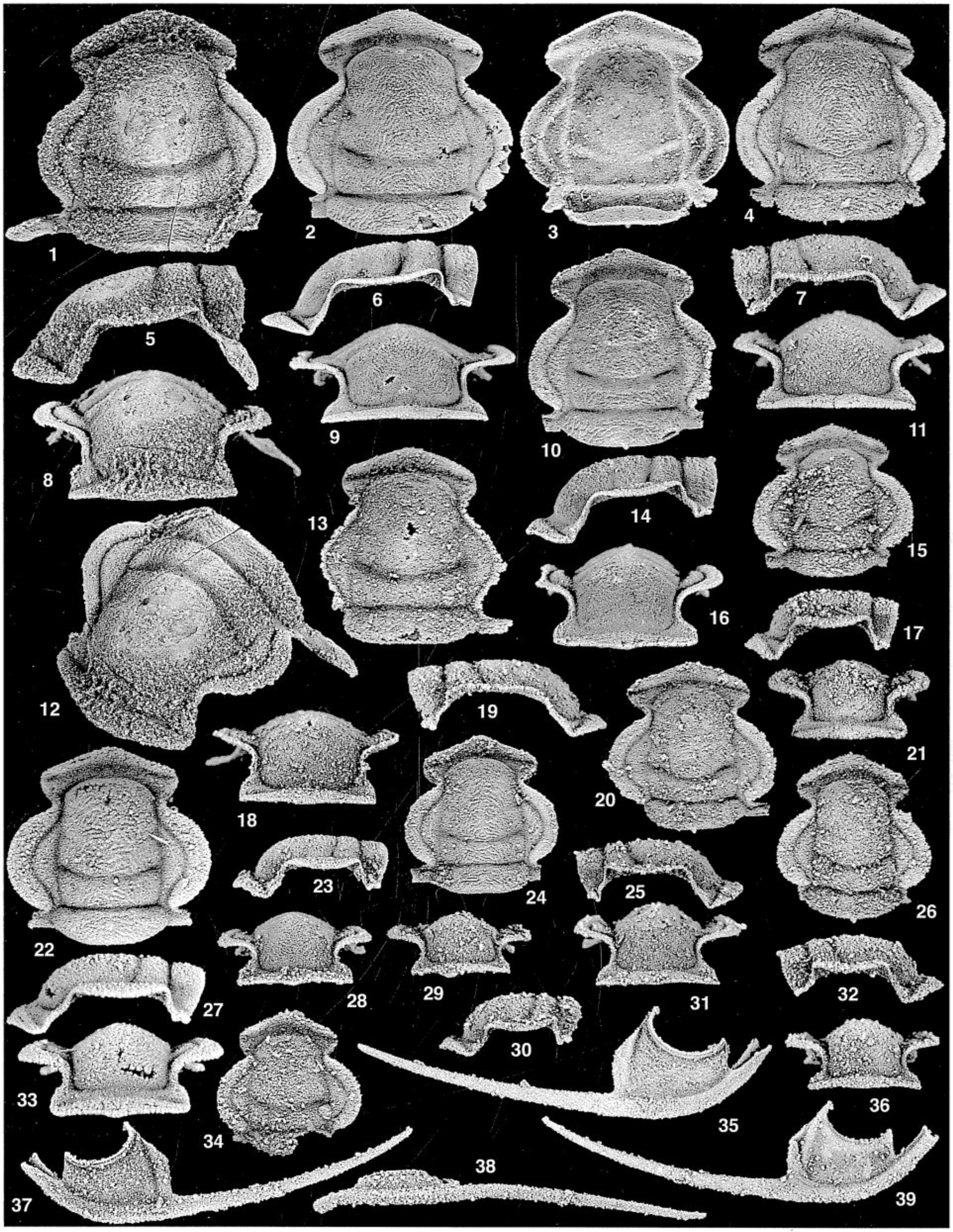
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EXPLANATION OF PLATE 2

Figure Page

1–39. *Prosaukia oldyelleri* new species. 11

1, 5, 8, 12. Cranidium, SUI 99052, dorsal, left lateral, anterior, and oblique views, ×4.
2, 6, 9. Cranidium, SUI 99053, dorsal, left lateral, and anterior views, ×7.5
3, 4, 7, 11. Cranidium, **holotype,** SUI 99054, ventral, dorsal, right lateral, and anterior views, ×7.5
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13, 18, 19. Cranidium, SUI 99056, dorsal, anterior, and right lateral views, ×7.5.
15, 17, 21. Cranidium, SUI 99057, dorsal, left lateral, and anterior views, ×10.
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22, 27, 33. Cranidium, SUI 99059, dorsal, left lateral, and anterior views, ×15.
23, 24, 28. Cranidium, SUI 99060, left lateral, dorsal, and anterior views, ×7.5.
26, 32, 36. Cranidium, SUI 99061, dorsal, right lateral, and anterior views, ×7.5.
29, 30, 34. Cranidium, SUI 99062, anterior, left lateral, and dorsal views, ×7.5.
35. Right librigena, SUI 99063, external view, ×7.5.
37–39. Left librigena, SUI 99064, external, ventrolateral, and internal views, ×7.5.

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1–41. *Prosaukia oldyelleri* new species. 11

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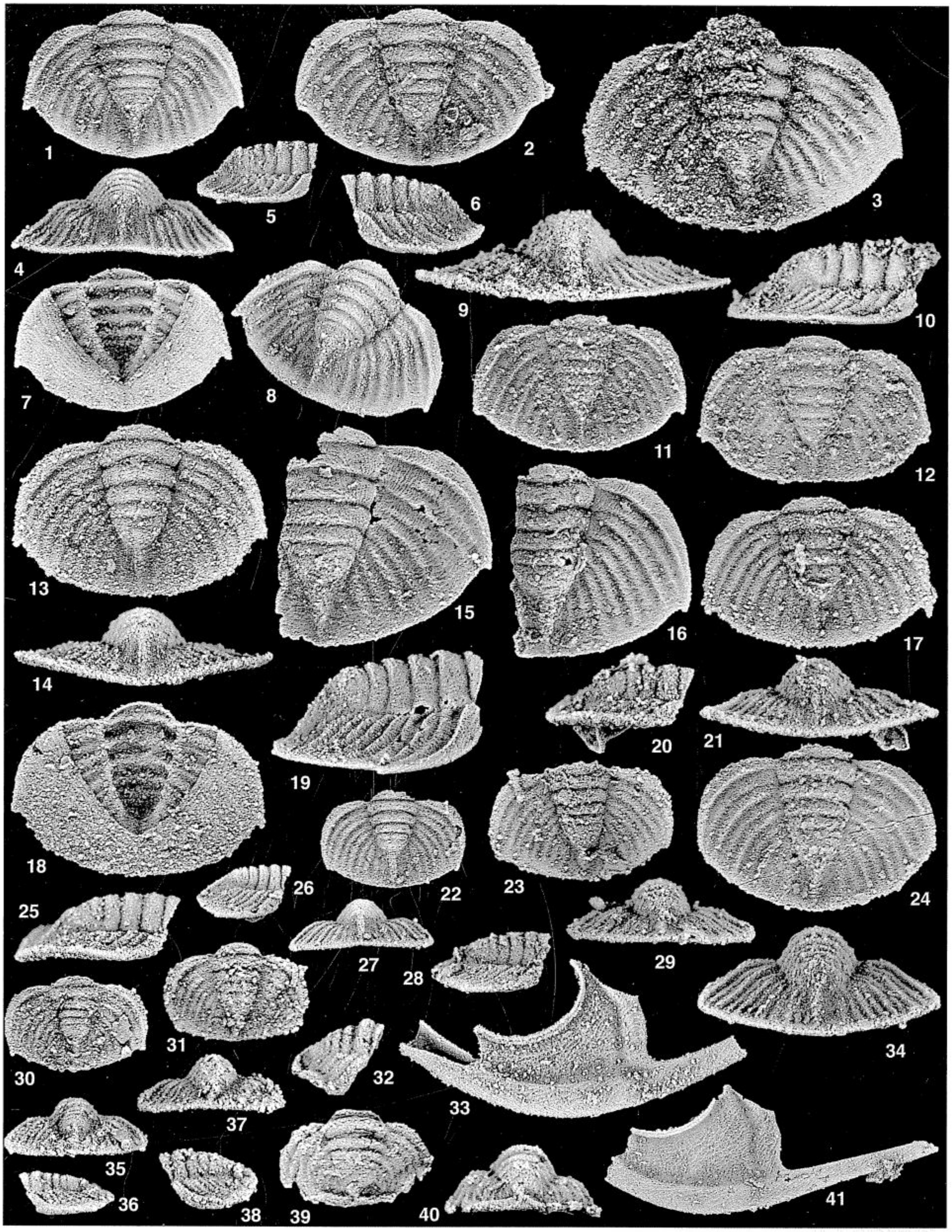
2, 6. Pygidium, SUI 99066, dorsal and left lateral views, ×7.5.
3, 9, 10. Pygidium, SUI 99067, dorsal, posterior, and right lateral views, ×7.5.
11. Pygidium, SUI 99068, dorsal view, ×10.
12. Pygidium, SUI 99069, dorsal view, ×7.5.
13, 14, 18, 25. Pygidium, SUI 99070, dorsal, posterior, ventral, and right lateral views, ×7.5.
15, 19. Pygidium, SUI 99071, dorsal and right lateral views, ×10.
16. Pygidium, SUI 99072, dorsal view, ×10.
17, 20, 21. Pygidium, SUI 99073, dorsal, right lateral, and posterior views, ×10.
22, 26, 27. Pygidium, SUI 99074, dorsal, right lateral, and posterior views, ×10.
23, 28, 29. Pygidium, SUI 99075, dorsal, right lateral, and posterior views, ×10.
24, 34. Pygidium, SUI 99076, dorsal and posterodorsal views, ×10.
30, 35, 36. Pygidium, SUI 99077, dorsal, posterior, and left lateral views, ×12.
31, 37, 38. Pygidium, SUI 99078, dorsal, posterior, and left lateral views, ×15.
32, 29, 40. Transitory pygidium, SUI 99079, right lateral, dorsal, and posterior views, ×15.
33. Left librigena, SUI 99080, external view, ×7.5.
41. Left librigena, SUI 99081, external view, ×5.

PLATE 3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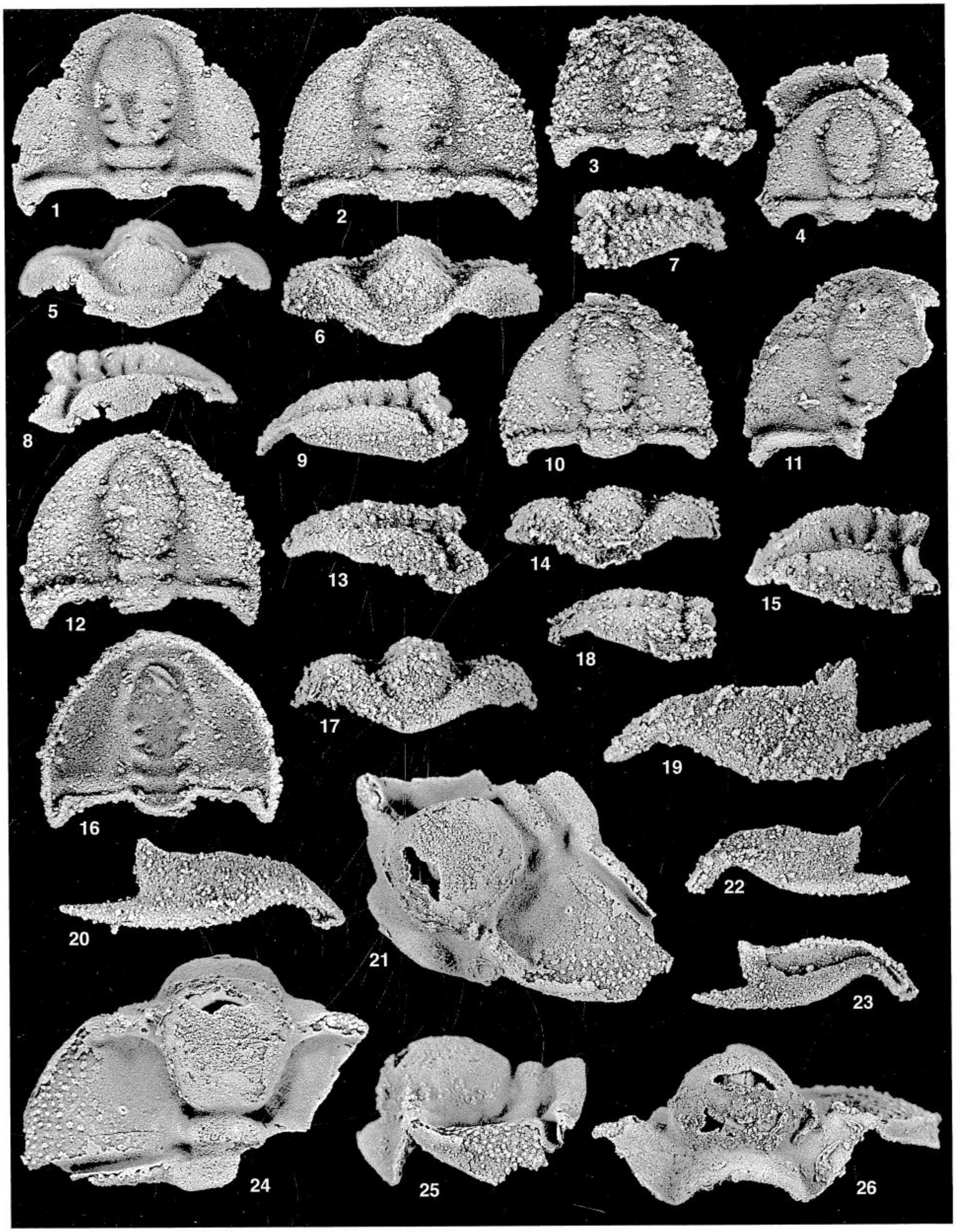
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1–20, 22, 23. *Idiomesus levisensis* (Rasetti, 1944). 13

1, 5, 8. Cranidium, SUI 99082, dorsal, anterior, and right lateral views, ×15.
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3, 7. Cranidium, SUI 99084, dorsal and right lateral views, ×15.
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11, 15. Cranidium, SUI 99087, dorsal and left lateral views, ×15.
12, 13, 16, 17. Cranidium, SUI 99088, dorsal, left lateral, ventral, and anterior views, ×15.
19. Left librigena, SUI 99089, external view, ×15.
20. Right librigena, SUI 99090, external view, ×15.
22, 23. Left librigena, SUI 99091, external and internal views, ×15.

21, 24–26. *Sunwaptia plutoi* new species. 13

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8, 9, 12. Cranidium, SUI 99095, dorsal, anterior, and left lateral views, ×20.
10, 14, 17. Cranidium, SUI 99096, dorsal, anterior, and right lateral views, ×15.
11, 15, 18. Cranidium, SUI 99097, dorsal, anterior, and left lateral views, ×12.
13, 16. Left librigena, SUI 99098, external and internal views, ×10.
19. Left librigena, SUI 99099, external view, ×12.
20. Left librigena, SUI 99100, external view, ×10.
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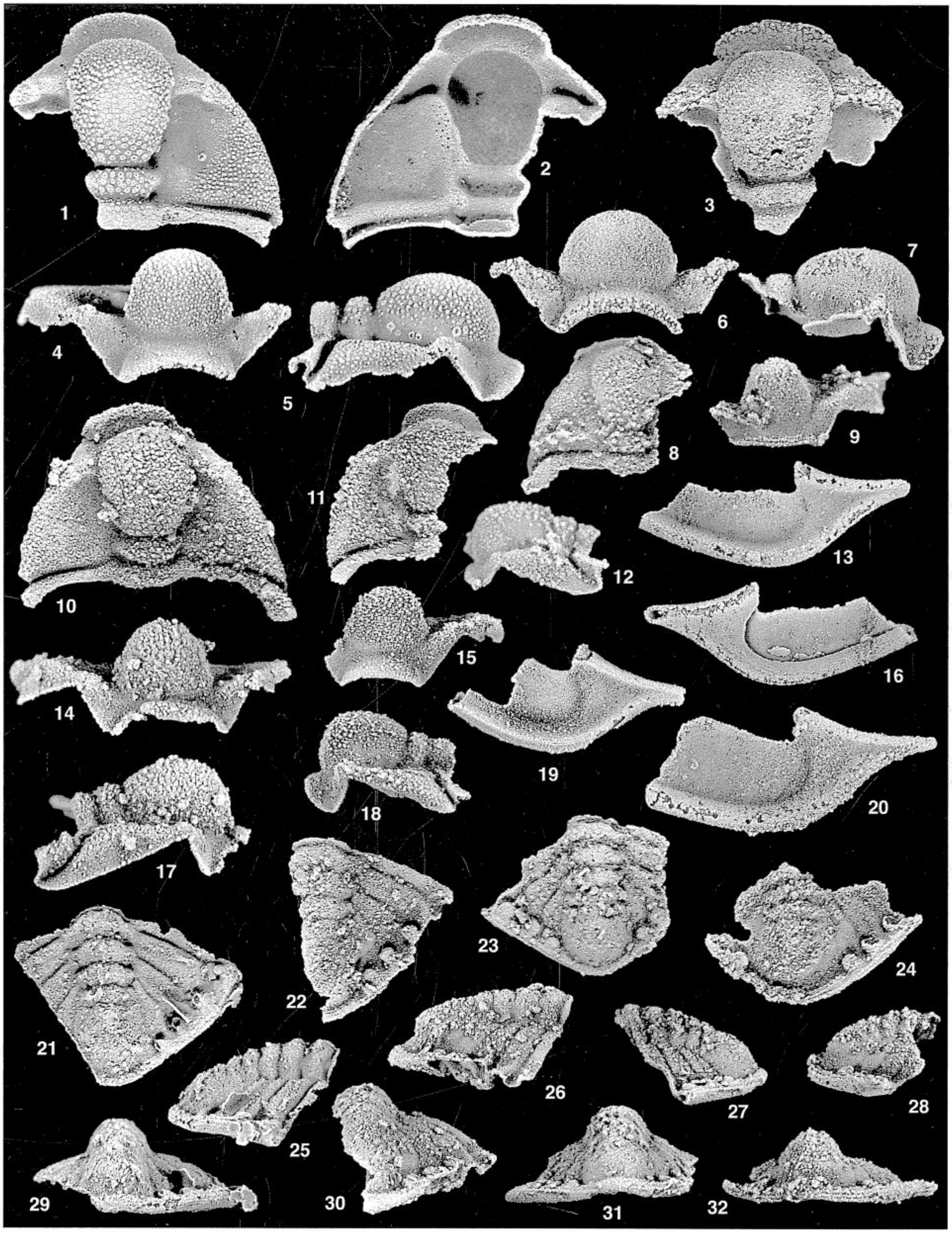
22, 26, 30. Pygidium, SUI 99102, dorsal, right lateral, and posterior views, ×10.
23, 27, 31. Pygidium, SUI 99103, dorsal, left lateral, and posterior views, ×10.
24, 28, 32. Pygidium, SUI 99104, dorsal, right lateral, and posterior views, ×12.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1–44. *Euptychaspis dougali* new species.	15

1, 5, 11, 12, 22. Cranidium, **holotype,** SUI 99105, dorsal, anterior, oblique, right lateral, and ventral views, ×12.
2, 3, 6, 9. Cranidium, SUI 99106, dorsal, ventral, anterior, and left lateral views, ×12.
4, 7, 10. Cranidium, SUI 99107, dorsal, anterior, and left lateral views, ×12.
8, 14, 16. Cranidium, SUI 99108, dorsal, anterior, and left lateral views, ×10.
13, 17, 18. Cranidium, SUI 99109, dorsal, left lateral and anterior views, ×10.
15, 20, 21. Cranidium, SUI 99110, dorsal, anterior, and right lateral views, ×12.
19. Left librigena, SUI 99111, external view, ×10.
23, 25, 26. Left librigena, SUI 99112, external, ventrolateral, and internal views, ×10.
24. Left librigena, SUI 99113, external view, ×10.
27. Right librigena, SUI 99114, external view, ×10.
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32. Right librigena, SUI 99117, external view, ×10.
33. Left librigena, SUI 99118, external view, ×12.
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41. Left librigena, SUI 99123, external view, ×20.

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1–37. *Illaenurus montanensis* Kobayashi, 1935	17

1, 2, 6, 7, 10. Cranidium, SUI 99124, dorsal, ventral, left lateral, anterior, and oblique views, ×7.5.
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4, 8, 12. Cranidium, SUI 99126, dorsal, anterior, and right lateral views, ×10.
5, 9, 14. Cranidium, SUI 99127, dorsal, left lateral, and anterior views, ×4.
11, 13. Cranidium, SUI 99128, dorsal and right lateral views, ×10.
15, 22, 25. Cranidium, SUI 99129, dorsal, left lateral, and anterior views, ×7.5.
16, 17, 23. Cranidium, SUI 99130, dorsal, anterior, and right lateral views, ×10.
18–20. Cranidium, SUI 99131, anterior, left lateral, and dorsal views, ×7.5.
21. Cranidium, SUI 99132, dorsal view, ×7.5.
24, 28. Cranidium, SUI 99133, left lateral and dorsal views, ×10.
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30, 31, 37. Cranidium, SUI 99135, left lateral, dorsal, and anterior views, ×7.5.
32, 33. Cranidium, SUI 99136, dorsal and right lateral views, ×7.5.
34–36. Cranidium, SUI 99137, right lateral, anterior, and dorsal views, ×10.

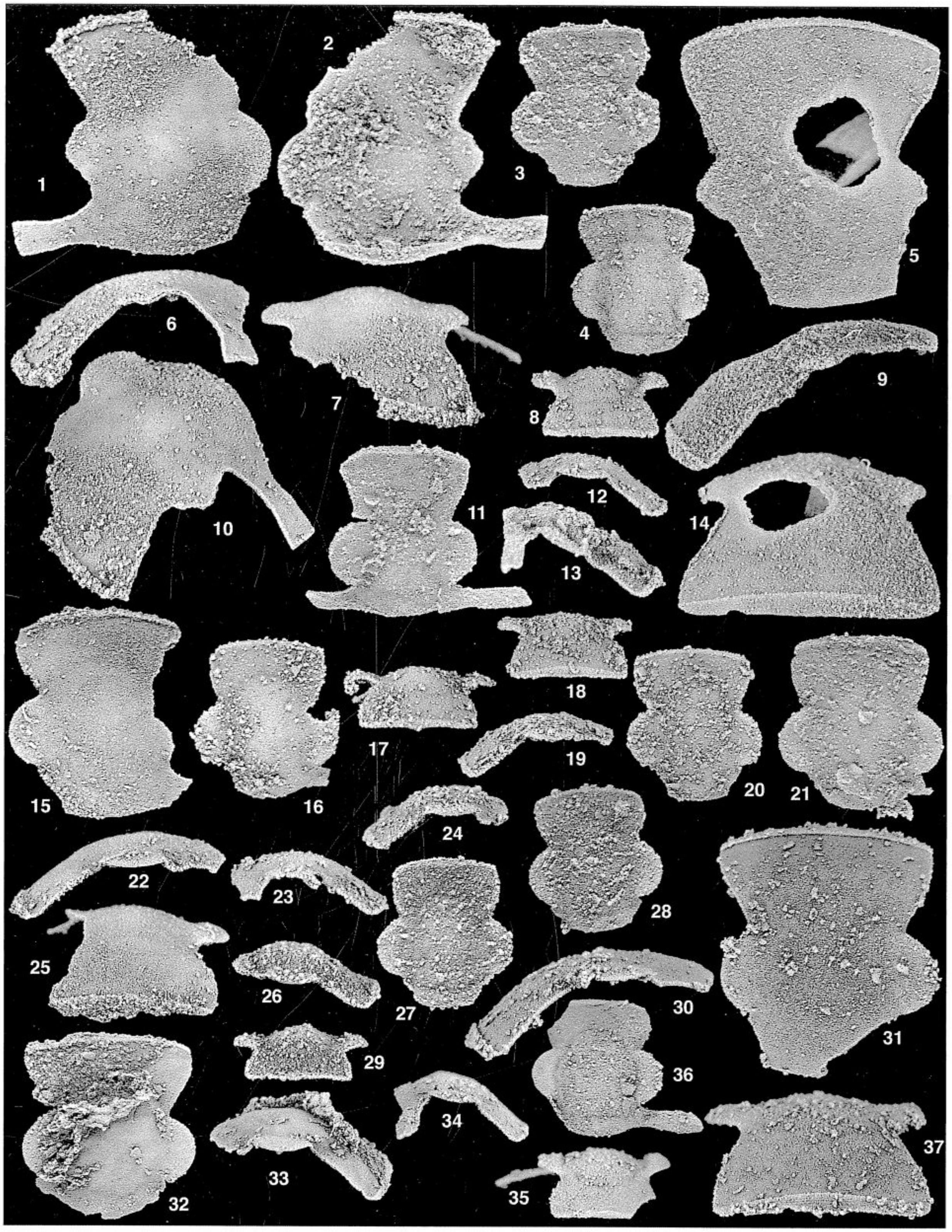
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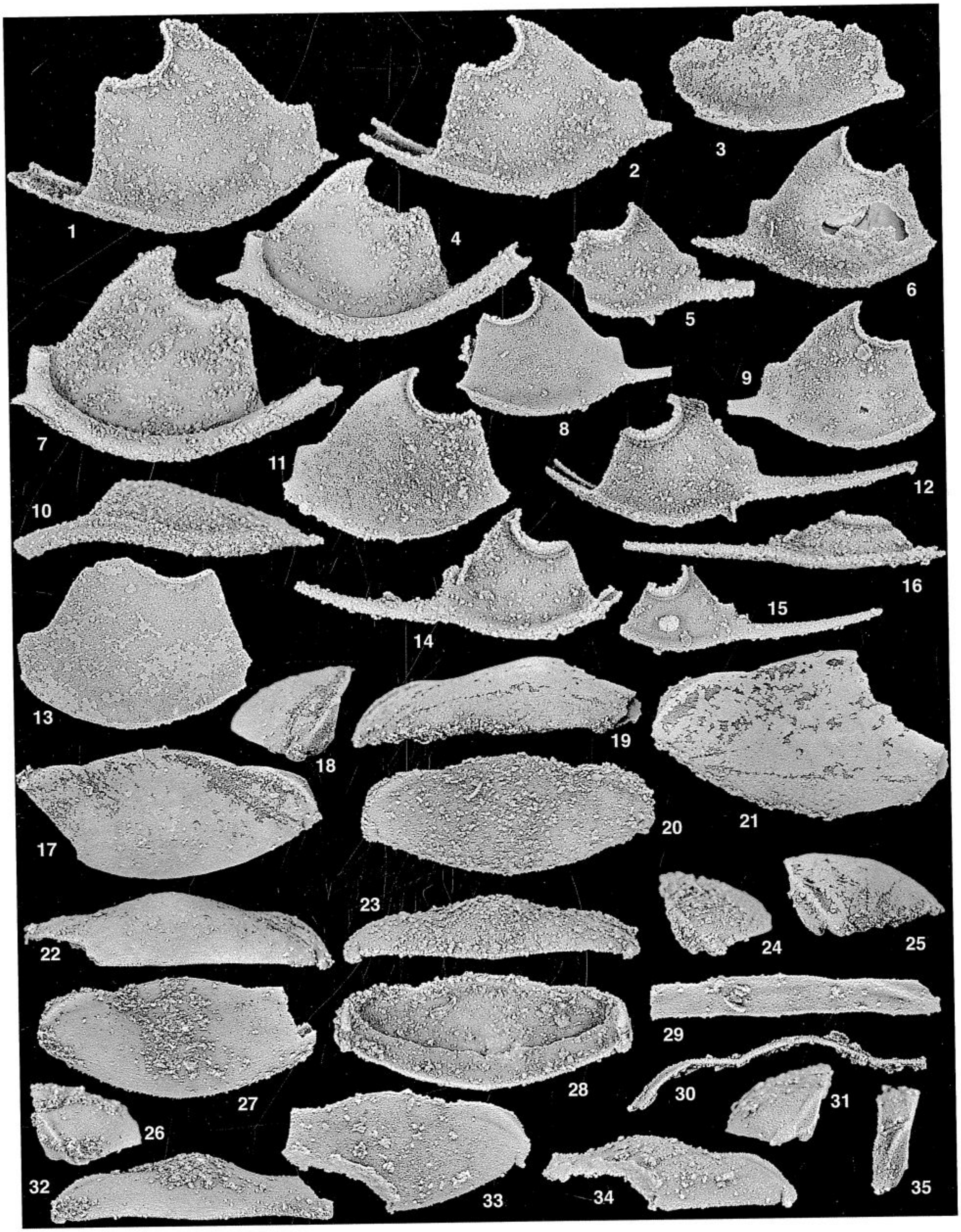
PLATE 8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EXPLANATION OF PLATE 8

Figure Page

1–35. *Illaenurus montanensis* Kobayashi, 1935. 17

1, 7, 10. Left librigena, SUI 99138, external, internal, and ventrolateral views, ×7.5.
2, 4. Left librigena, SUI 99139, external and internal views, ×7.5.
3. Left librigena, SUI 99140, external view, ×10.
5. Left librigena, SUI 99141, external view, ×10.
6. Right librigena, SUI 99142, external view, ×7.5.
8. Left librigena, SUI 99143, external view, ×7.5.
9. Right librigena, SUI 99144, external view, ×7.5.
11. Right librigena, SUI 99145, external view, ×7.5.
12. Left librigena, SUI 99146, external view, ×10.
13. Right librigena, SUI 99147, external view, ×10.
14, 16. Right librigena, SUI 99148, external and ventrolateral views, ×10.
15. Left librigena, SUI 99149, external view, ×10.
17, 18, 22. Pygidium, SUI 99150, dorsal, right lateral, and posterior views, ×6.
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20, 23, 24, 28. Pygidium, SUI 99152, dorsal, posterior, left lateral, and ventral views, ×7.5.
26, 27, 32. Pygidium, SUI 99153, left lateral, dorsal, and posterior views, ×7.5.
29, 30, 35. Thoracic segment, SUI 99154, dorsal, anterior, and right lateral views, ×10.
31, 33, 34. Pygidium, SUI 99155, right lateral, dorsal, and posterior views, ×10.

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1–25, 28, 32, 33. *Triarthropsis limbata* Rasetti, 1959. 18

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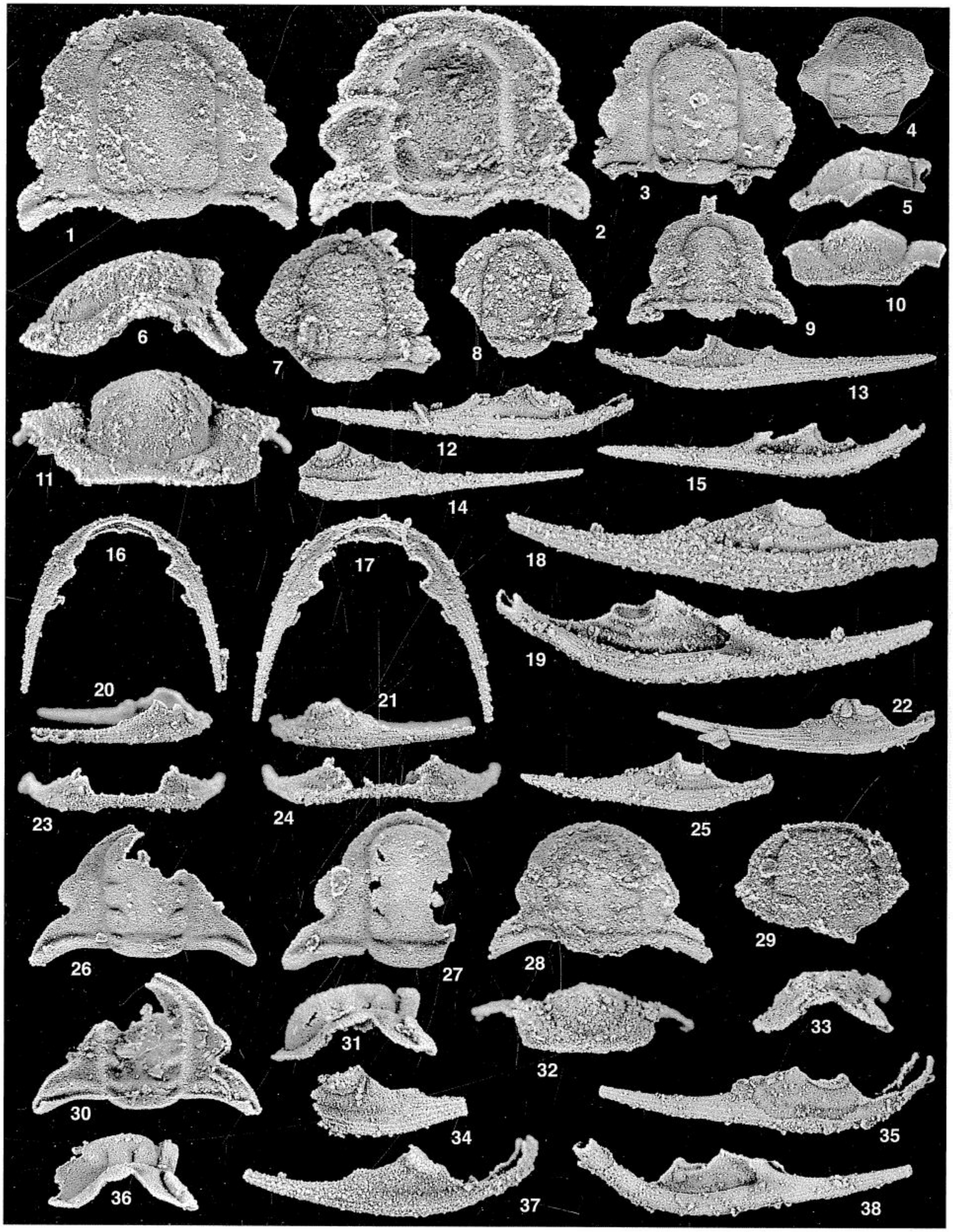
- 3. Cranidium, SUI 99157, dorsal view, ×10.
- 4, 5, 10. Cranidium, SUI 99158, dorsal, left lateral, and anterior views, ×10.
- 7. Cranidium, SUI 99159, dorsal view, ×15.
- 8. Cranidium, SUI 99160, dorsal view, ×10.
- 9. Cranidium, SUI 99161, dorsal view, ×10.
- 12. Right librigena, SUI 99162, external view, ×10.
- 13, 15. Left librigena, SUI 99163, external and internal views, ×10.
- 14. Left librigena, SUI 99164, external view, ×10.
- 16, 20, 23. Yoked librigenae, SUI 99165, dorsal, right lateral, and anterior views, ×10.
- 17, 21, 24. Yoked librigenae, SUI 99166, dorsal, left lateral, and anterior views, ×10.
- 18, 19. Right librigena, SUI 99167, external and internal views, ×10.
- 22. Right librigena, SUI 99168, external view, ×10.
- 25. Right librigena, SUI 99169, external view, ×10.
- 28, 32, 33. Cranidium, SUI 99170, dorsal, anterior, and left lateral views, ×12.

26, 27, ?29, 30, 31, 34–38. *Triarthropsis* sp. 1. 19

- 26, 30, 36. Cranidium, SUI 99171, dorsal, ventral, and left lateral views, ×10.
- 27, 31. Cranidium, SUI 99172, dorsal and left lateral views, ×15.
- 29. Cranidium, SUI 99173, dorsal view, ×10.
- 34. Left librigena, SUI 99174, external view, ×17.
- 35, 38. Right librigena, SUI 99175, external and internal views, ×10.
- 37. Right librigena, SUI 99176, external view, ×15.

PLATE 9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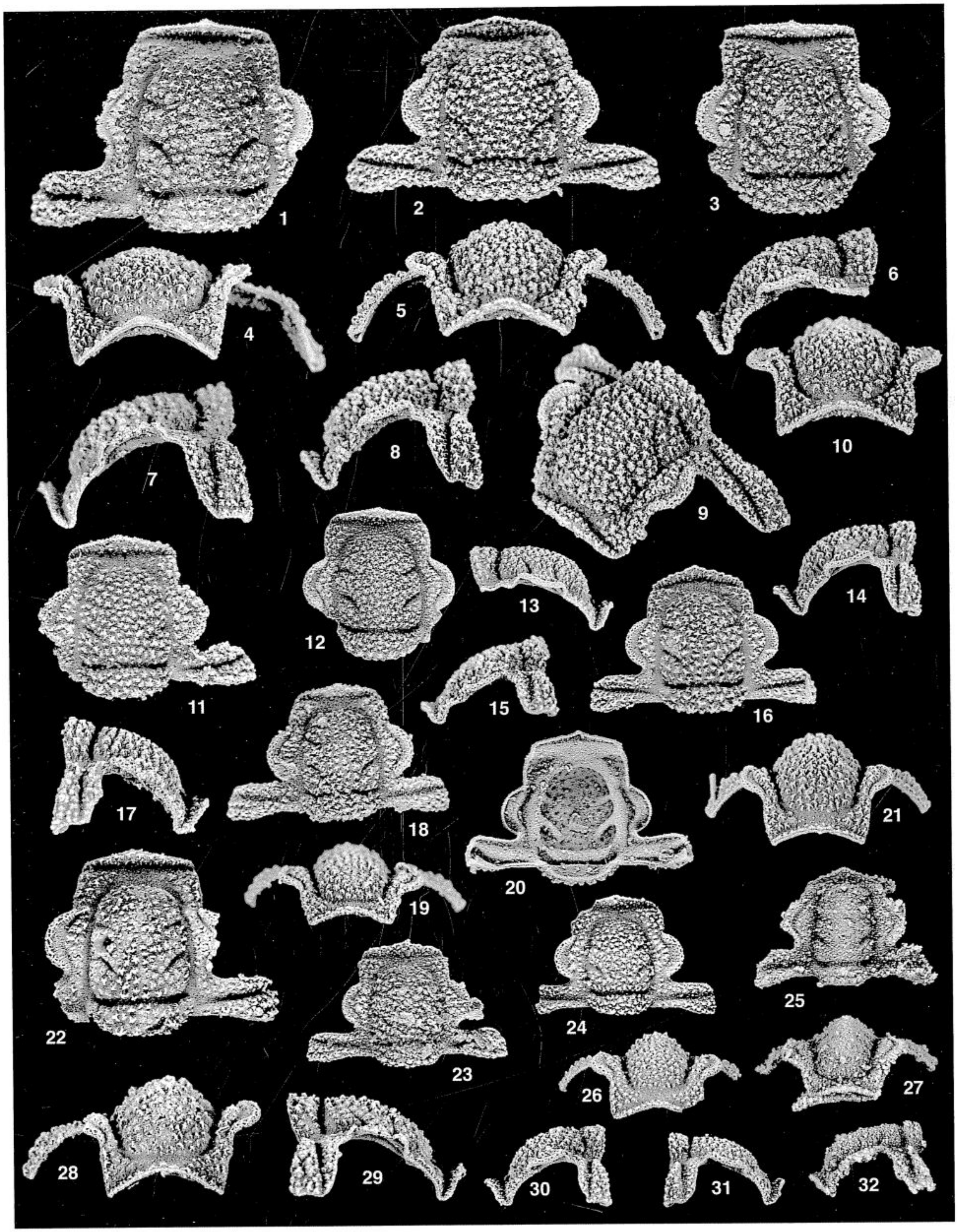
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EXPLANATION OF PLATE 10

Figure Page

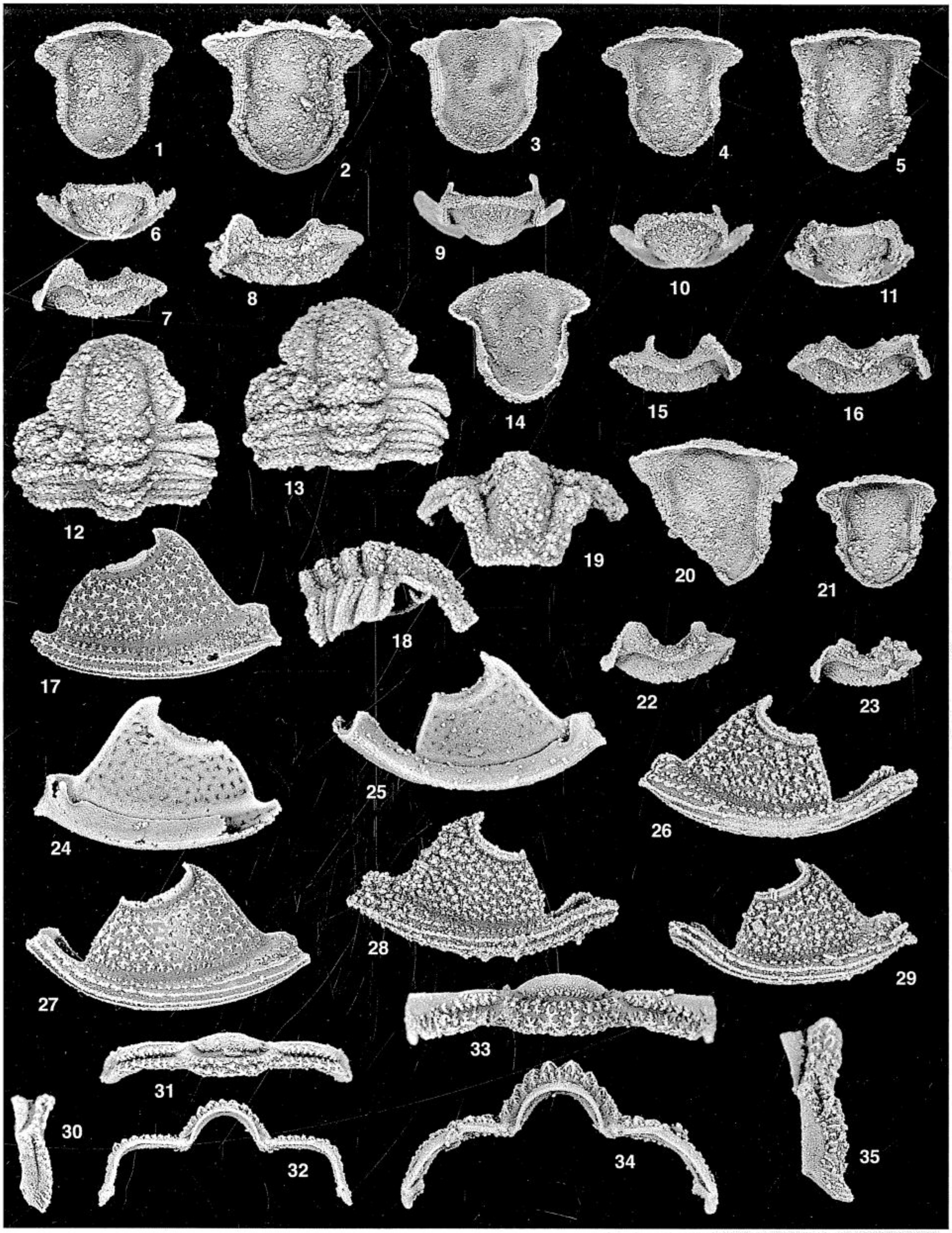
1–32. *Eurekia rintintini* new species. 19

1, 4, 7. Cranidium, SUI 99177, dorsal, anterior, and left lateral views, ×7.5.
2, 5, 8, 9. Cranidium, **holotype,** SUI 99178, dorsal, anterior, left lateral, and oblique views, ×7.5.
3, 6, 10. Cranidium, SUI 99179, dorsal, left lateral, and anterior views, ×7.5.
11, 17. Cranidium, SUI 99180, dorsal and right lateral views, ×10.
12, 13. Cranidium, SUI 99181, dorsal and right lateral views, ×7.5.
14, 16, 20, 21. Cranidium, SUI 99182, left lateral, dorsal, ventral, and anterior views, ×7.5.
15, 18, 19. Cranidium, SUI 99183, left lateral, dorsal, and anterior views, ×10.
22, 28, 29. Cranidium, SUI 99184, dorsal, anterior, and right lateral views, ×10.
23, 30. Cranidium, SUI 99185, dorsal and left lateral views, ×7.5.
24, 26, 31. Cranidium, SUI 99186, dorsal, anterior, and right lateral views, ×10.
25, 27, 32. Cranidium, SUI 99187, dorsal, anterior, and left lateral views, ×17.

EXPLANATION OF PLATE 11

Figure	Page
1–35. *Eurekia rintintini* new species.	19

1, 6, 7. Hypostome, SUI 99188, ventral, posterior, and left lateral views, ×7.5.
2, 8. Hypostome, SUI 99189, ventral and left lateral views, ×10.
3, 9. Hypostome, SUI 99190, ventral and posterior views, ×5.
4, 10, 14, 15. Hypostome, SUI 99191, ventral, posterior, dorsal, and left lateral views, ×7.5.
5, 11, 16. Hypostome, SUI 99192, ventral, posterior, and left lateral views, ×7.5.
12, 13, 18, 19. Cranidium and thoracic segments, SUI 99193, dorsal view of cranidium, dorsal view of thorax, right lateral, and anterior views, ×15.
17, 24. Left librigena, SUI 99194, external and internal views, ×7.5.
20, 22. Hypostome, SUI 99195, ventral and left lateral views, ×7.5.
21, 23. Hypostome, SUI 99196, ventral and left lateral views, ×10.
25, 26. Right librigena, SUI 99197, internal and external views, ×10.
27. Left librigena, SUI 99198, external view, ×10.
28. Right librigena, SUI 99199, external view, ×10.
29. Left librigena, SUI 99200, external view, ×10.
30–32. Thoracic segment, SUI 99201, left lateral, dorsal, and anterior views, ×7.5.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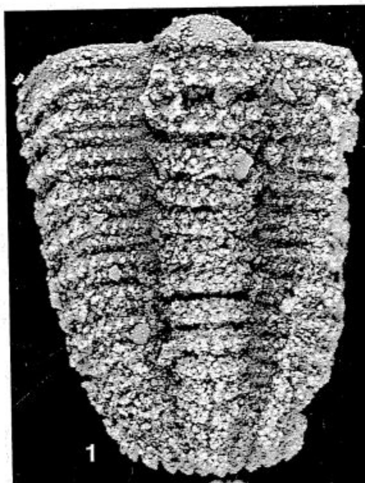
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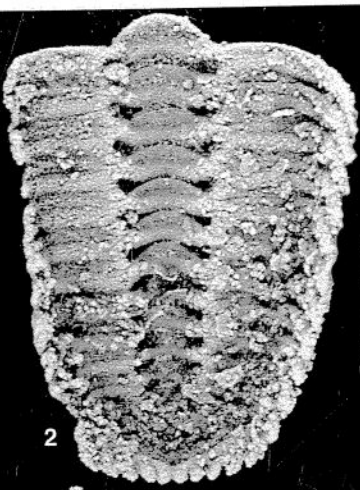
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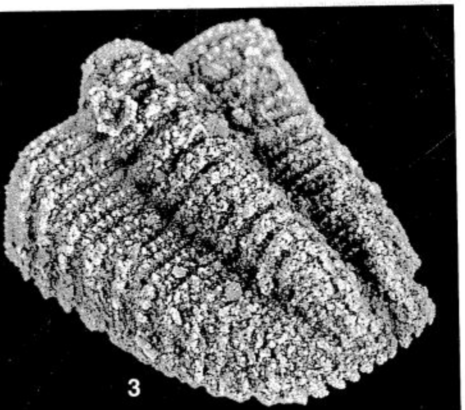
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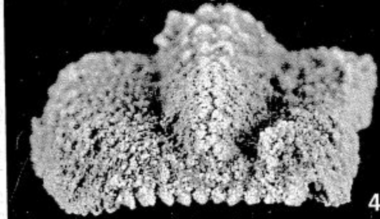
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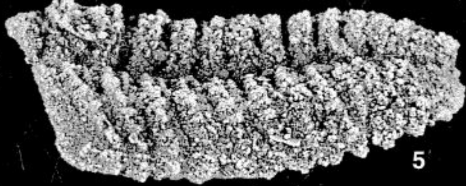
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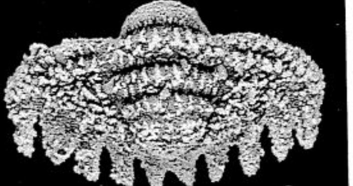
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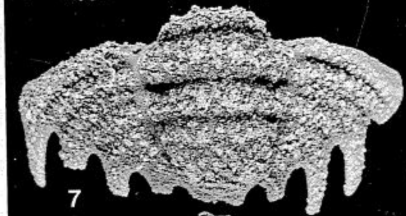
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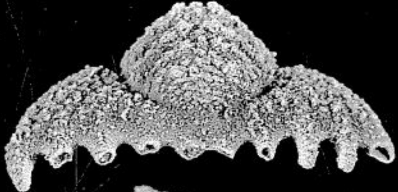
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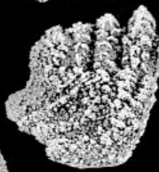
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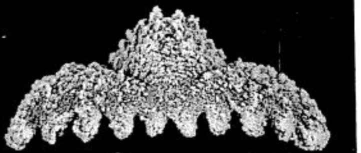
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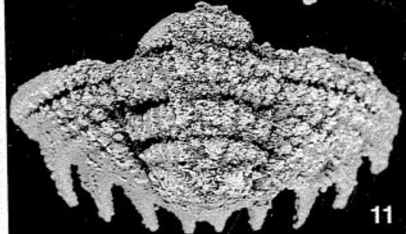
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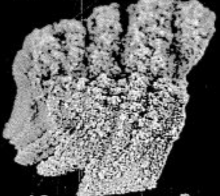
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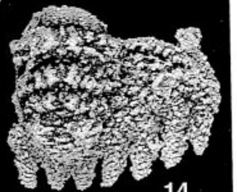
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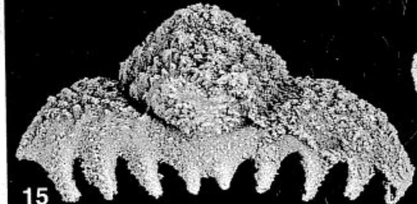
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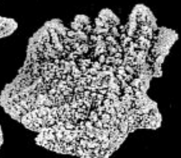
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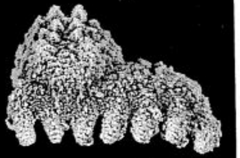
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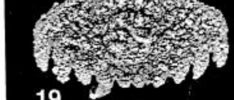
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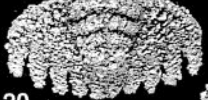
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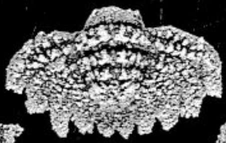
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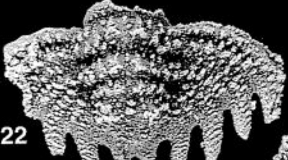
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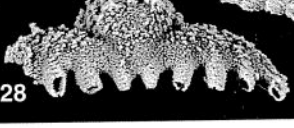
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EXPLANATION OF PLATE 12

Figure Page

1–29. *Eurekia rintintini* new species. 19

1–5. Thoracopygidium, SUI 99203, dorsal, ventral, oblique, posterior, and left lateral views, ×15.

6, 9, 10. Pygidium, SUI 99204, dorsal, right lateral, and posterior views, ×10.

7, 8, 13. Pygidium, SUI 99205, dorsal, posterior, and left lateral views, ×7.5.

11, 12, 15, 16. Pygidium, SUI 99206, dorsal, right lateral, posterior, and ventral views, ×5 (note inverted cranidum of *Bowmania lassieae* n. sp. visible in fig. 16).

14, 17, 18. Pygidium, SUI 99207, dorsal, right lateral, and posterior views, ×10.

19, 23. Pygidium, SUI 99208, dorsal and posterior views, ×10.

20, 24, 25. Pygidium, SUI 99209, dorsal, posterior, and right lateral views, ×10.

21, 26, 27. Pygidium, SUI 99210, dorsal, posterior, and right lateral views, ×12.

22, 28, 29. Pygidium, SUI 99211, dorsal, posterior, and right lateral views, ×10.

EXPLANATION OF PLATE 13

Figure Page

1–28. *Corbinia implumis* Winston and Nicholls, 1967 . . . 21

1, 11, 12, 14, 15. Cranidium, SUI 99212, dorsal, ventral, right lateral, anterior, and oblique views, ×4.

2, 7, 8, 13. Cranidium, SUI 99213, dorsal, anterior, right lateral, and oblique views, ×10.

3, 5, 9. Cranidium, SUI 99214, dorsal, anterior, and right lateral views, ×10.

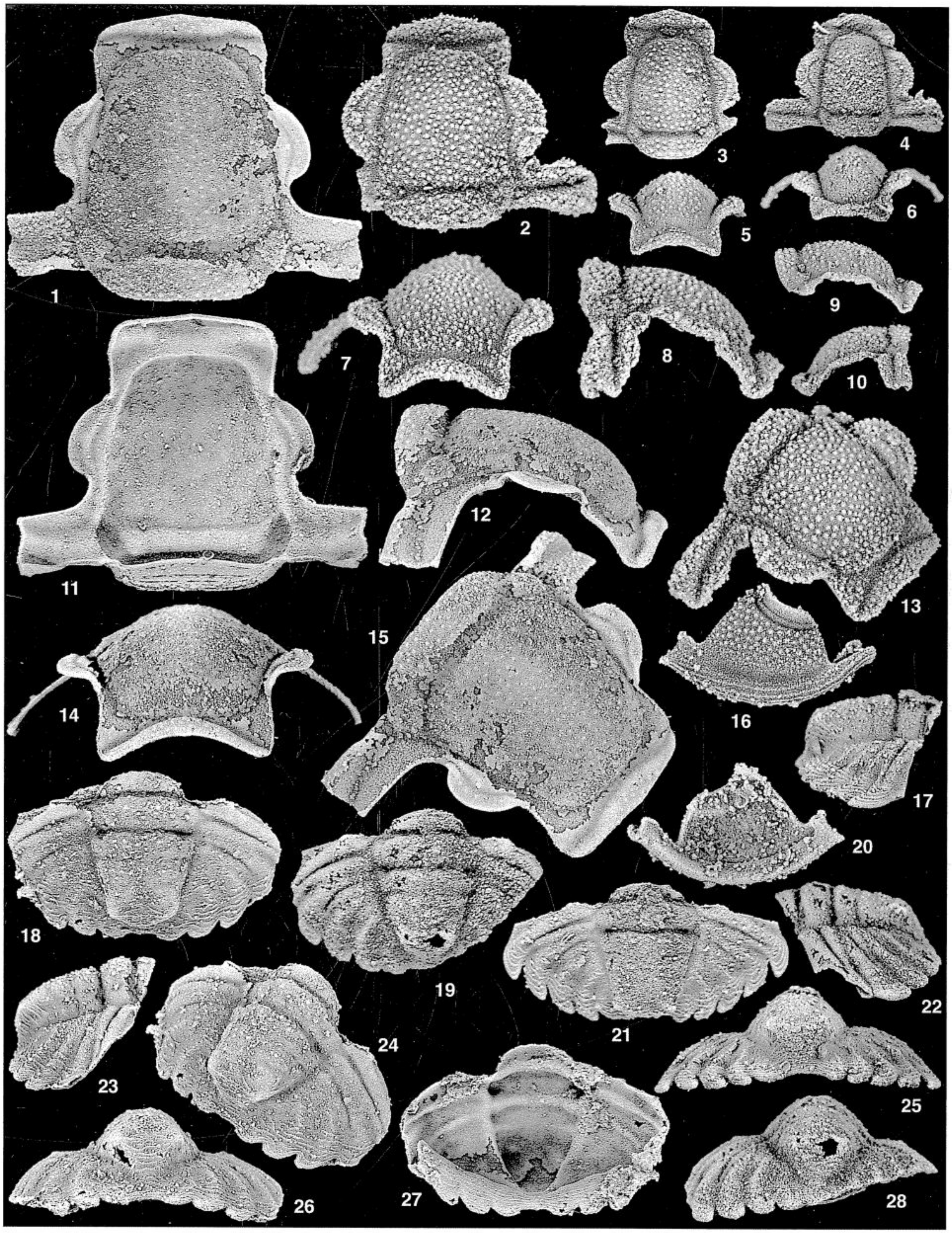
4, 6, 10. Cranidium, SUI 99215, dorsal, anterior, and left lateral views, ×10.

16, 20. Right librigena, SUI 99216, external and internal views, ×10.

17, 21, 25. Pygidium, SUI 99217, right lateral, dorsal, and posterior views, ×6.

18, 23, 24, 26, 27. Pygidium, SUI 99218, dorsal, right lateral, oblique, posterior, and ventral views, ×5.

19, 22, 28. Pygidium, SUI 99219, dorsal, left lateral, and posterior views, ×5.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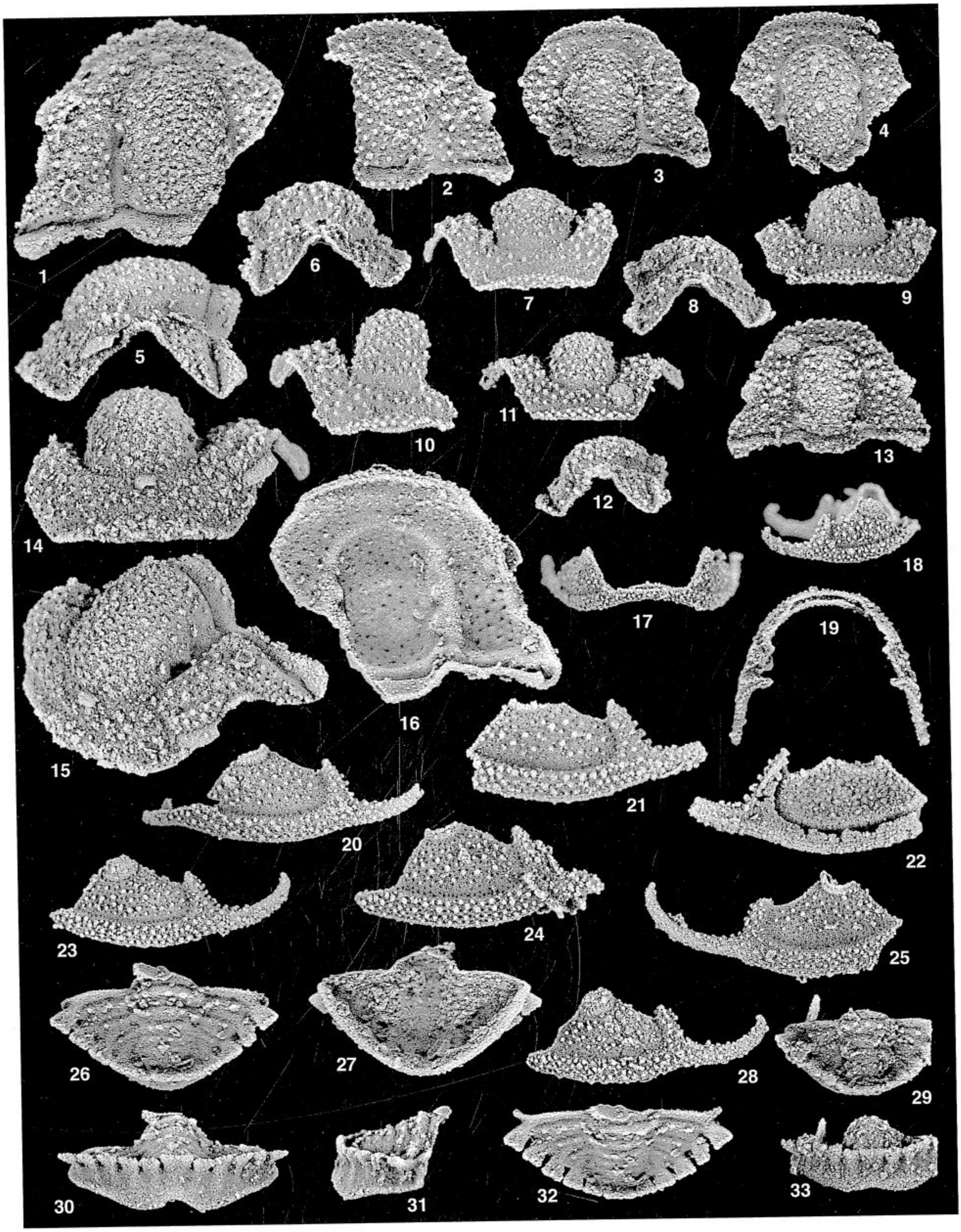
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EXPLANATION OF PLATE 14

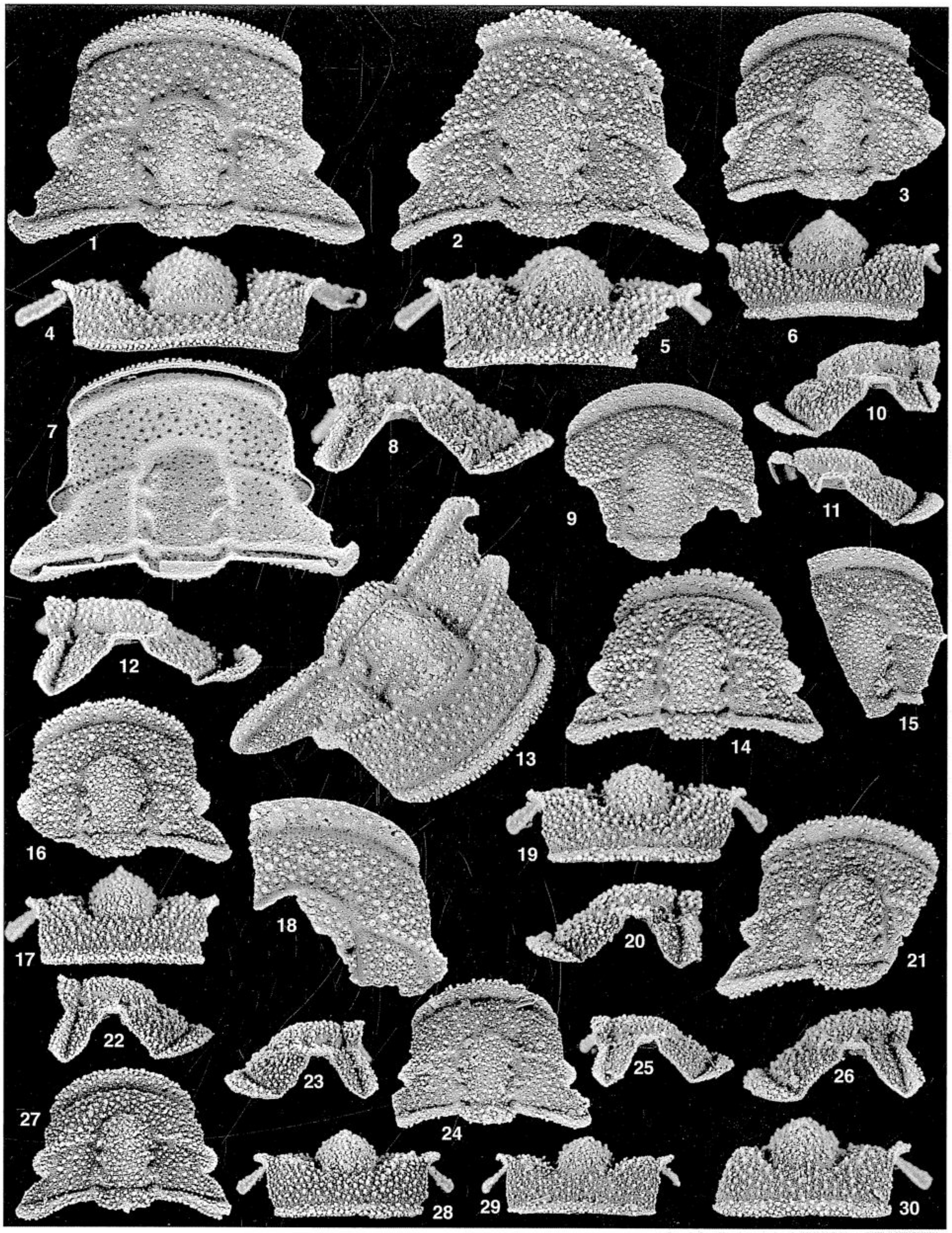
Figure	Page
1–33. *Heterocaryon vargum* Westrop, 1986b.	23

1, 5, 14 16. Cranidium, SUI 99220, dorsal, left lateral, anterior, oblique, and ventral views, ×10.
2, 6, 10. Cranidium, SUI 99221, dorsal, right lateral, and anterior views, ×10.
3, 7, 8. Cranidium, SUI 99222, dorsal, anterior, and right lateral views, ×10.
4, 9. Cranidium, SUI 99223, dorsal and anterior views, ×10.
11–13. Cranidium, SUI 99224, anterior, left lateral, and dorsal views, ×12.
17–19. Yoked librigenae, SUI 99225, anterior, right lateral, and dorsal views, ×12.
20. Left librigena, SUI 99226, external view, ×15.
21, 22. Left librigena, SUI 99227, external and internal views, ×15.
23. Left librigena, SUI 99228, external view, ×12.
24. Left librigena, SUI 99229, external view, ×10.
25. Right librigena, SUI 99230, external view, ×10.
26, 27, 30–32. Pygidium, SUI 99231, dorsal, ventral, posterior, right lateral, and anterodorsal views, ×10.
28. Left librigena, SUI 99232, external view, ×12.
29, 33. Pygidium, SUI 99233, dorsal and posterior views, ×10.

EXPLANATION OF PLATE 15

Figure	Page
1–30. *Bowmania lassieae* new species	23

1, 4, 7, 12, 13. Cranidium, **holotype,** SUI 99234, dorsal, anterior, ventral, right lateral, and oblique views, ×7.5.
2, 5, 8. Cranidium, SUI 99235, dorsal, anterior, and right lateral views, ×7.5.
3, 6, 10. Cranidium, SUI 99236, dorsal, anterior, and left lateral views, ×7.5.
9, 11. Cranidium, SUI 99237, dorsal and right lateral views, ×7.5.
14, 19, 20. Cranidium, SUI 99238, dorsal, anterior, and left lateral views, ×10.
15. Cranidium, SUI 99239, dorsal view, ×7.5.
16, 17, 22. Cranidium, SUI 99240, dorsal, anterior, and right lateral views, ×7.5.
18. Cranidium, SUI 99241, dorsal view, ×7.5.
21, 26, 30. Cranidium, SUI 99242, dorsal, left lateral, and anterior views, ×7.5.
23, 27, 28. Cranidium, SUI 99243, left lateral, dorsal, and anterior views, ×7.5.
24, 25, 29. Cranidium, SUI 99244, dorsal, right lateral, and anterior views, ×7.5.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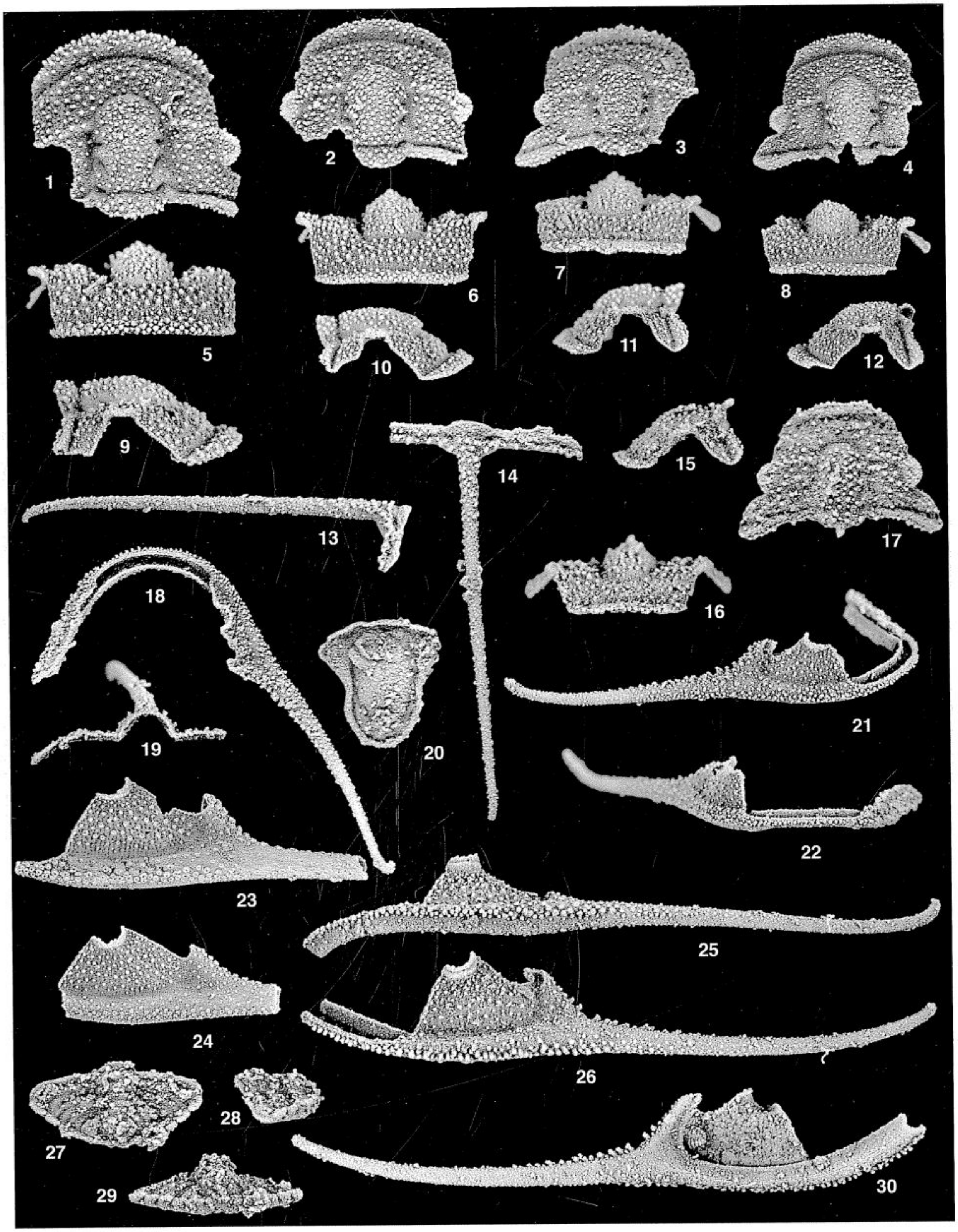
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EXPLANATION OF PLATE 16

Figure Page

1–30. *Bowmania lassieae* new species 23

1, 5, 9. Cranidium, SUI 99245, dorsal, anterior, and right lateral views, ×10.
2, 6, 10. Cranidium, SUI 99246, dorsal, anterior, and right lateral views, ×10.
3, 7, 11. Cranidium, SUI 99247, dorsal, anterior, and left lateral views, ×10.
4, 8, 12. Cranidium, SUI 99248, dorsal, anterior, and left lateral views, ×10.
13, 14, 19. Thoracic segment, SUI 99249, right lateral, dorsal, and anterior views, ×10.
15–17. Cranidium, SUI 99250, left lateral, anterior, and dorsal views, ×15.
18, 21, 22. Yoked librigenae, SUI 99251, dorsal, external of right librigena, and anterior views, ×7.5.
20. Hypostome, SUI 99252, ventral view, ×15.
23. Left librigena, SUI 99253, external view, ×7.5.
24. Left librigena, SUI 99254, external view, ×10.
25, 26, 30. Left librigena, SUI 99255, ventrolateral, external, and internal views, ×10.
27–29. Pygidium, SUI 99256, dorsal, left lateral, and posterior views, ×10.

EXPLANATION OF PLATE 17

Figure Page
1–16, 18–20, 23, 25, 26, 28. *Bowmania lassieae* new species. 23
1, 5, 8. Pygidium, SUI 99257, dorsal, right lateral, and posterior views, ×10.
2, 6, 9, 13. Pygidium, SUI 99258, dorsal, right lateral, posterior, and ventral views, ×10.
3, 4, 7. Pygidium, SUI 99259, dorsal, left lateral, and posterior views, ×10.
10, 14, 15. Pygidium, SUI 99260, dorsal, right lateral, and posterior views, ×10.
11, 12. Pygidium, SUI 99261, left lateral and dorsal views, ×10.
16, 23, 25. Pygidium, SUI 99262, dorsal, posterior, and left lateral views, ×10.
18–20. Pygidium, SUI 99263, dorsal, left lateral, and posterior views, ×10.
26, 28. Pygidium, SUI 99264, dorsal and posterior views, ×10.

17, 21, 22, 24, 27, 29, 30, 34, 36. Unidentified thoracic segments.
17, 24, 29. Thoracic segment, SUI 99265, dorsal, left lateral, and anterior views, ×7.5.
21, 27, 34. Thoracic segment, SUI 99266, dorsal, left lateral, and anterior views, ×7.5.
22, 30, 36. Thoracic segment, SUI 99267, dorsal, left lateral, and anterior views, ×7.5.

48, 49. *Cherrycreekia benjii* new species. 26
48, 49. Thoracic segment, SUI 99268, dorsal and anterior views, ×10.

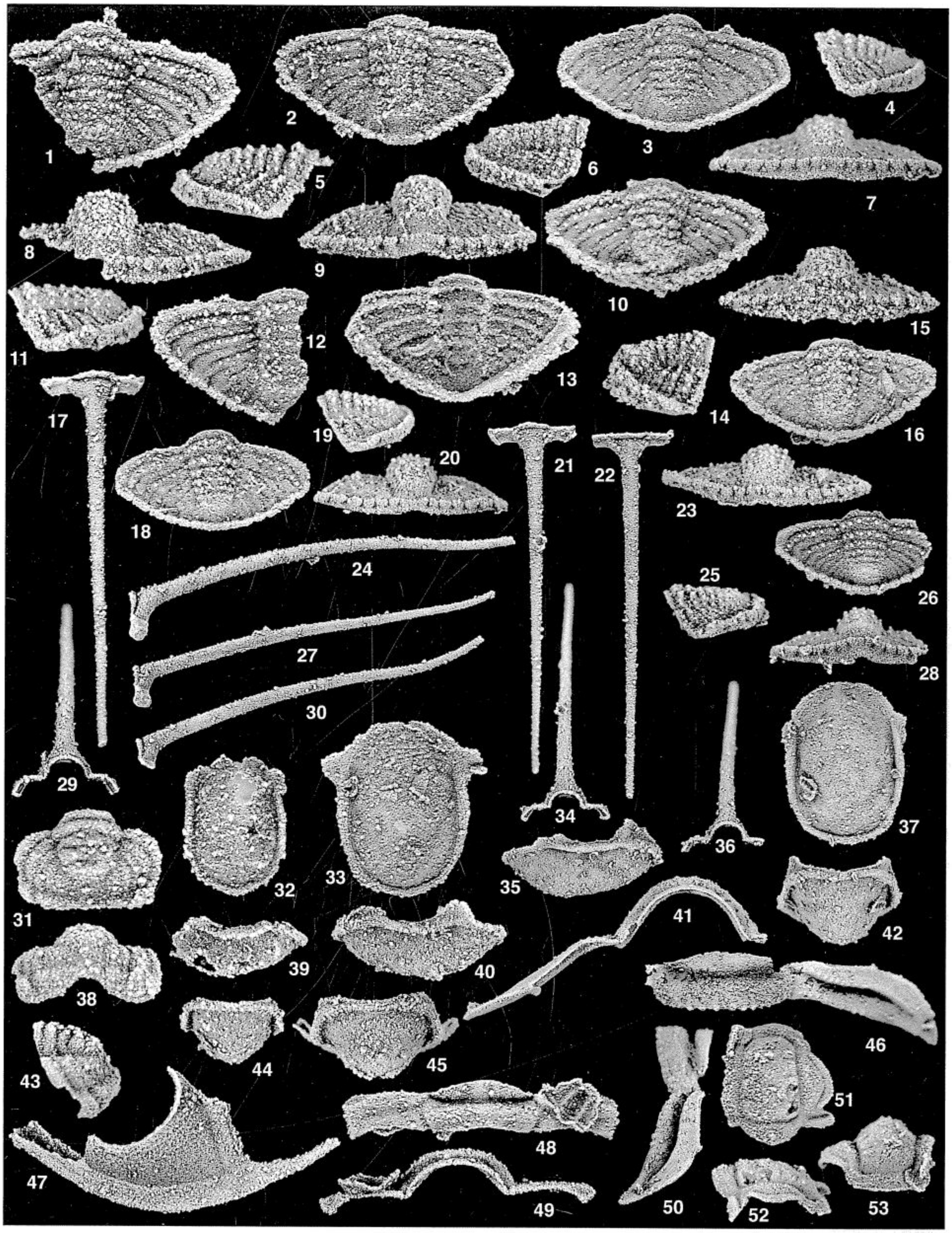
31, 38, 43. Unidentified pygidium, SUI 99269, dorsal, posterior, and left lateral views, ×20.
32, 33, 35, 37, 39, 40, 42, 44, 45. Unidentified hypostomes.
32, 39, 44. Hypostome, SUI 99270, ventral, left lateral, and posterior views, ×10.
33, 40, 45. Hypostome, SUI 99271, ventral, left lateral, and posterior views, ×10.
35, 37, 42. Hypostome, SUI 99272, left lateral, ventral, and posterior views, ×7.5.

41, 46, 50. Unidentified thoracic segments.
41, 46, 50. Thoracic segment, SUI 99273, anterior, dorsal, and right lateral views, ×5.

47. *Prosaukia*? sp., left librigena, SUI 99274, external view, ×7.5.

51–53. Unidentified cranidium, SUI 99275, dorsal, right lateral, and anterior views, ×15.

PLATE 17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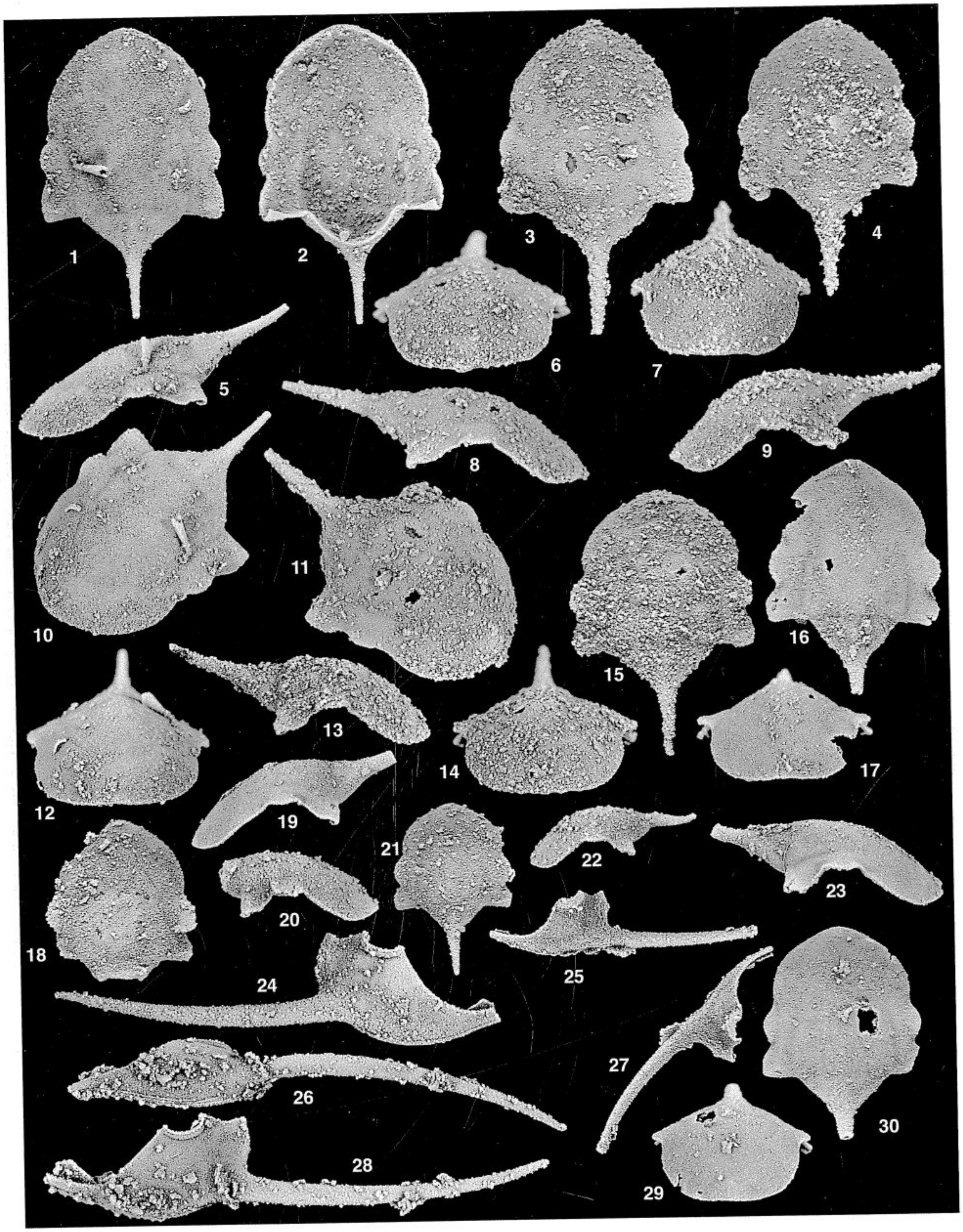
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EXPLANATION OF PLATE 18

Figure Page

1–30. *Cherrycreekia benjii* new species. 26

1, 2, 5, 10, 12. Cranidium, **holotype,** SUI 99276, dorsal, ventral, left lateral, oblique, and anterior views, ×7.5.
3, 6, 8, 11. Cranidium, SUI 99277, dorsal, anterior, right lateral, and oblique views, ×7.5.
4, 7, 9. Cranidium, SUI 99278, dorsal, anterior, and left lateral views, ×10.
13–15. Cranidium, SUI 99279, right lateral, anterior, and dorsal views, ×7.5.
16, 17, 23. Cranidium, SUI 99280, dorsal, anterior, and right lateral views, ×10.
18, 20. Cranidium, SUI 99281, dorsal and right lateral views, ×10.
21, 22. Cranidium, SUI 99282, dorsal and left lateral views, ×10.
24. Right librigena, SUI 99283, external view, ×10.
25, 27. Left librigena, SUI 99284, external and dorsal views, ×10.
26, 28. Left librigena, SUI 99285, ventrolateral and external views, ×10.
29, 30. Cranidium, SUI 99286, anterior and dorsal views, ×10.

EXPLANATION OF PLATE 19

Figure Page

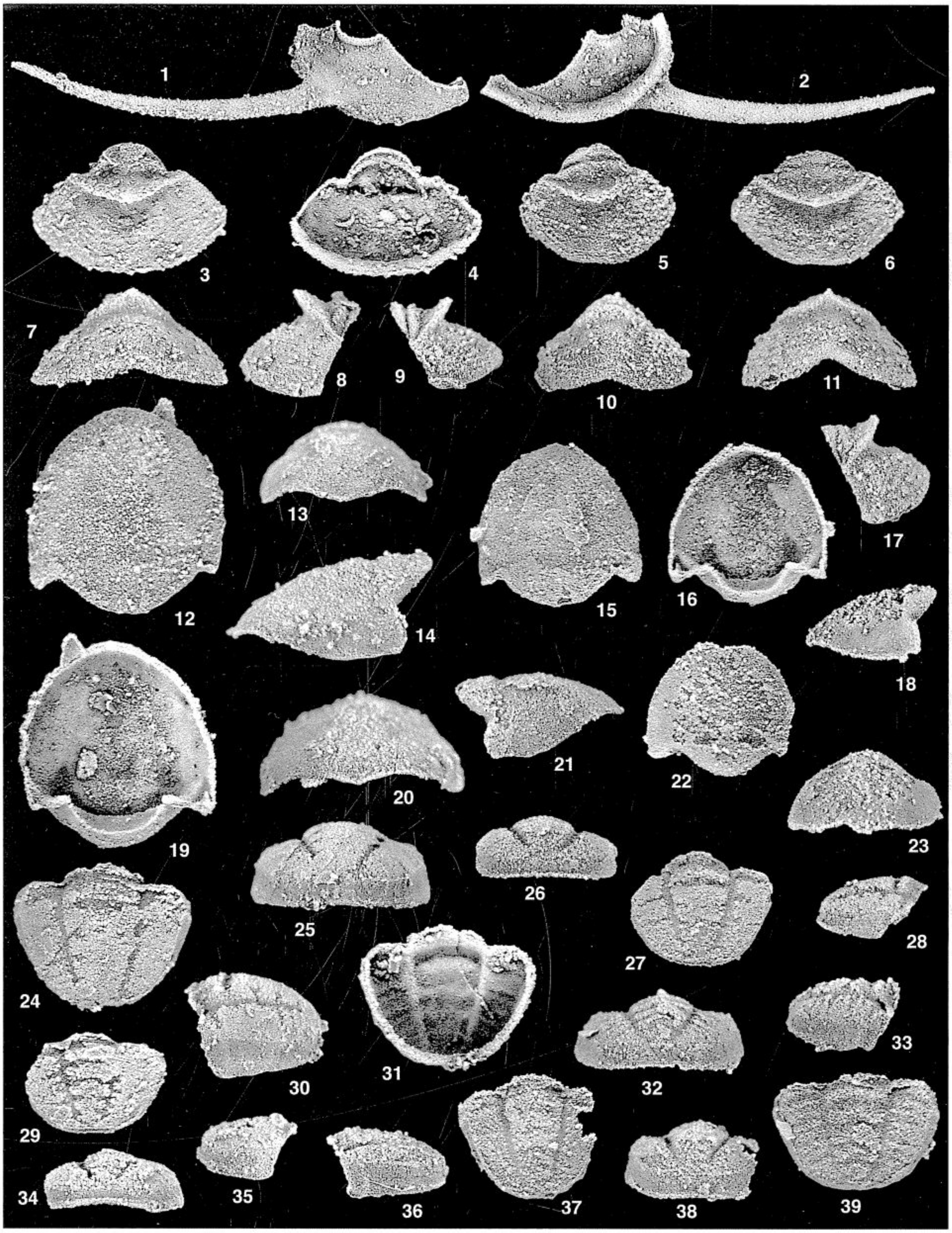
1–11, 17. *Cherrycreekia benjii* new species 26

1, 2. Right librigena, SUI 99287, external and internal views, ×10.
3, 4, 7, 8. Pygidium, SUI 99288, dorsal, ventral, posterior, and right lateral views, ×10.
5, 9, 10. Pygidium, SUI 99289, dorsal, left lateral, and posterior views, ×10.
6, 11, 17. Pygidium, SUI 99290, dorsal, posterior, and left lateral views, ×12.

12–16, 18–39. *Glaberaspis scoobydooi* new species 28

12, 14, 19, 20. Cranidium, **holotype,** SUI 99291, dorsal, left lateral, ventral, and anterior views, ×15.
13, 15, 16, 21. Cranidium, SUI 99292, anterior, dorsal, ventral, and right lateral views, ×15.
18, 22, 23. Cranidium, SUI 99293, left lateral, dorsal, and anterior views, ×15.
24, 25, 30, 31. Pygidium, SUI 99294, dorsal, posterior, left lateral, and ventral views, ×15.
26–28. Pygidium, SUI 99295, posterior, dorsal, and right lateral views, ×15.
29, 34, 35. Pygidium, SUI 99296, dorsal, posterior, and right lateral views, ×20.
32, 33, 39. Pygidium, SUI 99297, posterior, right lateral, and dorsal views, ×15.
36–38. Pygidium, SUI 99298, left lateral, dorsal, and posterior views, ×15.

PLATE 19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