HOLMIIDAE (TRILOBITA: OLENELLINA) OF THE MONTEZUMAN STAGE (EARLY CAMBRIAN) IN WESTERN NEVADA

J. STEWART HOLLINGSWORTH

729 25 Road, Grand Junction, Colorado 81505, <stewholl@aol.com>

ABSTRACT—Holmiids are a major component of the trilobite fauna in the middle part of the Montezuman Stage, the lowermost stage of the Cambrian of Laurentia with a continuous trilobite record. They are less common in the upper Montezuman where nevadiids predominate and other trilobite families appear. New material from western Nevada allows a revision of these holmiids. *Palmettaspis parallela* Fritz, 1995 and *Palmettaspis cometes* (Fritz, 1995) are assigned to a new genus, *Montezumaspis*, based primarily on thoracic characters, including a prominent axial spine on the thorax. A second new genus, *Grandinasus*, is based on *Esmeraldina argenta* (Walcott, 1910), in which the L3 lobe is incorporated in an expanded anterior lobe (LA) of the glabella. New species described are *Esmeraldina elliptica*, *Grandinasus auricampus*, *G. patulus*, *Holmiella falx*, and *H. millerensis*. The Laurentian taxa appear to be more primitive than the holmiids of Baltica by having simple, unfurrowed ocular lobes that are separated from the LA by an axial furrow. Three informal biofacies are suggested with a holmiid-dominated biofacies in a deep subtidal dysoxic environment, and two nevadiid-dominated biofacies in shallower subtidal environments.

INTRODUCTION

INTERCONTINENTAL CORRELATION of the lower part of the Cambrian is complicated by the provinciality of the trilobite faunas (Palmer, 1998b, 1998c) and the long ranges of small shelly fossils (Qian and Bengtson, 1989). Until recently, the lack of a formal stage nomenclature for the lower Cambrian of Laurentia has been an additional problem for such Cambrian correlations (Palmer, 1995). In 1992, W. H. Fritz began a field program to study the biostratigraphy surrounding the base of the Waucoban Series in Nevada (Walcott, 1912a; Fritz, 1995); I joined Fritz in this effort. Palmer (1998c) formally proposed a stage nomenclature for Laurentia, including the Montezuman and Dyeran stages (Fig. 1) based on some of this field work. The base of the Montezuman Stage is drawn on the base of the abundance zone of an *Eofallotaspis*-like trilobite found in the western part of the Montezuma Range, Esmeralda County, Nevada (Fig. 2.5), boundary stratotype section MW-3S (Hollingsworth, 1999a). This point is approximately 30 m above the base of the Montenegro Member of the Campito Formation. The stage includes the "*Fallotaspis*" and "*Nevadella*" zones of Fritz (1972; Palmer and Repina, 1993). The base of the succeeding Dyeran Stage is at the base of the *Olenellus* Zone (Fritz, 1972; Palmer and Repina, 1993) in the middle member of the Poleta Formation (Fig. 1), boundary stratotype section IS-4, in Indian Springs Canyon, northern Montezuma Range (Figs. 2.5, 3) (Hollingsworth, 1999b).

Studies of the trilobite faunas of the Montezuman Stage in the Great Basin began when Walcott (1910) described several forms collected from the lower Cambrian of Esmeralda County and adjacent areas of California. Nelson (1976; also Nelson and Durham, 1966) illustrated a few of the many trilobites found during field mapping in California. Otherwise, the faunas of this area languished until Fritz (1995) redescribed the fauna of Walcott's 1f collection from Barrel Spring in Esmeralda County (Fig. 2, for details see *Discussion of Palmettaspis consorta* Fritz, 1995). More recently, Lieberman (2001, 2002) and McMenamin (2001) described a few trilobites from the Montezuman Stage. This report deals only with the holmiids of the Montezuman Stage in western Nevada. The Holmiidae are the first elements of the Olenelloidea, a predominant lower Cambrian trilobite group (Palmer and Repina, 1997). Here they are preceded by fallotaspidids and archaeaspidids. The holmiids appear at essentially the same point as the nevadiids.

STRATIGRAPHY

The materials used in this study come primarily from six measured sections through parts of the Montenegro Member of the Campito Formation and the Poleta Formation in the northern Montezuma Range (Figs. 2.5, 3, 4) and from several other measured sections and sites in various other mountain ranges of Esmeralda County, Nevada (Fig. 2). A composite of the individual sections in the Montezuma Range (Fig. 5) shows the occurrence and ranges of all holmiid material discussed herein.

Lithostratigraphy.—In the Montezuma Range, the Montenegro Member of the Campito Formation (Fig. 5) is 349 m thick. The lower 144 m is light brown sericitic siltstone and fine sandstone. The next 21 m interval contains siltstone with quartzite and sandstone beds, and lenses of bioclastic carbonate packstone and glauconitic arenaceous limestone. Trace fossils, ripple marks, and soft-sediment deformation features are common. This interval is interpreted as a transgressive event. The upper 184 m of the Montenegro Member is greenish gray shaly siltstone with occasional lenses of fine sandstone. Near the top of the member there are thin beds of sandstone and bioclastic limestone. Beginning 36 m above the base of the member and extending to the top, trilobites are rare to common with fewer brachiopods and hyoliths. In other mountain ranges of Esmeralda County, cleavage and metamorphism frequently preclude recovery of fossils from the Montenegro Member.

The overlying Poleta Formation is divided into three informal members (McKee and Moiola, 1962; Stewart, 1970), a lower carbonate member, a middle siliciclastic-carbonate member, and an upper carbonate member. In the Montezuma Range, the lower member can be further subdivided into three units. The lower unit begins with 2 m of very light brown clayey shale with lesser thin beds of micritic carbonate in sharp contact with Montenegro siltstone, then grades rapidly upward into thin-bedded limestone with minor interbeds of shale and dolomite for 31 m. Archaeocyathids occur in some of the upper beds, and trilobites are rare, except in bioclastic beds near the top of this unit. The second unit is 29 m of light brown shale with locally common trilobite sclerites and brachiopods. This is succeeded by the main carbonate unit of the lower Poleta, about 70–80 m thick, incorporating beds and bioherms of algal-archaeocyathan boundstones and medium to thick beds of carbonate grainstone, often oolitic. Elsewhere in Esmeralda County, the lower Poleta varies considerably from this simple picture. To the west, at the Fish Lake Valley section (Fig. 2.2), the intermediate shale unit of the lower Poleta is much thicker and contains isolated mounds of algal-archaeocyathan limestone. Southward, at the Stewart Mill (Fig. 2.7) section, the lower thin-bedded carbonate grades rapidly upward to thrombolitic then algal-archaeocyathan carbonate, and the intermediate shale is thin
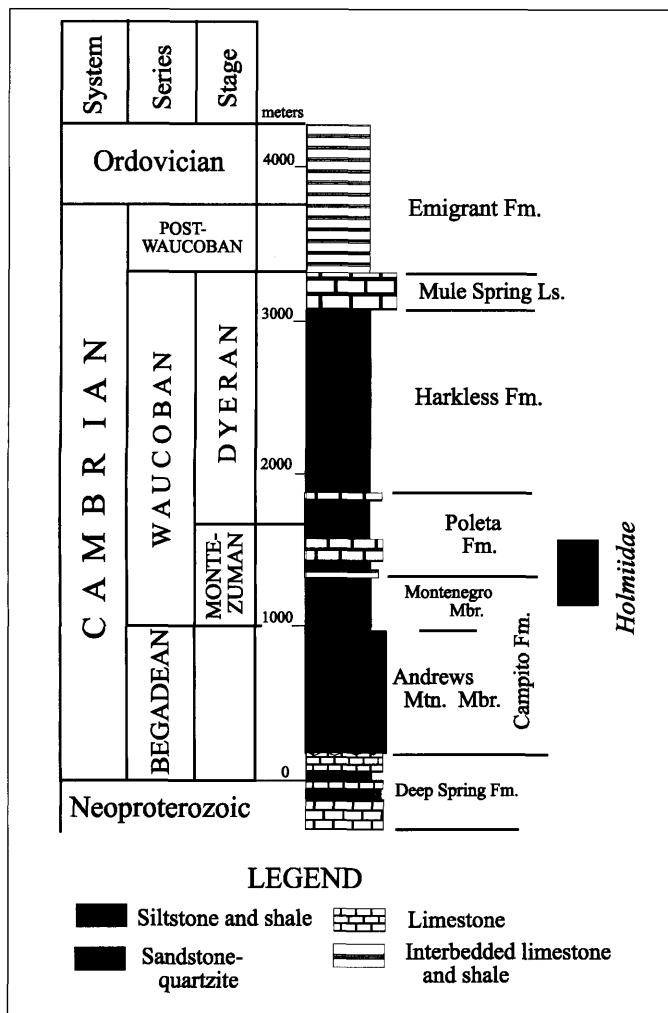
FIGURE 1—Composite stratigraphic section for Cambrian strata in Esmeralda County, Nevada, and composite range of holmiid trilobites (Albers and Stewart, 1972; McCollum, personal commun., 2002).
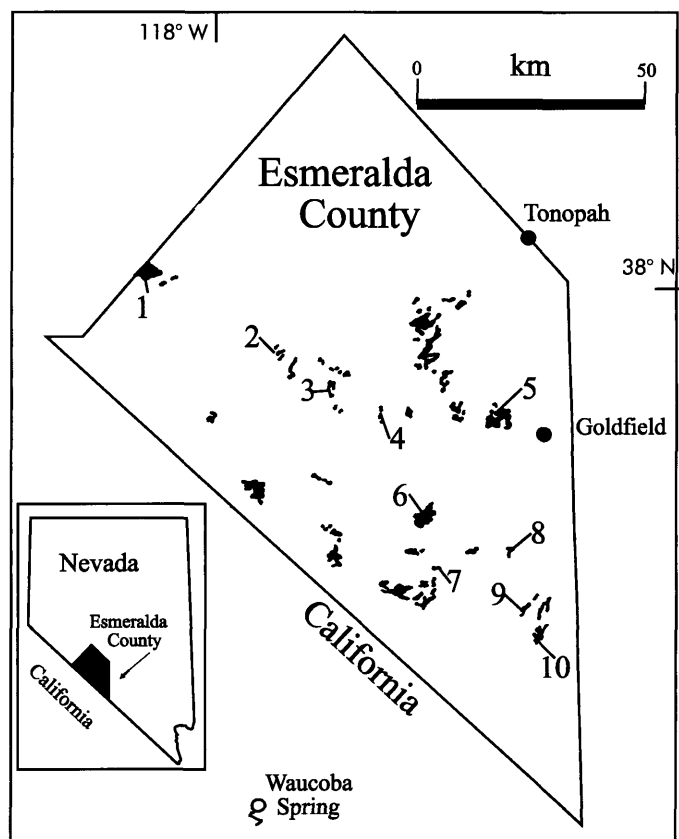

FIGURE 2—Location of stratigraphic sections and collecting sites in Esmeralda County, Nevada. Black areas are the outcrops of the Montenegro Member of the Campito Formation and the Poleta Formation from map by Albers and Stewart (1972). Numbers refer to specific sites or study areas: (1) Miller Mountain, (2) Fish Lake Valley, (3) Mineral Ridge, (4) Alcatraz Island, (5) Montezuma Range, (6) Barrel Springs (probable location), (7) Stewart's Mill, (8) east of Mount Jackson, (9) Gold Point, (10) Slate Ridge (see Appendix for details).

or absent in a complex of algal-archaeocyathan bioherms succeeded by the upper unit of oolitic grainstone (Rowland, 1981). The details of lower Poleta stratigraphy are still being studied.

The middle Poleta is 198 m thick in the Montezuma Range, and the bottom third is greenish gray shaly siltstone with occasional thin bioclastic carbonate beds. The middle third is siltstone with considerable sandstone and subordinate thin bioclastic carbonate beds also with several meter-scale micritic limestone units. The upper third has considerably more sandstone, some of which is calcareous, occasionally with distinct calcareous laminae. Trilobites are a major component of a varied fauna that is well preserved in the middle Poleta. The upper Poleta is 35 m of gray limestone.

For the discussions of trilobite ranges in this paper, the term "lower Montezuman Stage" refers to the lower part of the Montenegro Member terminating at the top of the carbonate-quartzite transgressive interval (Fig. 5). The upper 184 m of the Montenegro Member is termed "middle Montezuman." That part of the stage occurring in the Poleta Formation, a thickness of 222 m in the composite Montezuma Range section, is termed "upper Montezuman."

Biostratigraphy.—The holmiids of the Montezuman Stage range through most of the "Nevadella" Zone as defined by Fritz (1972), which comprises the middle and upper Montezuman (Fig.

5). When taxonomic studies of all the trilobites of the Montezuman Stage are completed, a revised biozonation of this interval may be recommended.

The lower Montezuman is characterized by fallotaspidid and related trilobites. Nevadiid and holmiid trilobites appear at the base of the middle Montezuman Stage, the latter as Montezumaspis parallela (Fritz, 1995) n. gen. followed quickly by M. cometes (Fritz, 1995), which together range through about 60 m of strata. Esmeraldina rowei (Walcott, 1910) appears about 26 m above the first appearance of M. parallela, and continues for 105 m. Esmeraldina elliptica n. sp. appears somewhat later than E. rowei and is rather uncommon (Fig. 5).

Grandinasus auricampus n. gen. and sp. and G. patulus n. sp. appear near the top of the middle Montezuman, 28 m below the base of the Poleta Formation in the Montezuma Range; G. patulus appears to be gone in the lowest unit of the Poleta while G. auricampus is common in the lowermost Poleta of the Gold Point area. Grandinasus argentus (Walcott, 1910) is fairly common in the middle shale unit of the lower Poleta in the Montezuma Range and elsewhere. Holmiella falx n. sp. also occurs in this shale unit of the lower Poleta. A form questionably referred to G. auricampus has been found at the top of the lower Poleta in the Gold Point area. Only a single questionable holmiid has been found in the middle Poleta.
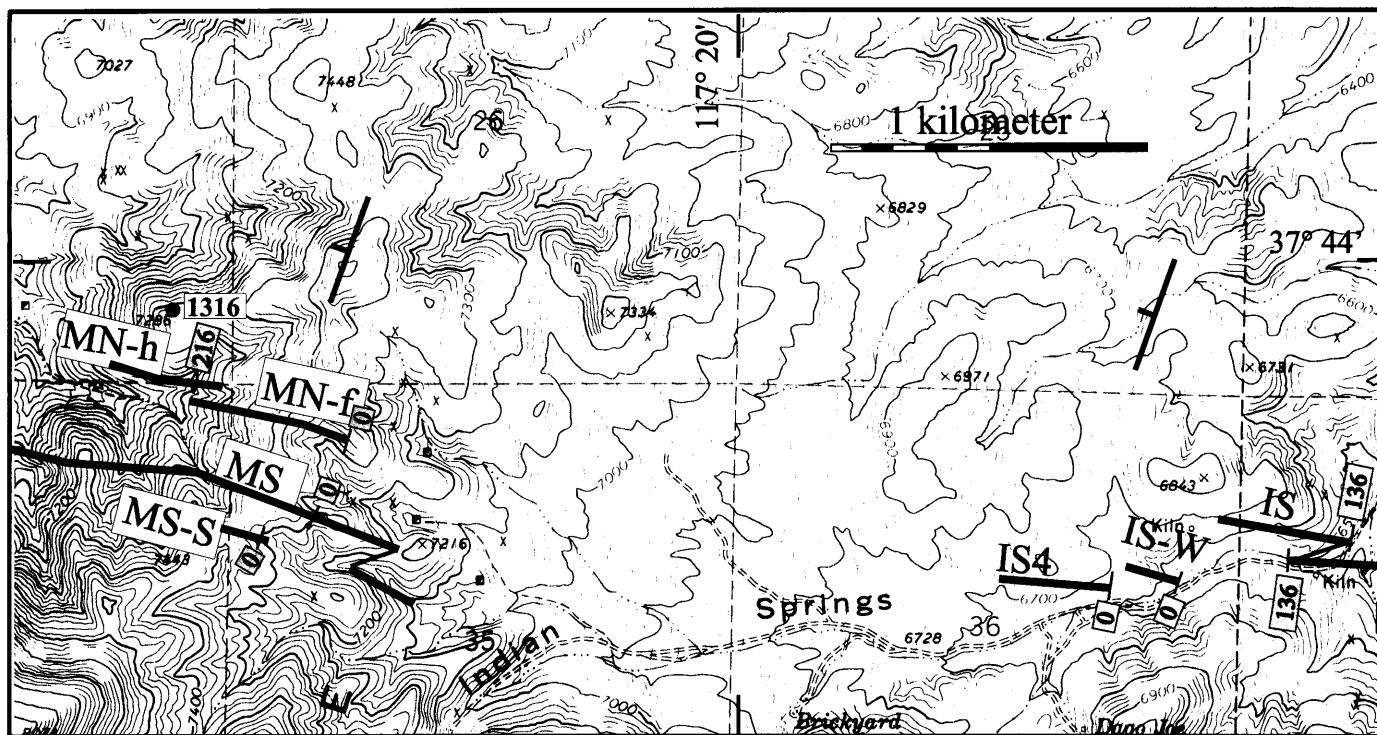
FIGURE 3—Locations of stratigraphic sections in the northern Montezuma Range, with locality 1316 and generalized dip of Cambrian strata. Topography from the U.S. Geological Survey Montezuma Peak Quadrangle, 7.5-minute series, 1970 edition. Base or key position shown on each section. Sections MN-f, IS, and IS-W measured by W. H. Fritz with JSH assisting.

Biofacies.—Three informal trilobite biofacies, a holmiid-dominated biofacies in the upper part of the Montenegro Member, a nevadiid-dominated mixed biofacies in the lower member of the Poleta Formation, and a nevadiid biofacies in the middle member of the Poleta, are suggested in this study. Few of the biostratigraphic collections that form the basis of this study are large enough for formal biofacies analysis (Ludvigsen et al., 1986), but counts of cephala in all collections from specific stratigraphic intervals provide some data for biofacies interpretation. Holmiid specimens comprise 60% of the trilobite fauna from 170 to 215 m in the composite Montezuma Range section (Fig. 5) increasing to 75% for the interval from 215 m to the top of the Montenegro, with nevadiids making up the rest of the trilobite fauna. This constitutes the holmiid-dominated biofacies which occurs in a relatively deep subtidal and dysaerobic mud bottom.

In the lower member of the Poleta Formation in the Montezuma Range, *Grandinasus* n. gen. constitutes 7% of the trilobite fauna which is dominated by nevadiids. *Holmiella* Fritz, 1972 appears with *Grandinasus* in other areas of Esmeralda County, and at Miller Mountain *Holmiella* is the only holmiid in the trilobite fauna. At the Gold Point, Slate Ridge and Fish Lake Valley sections, however, solenopleurids, corynexochids, and *Bradyfallotaspis* Fritz, 1972 are about as abundant as the associated holmiids, but nevadiids are still the predominant trilobites. This nevadiid-dominated mixed biofacies occurs in a relatively shallow, mixed carbonate-siliciclastic environment. Trilobites are occasionally common in the ribbon limestone and in the shaly middle unit of the lower member of the Poleta, but very rare, except as small fragments, in the carbonate grainstones.

In most of the lower part of the middle Poleta, the trilobites are almost exclusively nevadiids with a single holmiid? occurrence in a thin bioclastic limestone. This nevadiid-dominated biofacies occurs on a subtidal siliciclastic mud bottom (see also Bohach, 1997, p. 36).

Regional distribution.—Rocks of the "*Nevadella*" Zone of the Montezuman Stage are present along the western margin of Laurentia in many areas from northern Mexico (Stewart et al., 2002) to northwestern Canada. Outside the White-Inyo-Esmeralda County region, *Esmeraldina* Resser and Howell, 1938 has been noted in the Caborca region of Mexico (see *Discussion* of *Esmeraldina rowei*), the Cassiar Mountains of British Columbia (Fritz, 1978b, 1995), and in the Mackenzie Mountains (Fritz, personal commun., 2001). *Holmiella* is abundant in parts of the Sekwi Formation of the Mackenzie Mountains (Fritz, 1976, 1978a). In eastern Laurentia, Montezuman rocks are present in northern Greenland, but holmiids are not known there. Holmiids are the only olenelloid trilobites in Baltica, but they seem to represent a more advanced clade compared to the western Laurentian forms. Holmiids have also been reported from western Gondwana (Geyer and Palmer, 1995) and from Siberia (Palmer and Repina, 1997).

SYSTEMATIC PALEONTOLOGY

The terminology used in the descriptions follows the new trilobite volume of the *Treatise on Invertebrate Paleontology* (Whittington, 1997). The designations LA and L0 are used throughout for the frontal lobe of the glabella and for the occipital ring, respectively (Bergström, 1973; Whittington and Kelly, 1997, p. 321). The length of the glabella includes L0 in the descriptions. Thoracic segments and pleural spines are described using terminology proposed by Palmer and Repina (1993) and Palmer (1998a). Most of the trilobite material from the Montenegro Member of the Campito Formation is internal or external molds. Exoskeletal material is either absent or replaced by a mat of high-iron chlorite (Hood, personal commun., 1999). Little can be contributed to the understanding of the ontogeny of these holmiids. A few late-stage meraspides, generally defined by size, are described from siltstone surfaces from the Montenegro Member and limestone blocks from the Poleta Formation.
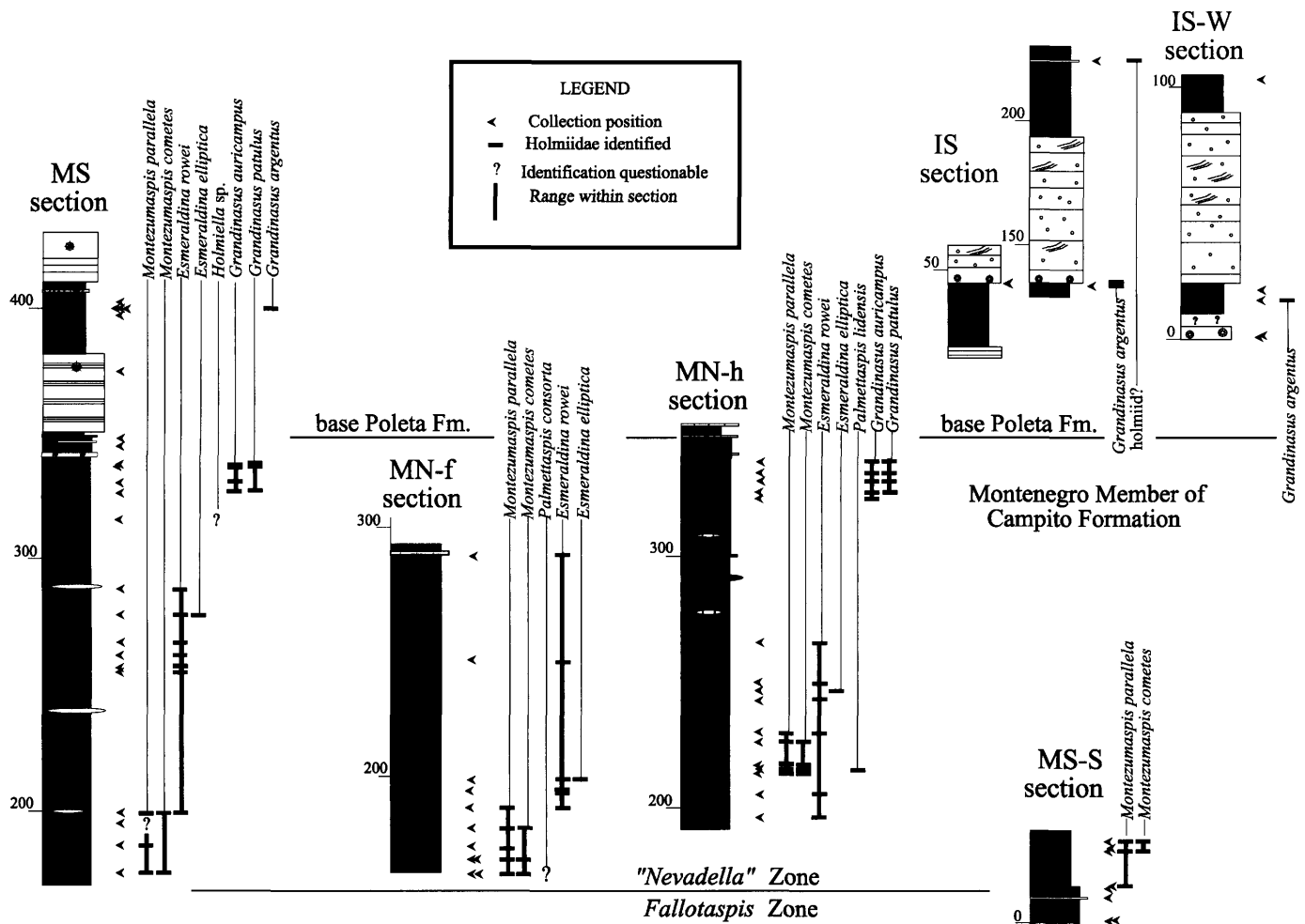
FIGURE 4—Stratigraphic sections in the Montezuma Range, Esmeralda County, Nevada, showing the positions of fossil collections and the occurrence of the various holmiid trilobites. See Figure 3 for the location of the individual sections and Figure 5 for lithologic legend.

Illustrated specimens and key specimens are reposited in the collections of the Department of Paleobiology, National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC, the University of California at Los Angeles (UCLA), and the Institute for Cambrian Studies reference and replica collection (ISC). The remainder of the biostratigraphic collections is housed in my personal collection.

Family HOLMIIDAE Hupé, 1953b

The concept and taxonomic history of the Holmiidae was reviewed by Lieberman (1999, p. 67–69). He restricts this family to *Holmia* Matthew, 1890, *Kjerulfia* Kiaer, 1917, *Schmidtiellus* Moberg in Moberg and Segerberg, 1906, *Palmettaspis* Fritz, 1995, *Esmeraldina*, and *Holmiella*, removing *Andalusiana* Sdzuy, 1961, *Callavia* Matthew, 1897, *Cambropallas* Geyer, 1993, *Elliptocephala* Emmons, 1844, and *Iyouella* Geyer and Palmer, 1995, which were included in the family by Palmer and Repina (1997). Lieberman (1999, p. 76) erected *Baltobergstroemia* with *Holmia mobergi* Bergström, 1973 as the type species, but Ebbestad et al. (2003) regard *Baltobergstroemia* as a junior synonym of *Holmia*.

Lieberman's (1999) cladistic studies suggest that *Holmia* is primitive with respect to the Laurentian holmiids *Palmettaspis*, *Esmeraldina*, and *Holmiella* (see also Lieberman, 1998, p. 63). This conclusion is not consistent with the biostratigraphy emerging from studies of the Montezuman trilobites (see Lieberman's reservations, 1999, p. 65–67) and it may result from his choice of *Wanneria walcottana* (Wanner, 1901) as outgroup for the analysis of the Holmiidae. Instead, the arrangement of the ocular lobes of Baltic and Moroccan holmiids (Geyer and Palmer, 1995), which have a wide ocular lobe with an ocular furrow and the inner band merging with the LA without an axial furrow, is interpreted as advanced compared with the arrangement of the simple ocular lobes of Laurentian holmiids, which are separated from the LA with a prominent axial furrow. Lieberman (1998, p. 77, character 14) remarks that this furrow is unique among olenelloids. Ocular lobes merged with LA and with an ocular furrow are found on younger olenellines (Palmer and Repina, 1997). Two new genera, *Montezumaspis* and *Grandinasus*, are described within Holmiidae.

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FIGURE 5—Composite range chart for the Holmiidae of the Montezuman Stage plotted against a composite stratigraphic column for the Montezuma Range.
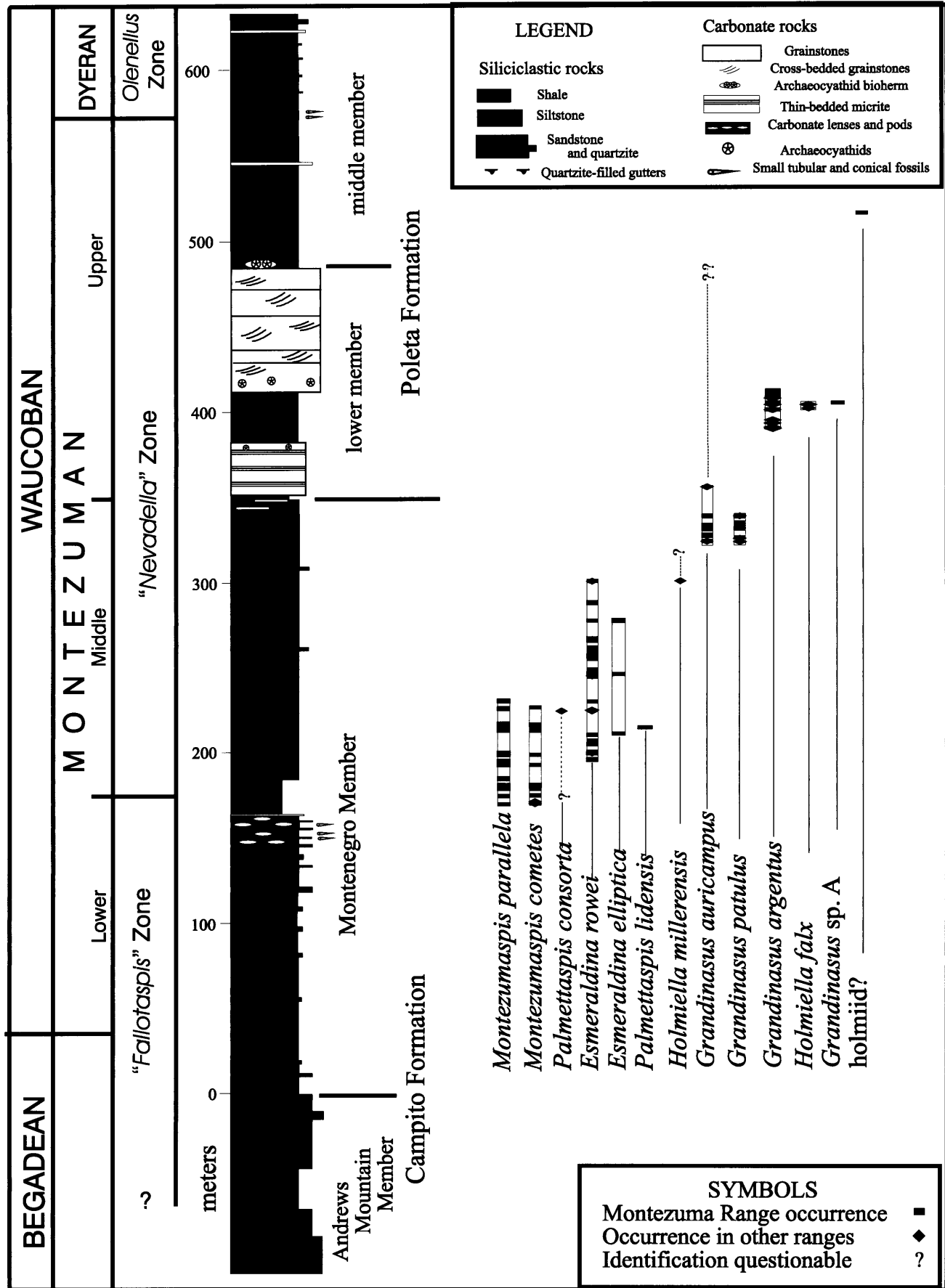
Emended diagnosis.—Glabella straight-sided to somewhat constricted, mostly expanding forward, frontal lobe usually broad, rounded. Glabellar furrows usually curved, moderately incised, rarely complete across glabellar axis. S3 strongly curved and may be obsolete. Ocular lobes of Baltic holmiids are often wide with an ocular furrow, inner band merging with LA without axial furrow. Laurentian holmiids have unfurrowed ocular lobes separated from LA by axial furrow. Genal spine extends back at least to T4. Intergenal margin normally marked by spine behind the lateral margin of ocular lobe or somewhat abaxial of that point. Posterior border of cephalon from axial furrow to intergenal angle transverse or directed posteriorly. T3 generally unmodified. Anterior thoracic pleural spines weakly to strongly thornlike except in *Kjerulfia* and *Grandinasus*.

Discussion.—Many other characters diagnosed by others (Ahlberg et al., 1986; Palmer and Repina, 1997; Lieberman, 1999) differ among the taxa included in the Holmiidae. Details of glabellar furrows are often taphonomically modified. The length of ocular lobes is an ontogenetic variable (Palmer, 1957; Webster, 2003). The angle with the sagittal axis formed by a line between the most anterior point and the posterior tip of the ocular lobe varies between species. The ratio of the transverse width of the extraocular area to the width of the interocular area, the character of the extraocular area, and the character of the anterior and lateral borders are all variable among taxa. A revised character set for cladistic analysis is under consideration for a future study.

Genus MONTEZUMASPIS new genus

Type species.—*Palmettaspis parallela* Fritz, 1995.
Included species.—*Esmeraldina*? *cometes* Fritz, 1995.
Diagnosis.—Holmiid with preglabellar field. Glabella narrow, LA equal to or slightly wider than L0, S3 faint, L3 shorter (exsag.) than L2, L1, or L0 which are about equal, L0 with posterior axial spine, axial furrow uniform. Ocular lobes long. Extraocular area wide. Reticulate sculpture prominent on larger cephala. Thorax of 17 segments, T3 mildly amplipleural, pleural spines weakly thornlike to sentate. T13 has long, posteriorly directed axial spine; posterior to T13, thorax strongly tapered. Pygidium expands backward, posterior margin straight, posterolateral corners rounded. Axis triangular to subtriangular, not reaching posterior margin.

Etymology.—Named by combining Greek *aspis*, shield, with Montezuma for the Montezuma Range where several complete specimens were found.

Occurrence.—Lower middle Montezuman Stage in the Montezuma Range sections, in other mountain ranges of Esmeralda County, Nevada, and in the White-Inyo Range, Inyo County, California.

Discussion.—This genus accommodates two species that have primitive holmiidlike features and a long axial spine on T13. *Montezumaspis cometes* is closer to *Esmeraldina* in having small axial nodes or spines on each axial ring of the thorax, and with the axial spine on T13 being shorter than the telsonlike spine on *M. parallela*. Lieberman (1999) included *M. cometes* within *Palmettaspis*, but noting the relationship to be paraphyletic. This is addressed by moving this species to a new genus. *Montezumaspis* fits well within the diagnostic features of Holmiidae stated by Ahlberg et al. (1986) with the exception of the absence of an ocular furrow on all of the Great Basin holmiids. Lieberman (1999) assigns *Palmettaspis* (now *Montezumaspis*) and specifically *P. parallela* to the Holmiidae in spite of his emphasis that L3 must bulge laterally with respect to L1 to qualify as an olenelloid (Lieberman, 1998). This feature is variable on *M. parallela*. To accommodate *Montezumaspis* within the Holmiidae, two of Lieberman's (1999) other characters must be emended: T3 is somewhat amplipleural and thoracic axial rings lack anterolateral

lobes. Nevertheless, the assignment of *Montezumaspis* to Holmiidae is recommended herein.

Schmidtiellus from the Baltic region has a prominent axial spine on the thorax. The resemblance to *Montezumaspis* is enhanced by the relatively wide extraocular area and distinct longitudinal ridges on the thoracic axial rings of *S. reetae* (Bergström, 1973) anterior to the axial spine. Significant differences are the shape of the cephalon, the absence of a preglabellar field, the presence of a strong S3 furrow, and the presence of five thoracic segments behind the axial spine on *Schmidtiellus*. Bergström (1973, fig. 14d) described and illustrated the pygidium of *S. mickwitzi torelli* (Moberg, 1899), which has an evenly elevated axis with two apparent segments, narrow flat pleural fields, and tiny posterolateral spines. It is distinctly narrower than the pygidium of *Montezumaspis*.

MONTEZUMASPIS PARALLELA (Fritz, 1995)
Figures 6.1–6.14, 7.2, 7.3

Holmia rowei WALCOTT, 1910 (in part), p. 292–296, pl. 29, figs. 5, 6, non 1–4, 7–11.
Palmettaspis parallela FRITZ, 1995, p. 720–722, figs. 5.5, 5.6, 9.1–9.5; LIEBERMAN, 1999, p. 76–77 (coded), 84.

Emended diagnosis.—Sagittal length of preglabellar field equal to or slightly less than sagittal length of anterior border. Glabella typically parallel-sided with LA equal in width (tr.) to L0, anterior of LA rounded to somewhat pointed. L3 wider (tr.) than L2, S2 short and faint or absent at axial furrow. Ocular lobes gently curved, close to axial furrow. Narrow occipital spine arises as ridge on posterior half of L0. Axial rings of thorax have small longitudinal ridge on posterior half. Lateral margins of pleural spines backward-directed.

Description.—New material allows information to be added to the description provided by Fritz (1995).

Anterior border furrow shallow to indistinct laterally. Posterior margin slightly inclined back to intergenal spine then transverse to slightly inclined forward to genal angle which is laterally aligned with anterior half L0. Glabella parallel-sided, or with slight constriction at S2. LA often slightly tapered forward suggesting a broadly rounded point. Preglabellar field equal to or slightly less than sagittal length of anterior border. Glabellar furrows do not cross glabellar axis, but furrows often appear complete due to compaction. L1 and L2 of equal length (exsag.), L3 slightly to considerably shorter, L3 wider (tr.) than L2. S2 short, faint, or absent at axial furrow, S3 weak, arched forward. Width (tr.) between distal margins of ocular lobes about equal to glabellar length (sag.). Extraocular area more than twice as wide as interocular area; widest on large cephala. Anterior ocular line occasionally present. Sculpture of polygonal network observed on larger (15 mm or greater) cephala.

Hypostome longitudinally elongate, up to 11 mm in length, probably natant (Fig. 6.13) (Fortey, 1990). Anterior lobe of hypostome oval. Middle body oval. Anterior border not preserved. Posterior lobe is a substantial ridge surrounding posterior third of anterior lobe, middle furrow sharp laterally, shallowest at midline (Fig. 6.11). Posterior border flat, limited to transverse width of hypostome, posterolateral corners have outward-directed projections with a small spine at interior corner and small nodes along margin to external corner.

Anterior 13 segments of thorax narrow (tr.), as a unit nearly parallel-sided to slightly tapered on larger specimens, length (sag.) one-sixth more than cephalic length; prominent, broad-based spine on thirteenth segment; spine length over one-third and ranging to slightly more than full length of anterior part of thorax on largest specimens. Axis wide, one-fourth to two-fifths thoracic width including pleural spines, widest on larger specimens, with
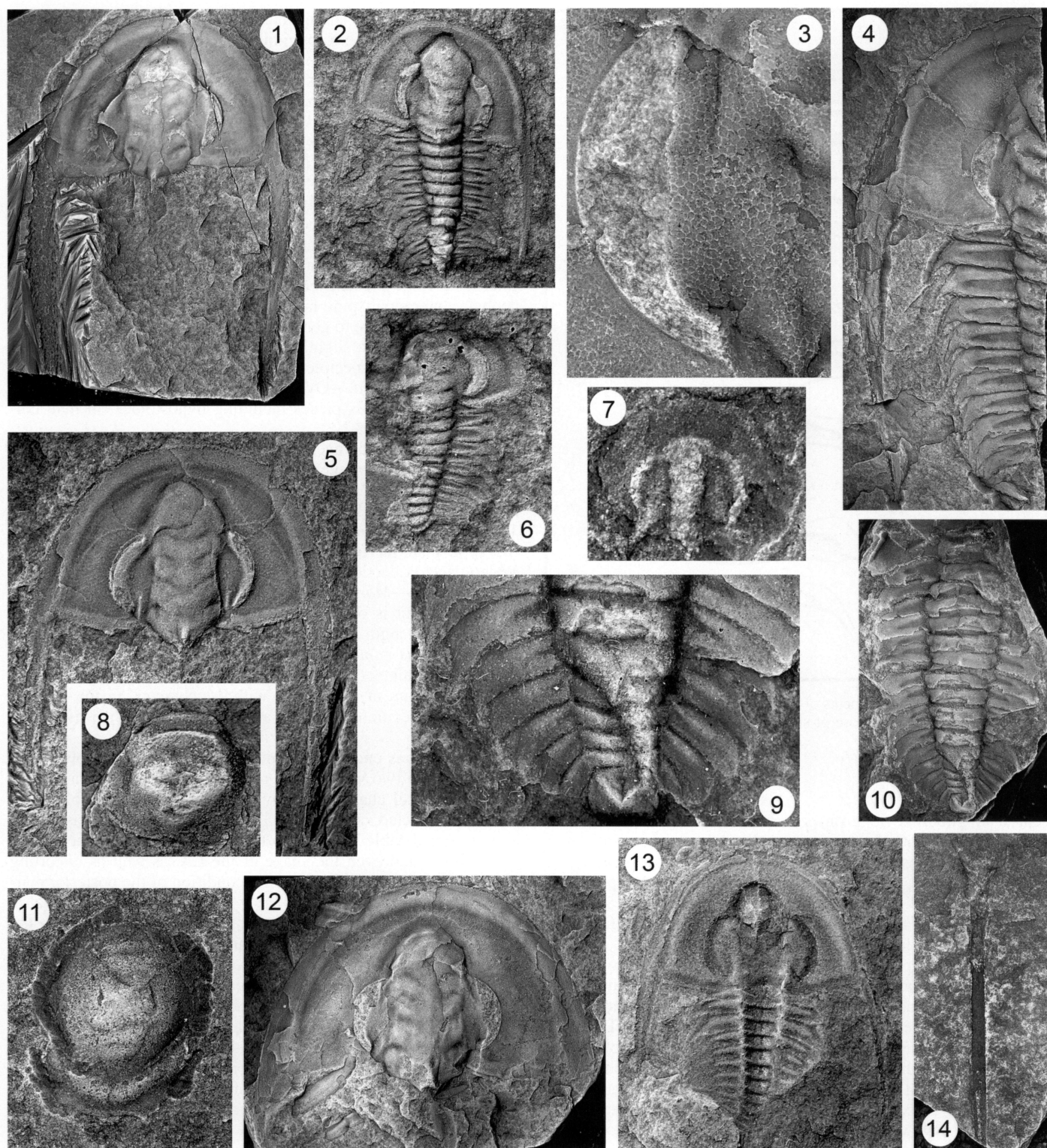
FIGURE 6—*Montezumaspis parallela* (Fritz, 1995) n. gen., from the Montenegro Member of the Campito Formation, Montezuma Range; *1,* cephalon, ICS 3755, section MN-f 188, ×1; *2,* small cephalon and thorax showing base of large thoracic axial spine, USNM 520953, section MN-f 181, ×3; *3, 4,* USNM 520947, section MN-f 163, *3,* interocular area showing reticulate pattern, ×4, *4,* half of an articulated carapace, ×1; *5,* cephalon, some exoskeletal material on genal spines, USNM 520950, section MN-f 163, ×3; *6,* latex cast of late-stage meraspid?, USNM 520957, section MN-h 226, ×6; *7,* meraspid cephalon, USNM 520952, section MN-f 166–168, ×11; *8,* isolated pygidium, USNM 520949, section MN-h 216.5, ×6; *9, 10,* USNM 520951, section MN-f 181, *9,* enlarged to show pygidium and base of prominent axial spine on T13, ×6, *10,* complete thorax with part of cephalon, ×2; *11,* tentatively assigned hypostome, USNM 520956, section MN-f 163, ×3; *12,* large cephalon with broken occipital spine, USNM 520954, section MS 175, ×1; *13,* external mold showing natant hypostome in position, USNM 520955, section MN-f 163, ×6; and *14,* isolated large thoracic axial spine, USNM 520948, section MN-f 163, ×1.75.
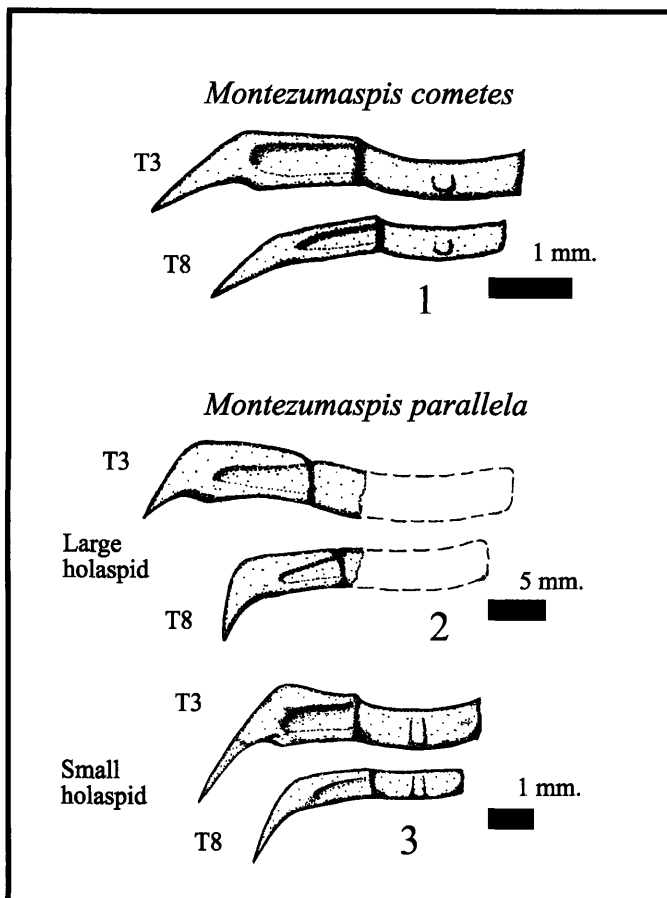
FIGURE 7—1, Thoracic segments of *Montezumaspis cometes* (Fritz, 1995) n. gen. compared with those of small and large holaspides of *M. parallela* (2 and 3).

central longitudinal ridge on posterior axial rings (T6–T13). T3 amplipleural, slightly longer (exsag.) than adjacent segments, with deep, broad, triangular pleural furrow that is rounded distally. T3 has short, narrow pleural spine with thornlike base, tip aligned with middle of T4 on small holaspides and anterior part of T4 on large ones (Fig. 7). Anterolateral margin of pleural spine on T5 directed at an angle from sagittal axis varying from 32° on small to 18° on large specimens. T2 similar to T3. T1 narrower (tr.) with short, more laterally directed slightly thornlike pleural spine. Segments posterior to T6 have smoothly sentate pleural spines. Behind axial spine on T13, thorax has four segments (Fig. 6.9), thorax and axis taper more rapidly than anterior part of thorax, pleurae outward-directed (65° from sagittal axis) to backward-directed (15° from sagittal axis) on last segment, pleural furrow a shallow pit at axis on forward two segments, obsolete on last two, all four have wide anterior ridges. Pleural spines short, backward-directed.

Pygidium (Fig. 6.9) trapezoidal, expanding posteriorly with broadly rounded posterolateral margins, anterior width equal to pygidial length. Axis triangular, apex backward, strongly elevated at apex two-thirds distance to posterior margin, with central portion of axis depressed, shallow lateral pits near anterior faintly suggest a single segment. A much larger (4.5 mm, Fig. 6.8), isolated pygidium also belongs to this species, axis rounded instead of sharply elevated, central portion of axis depressed with faint pits suggesting a single segment. Articulating ring widest (sag.)

at center tapering to lateral margins of axis, defined by distinct furrow with steep rise to pygidium.

Nine small cephala, three with attached thorax, are provisionally assigned as meraspides of this species. Cephalic length ranges from 1.5 to 3.3 mm, outline ranges from nearly circular to somewhat parabolic anteriorly, with transverse posterior margin. Preglabellar field (sag.) much wider than border in small cephala (Fig. 6.7) to nearly equal to border width (sag.) on larger cephala. LA round, slightly expanded. S0 strong, shallow across midline. L0 slightly extended posteriorly with small node or tiny spine. Ocular lobe long, contacting LA posterolaterally (contacting LA laterally on smallest cephalon), separated from LA by distinct axial furrow. Extraocular area approximately same width as interocular area. Intergenal ridge present, continues as interocular ridge on small cephala. Intergenal spine large on small cephala, located at proximal third of distance to genal angle which is somewhat advanced. Thorax narrow, with slightly amplipleural third segment; 12 segments observed on specimens with 3.1–3.3 mm cephala (Fig. 6.6).

Material examined.—Over 100 cephala, 9 complete specimens, and 17 miscellaneous pieces including hypostomes (in field collections).

Occurrence.—Montenegro Member of the Campito Formation, from the northern Montezuma Range (sections MN-f 163, 166–168, 168, 172, 181, and 188; MN-h 213.5, 214–216, 216.5, 220–240, and 226; MS 167.5, 175, 185–187, 195.5, and 199; MS-S 14.7, 29, and 34) and from the Fish Lake Valley area (FLVS-N 6). Type material from Montenegro Member at Barrel Spring, Walcott's 1f collection (Fig. 2.6).

Discussion.—*Montezumaspis parallela* occurs commonly with *M. cometes* but is often larger; available cephala (120) average 11.7 mm in length with maximum cephalic length of 64 mm. *Montezumaspis cometes* cephala (76) average 8.9 mm in length with a maximum of 39 mm. Over 80% of the specimens of *M. parallela* occurs in collections with *M. cometes*, in the ratio of 10:7. Monospecific collections are nearly all less than five specimens.

Difficulty was encountered in separating over 170 isolated cephala of these two species due to often confusing overlap in the range of critical characters. Obviously much of the problem lies in the compacted condition of all but a few specimens which causes considerable variation in the condition of the glabellar furrows, lobes, and even the shape of the LA, as well as distorting the cephalic shape, particularly the condition of the posterior margin. Additional problems probably are caused by nonisometric growth along the holaspid trajectory. Distinct differences in the thorax from the earlier to later instars are present (Fig. 7). On *M. parallela* the axial width increases, the angle and length of the pleural spine decreases, and the length of the T13 axial spine increases considerably with advancing age. Finally, much of the variability appears to be intraspecific due to lability of many of the critical characters (Hughes, 1994).

The cephalon of *Montezumaspis parallela* differs from that of *M. cometes* in the following characters: ocular lobes evenly curved, but much less than a half-circle and located much closer to the axial furrow. Anterior shape of cephalon more parabolic than semicircular. LA narrow, approximately width of L0, not distinctly wider; also somewhat pointed anteriorly rather than well rounded. Glabella practically parallel-sided rather than slightly narrower at S1. Thick occipital spine arises from a longitudinal ridge in the posterior half of L0 compared with slender spine originating at the posterior margin of L0. The anterior ocular line (Raw, 1937; Palmer and Repina, 1993) is rarely observed whereas it is commonly seen on *M. cometes*. *M. parallela* is more easily distinguished from *M. cometes* by the characters of the thorax. The pleural spines of *M. cometes* are distinctly outward-directed

(Fig. 7), the thorax is wider, the pleural furrows are more rectangular, and there is a node or spine on all thoracic rings ahead of T13. The prominent spine on T13 is more like a telson on *M. parallela* while on *M. cometes* it is a longer-than-normal axial spine. The axis of the pygidium of *M. parallela* is more sharply triangular and more strongly elevated posteriorly with the central portion of the axis depressed when compared with the pygidium of *M. cometes*.

Cephala of *M. parallela* can be distinguished from cephala of *Palmettaspis consorta* in having a parallel-sided rather than expanding glabella, longer ocular lobes and longer, less advanced genal spines (Fritz, 1995). *Montezumaspis parallela* can resemble the narrow form of *Esmeraldina rowei* but is differentiated by the presence of a preglabellar field, low anterior and lateral border, wide extraocular areas, and genal spines directed straight back.

Among the Baltic species, *M. parallela* most resembles *Holmia* sp. Moczydłowska et al., 2001, from the Grammajukku Formation of Sweden, which is reported to be "one of the oldest Baltoscandian olenellids." The small cephalon (Moczydłowska et al., 2001, fig. 7a) bears a striking resemblance to the meraspid cephalon shown in Figure 6.6 with unfurrowed ocular lobes contacting the LA with a shallow furrow. *Montezumaspis parallela* differs from *Holmia* sp. in having the ocular lobes closer to the glabella, in lacking the faint ocular furrow in larger specimens, and in having an amplipleural third thoracic segment. *Montezumaspis parallela* also resembles *Kjerulfia orienta* (Orłowski, 1974), in having a parallel-sided glabella, wide extraocular area, and amplipleural third thoracic segment (Ebbestad et al., 2003). *Kjerulfia orienta* differs from *M. parallela* in having furrowed ocular lobes and a wide L3 configured much like *Holmia kjerulfi* (Linnarsson, 1873). Fritz (1995) discusses differences between *M. parallela* and *"Holmia" ljungneri* Kautsky, 1945. (Note that Ahlberg et al., 1986, regard the generic position of the latter species to be unresolved.) The lack of ocular furrows and the shallow furrow separating the ocular lobe from the LA on small cephala of *Holmia* sp. and *Holmia glabra* Orłowski (1974, p. 11 and pl. 2, fig. 8) suggest an early ontogenetic kinship between the Baltic holmiids and *M. parallela*.

The arrangement of S2 and L3 on the glabella of *M. parallela* is perhaps significant. L3 is wider (exsag.) than L2 and configured somewhat like a wide letter *M*, resulting in a short S2 furrow that often does not reach the axial furrow. This arrangement is not present on *M. cometes* or on species of *Esmeraldina*, *Palmettaspis*, or *Grandinasus* n. gen. The *M*-like L3 is well developed on many of the Baltic holmiids typified by *Holmia kjerulfi*, but in that species S2 extends to the axial furrow. The reduction of S2 to a short slitlike furrow separated from the axial furrow is a feature of much younger forms such as *Olenellus* Hall, 1861. The large thoracic axial spine of *M. parallela* is an unusual feature that is not repeated among the olenelline trilobites until early in the *Olenellus* Zone. These unique features on *M. parallela* suggest the possibility that this species may be very close to an ancestral form for not only the western Laurentian holmiids, but also for geographically distant and considerably younger forms as well.

MONTEZUMASPIS COMETES (Fritz, 1995)
Figures 7.1, 8.1–8.10

Esmeraldina? *cometes* FRITZ, 1995, p. 716, figs. 5.3, 9.8, 10.3–10.5.
Palmettaspis cometes (FRITZ, 1995). LIEBERMAN, 1999, p. 76–77 (coded), 85.
?*Fallotaspis* cf. *tazemmourtensis* NELSON AND HUPÉ, 1964, p. 40; NELSON AND DURHAM, 1966, pl. 2, fig. 1.
?*Fallotaspis* sp. NELSON, 1976, pl. 1, lower left corner.

Emended diagnosis.—Preglabellar field equal to sagittal length of anterior border on small specimens ranging to virtually absent on large specimens. Glabella slightly narrowed at S2. LA broadly rounded anteriorly and slightly wider (tr.) than L0. Ocular lobes semicircular. Occipital spine arises at posterior margin of L0. Axial rings of thorax have nodes or small spines. Lateral margins of pleural spines outward-directed, about 45° to sagittal axis.

Description.—Fritz's (1995) description of this species is based on two cephala, 23.4 mm (holotype) and 9.0 mm long. Several new articulated, but smaller, specimens, with cephala 5–6 mm long, provide additional information on this species.

Preglabellar field equal to sagittal length of anterior border on small specimens ranging to virtually absent on large specimens. LA one-third length (sag.) of glabella including L0. On full-relief specimen, glabella arched transversely with the highest point in lateral profile near L0. On smaller specimens LA expands anteriorly from contact of ocular lobe, on larger specimens maximum width of LA is at contact with ocular lobe. Anterior contact of ocular lobe merges with LA with only a slight to moderate depression. Faint anterior ocular line is present on most specimens (Fig. 8.5, 8.10). Width (tr.) between distal margins of ocular lobes one-fifth greater than glabellar length (sag.). Interocular area one-half to three-quarters of the width (tr.) of extraocular field. Polygonal network on dorsal surface observed on larger specimens only.

Hypostome nearly circular, domed, with length about one-third of cephalic length, natant, margins cannot be examined on available material. Isolated large hypostomes described as *M. parallela* may be from *M. cometes*.

Thorax nearly parallel-sided to T13, width (tr.) of this sector at T3 one-third greater than sagittal length which is slightly longer (sag.) than cephalon; prominent, broad-based spine on T13 which is three-fifths length of anterior part of thorax. Axis three-tenths thoracic width including pleural spines, with node or small spine on axial rings. Pleural furrows are deep, rectangular with lateral ridges, rounded distally. Pleural spine thornlike on anterior segments outward-directed, tip of spine opposite the anterior third of the succeeding segment (Fig. 7.1). Pleural spine sentate and outward-directed posterior to about T8. Anterolateral margin of pleural spine on T5 directed at 43° from sagittal axis. T3 is slightly wider (exsag.) than adjacent segments. T1 distinctly narrower (tr.) than T2 with short, outward-directed pleural spine. Thorax behind large axial spine tucked under on some specimens; consists of four narrow (sag.) segments one-third as wide (sag.) at axis as T13. Pleural region laterally directed on T14 and curved posteriorly on T17.

Pygidium small, with flat, posterolateral finlike projections, posterior margin indeterminate. Axis subtriangular, slightly elevated, a little over twice as wide (tr.) as long with three pairs of faint pits marking central portion, width (tr.) between pits increases posteriorly. Length (sag.) of pygidium is only about one-fifteenth cephalic length (Fig. 8.2).

A specimen with a cephalon 2.4 mm long and 11 thoracic segments is interpreted as a meraspid of this species, other meraspid cephala range from 1.6 to 3.1 mm. Cephala are similar to *M. parallela* except that cephalon is much wider, width (tr.) one and two-thirds to two times cephalic length (Fig. 8.3, 8.4) and genal spine is outward-directed. L0 has small spine. Ocular lobes widely spaced and contact LA on lateral (on smaller specimen) or posterolateral margin. Interocular area has prominent longitudinal interocular ridge continuous with intergenal ridge. Spines occur on all thoracic axial rings (Fig. 8.3).

Material examined.—A total of 82 cephala and cephalic fragments plus five complete specimens (in field collections).

Occurrence.—Montenegro Member of the Campito Formation, from the northern Montezuma Range (sections MN-f 163, 166–168, and 181; MN-h 213.5, 214–216, 216.5, and 226; MS 167.5, 168, and 175; and MS-S 29 and 34) and from the Slate Ridge
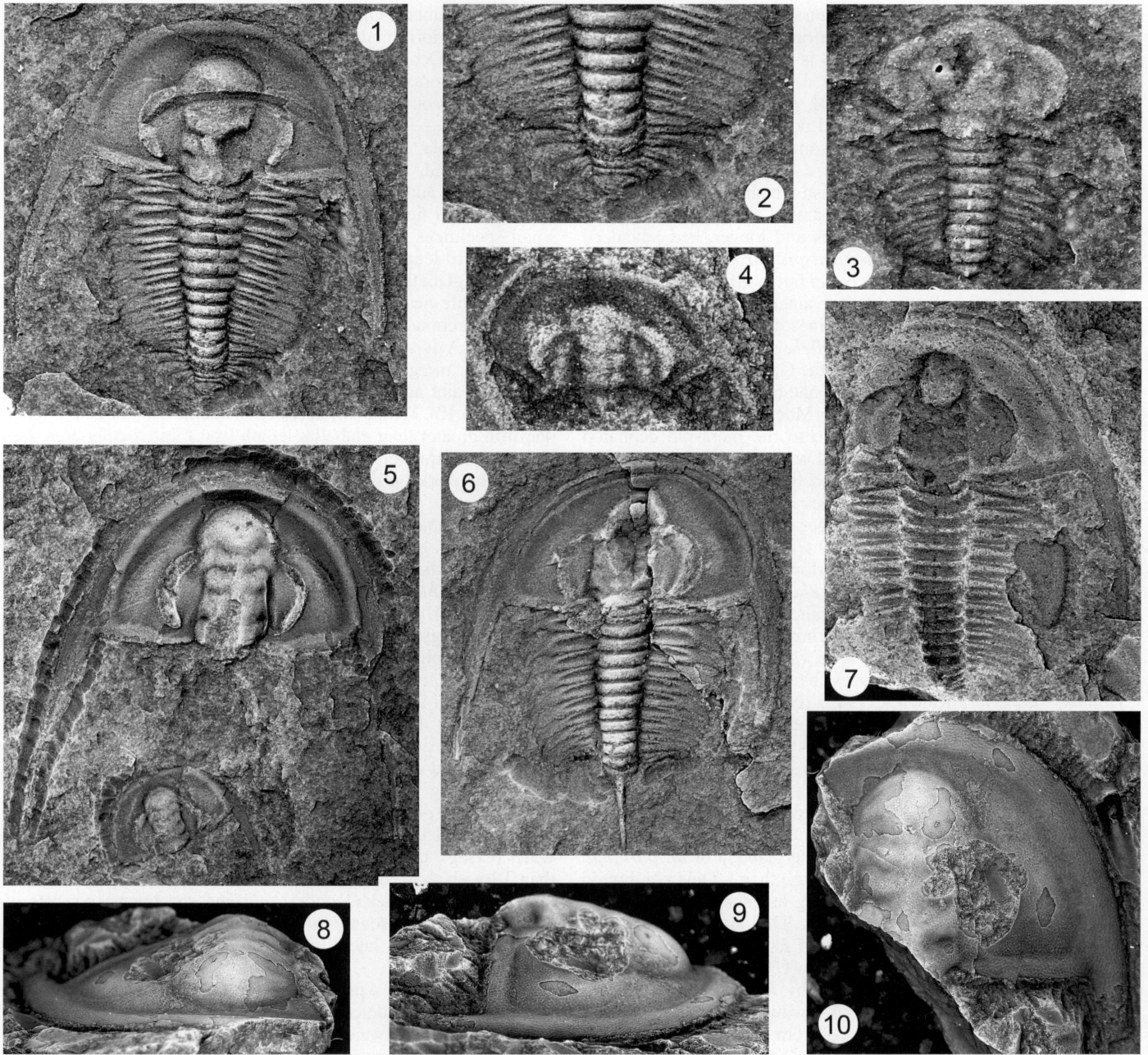
FIGURE 8—*Montezumaspis cometes* (Fritz, 1995) n. gen. from the Montenegro Member of the Campito Formation; *1–7,* from the Montezuma Range, and *8–10,* from the Slate Ridge area; *1, 2,* USNM 520959, section MN-f 163, *1,* complete carapace with rostral plate impressed on cephalon, ×5; *2,* posterior of thorax with pygidium, ×8; *3,* latex cast of late meraspid with faint cephalic outline, USNM 520962, section MS 167.5, ×10; *4,* meraspid cephalon, USNM 520964, section MN-f 163, ×10; *5,* large and small cephala, USNM 520960, section MN-h 213.5, ×3; *6,* articulated specimen showing prominent axial spine, USNM 520963, section MN-f 163, ×5; *7,* ventral view of external mold showing natant? hypostome, USNM 520961, section MN-f 163, ×8; and *8–10,* cephalon with small patches of exoskeleton preserved in limestone, USNM 520966, section SRN 87, ×3, *8,* anterior view, *9,* lateral view, and *10,* dorsal view.

area (sections SR 216 and SRN 87). Type material from Montenegro Member at Barrel Spring (Fig. 2), Walcott's 1f collection.

Discussion.—The differences between *Montezumaspis cometes* and *M. parallela* are discussed above under the latter species. *Montezumaspis cometes* is easily distinguished from the various species of *Esmeraldina* by the relatively small LA, longer ocular lobes, and long, narrow genal spines (Fritz, 1995). The preglabellar field distinguishes *M. cometes* from the narrow form of *Esmeraldina rowei.* The long, unadvanced genal spines and

relatively wide extraocular area distinguish *M. cometes* from *Palmettaspis consorta* and *P. lidensis* (Fritz, 1995).

Fritz (1995) compares *M. cometes* with the cephalon from Sweden figured as *Wanneria? lundgreni* (Moberg, 1892) by Bergström (1973, fig. 17) and later referred (Ahlberg et al., 1986, p. 52) to *Kjerulfia?*, noting that the Baltic form has a relatively larger glabella and much narrower extraocular area. *Montezumaspis cometes* also resembles *Holmia inusitata* Ahlberg and Bergström *in* Ahlberg et al., 1986 and *H. mobergi* in having a well-rounded

LA and relatively wide interocular field with strongly curved ocular lobes and outward-directed thornlike pleural spines on the thorax (Ebbestad et al., 2003). They are differentiated by their derived condition of L3 which is wider (tr.) than L2, the relatively shallow axial furrow, and the anterolateral margins of L3 against the anterior portion of the ocular lobe. The pleural regions of the thorax are distinctly narrower than on *M. cometes*. The presence of the large axial spine on the thorax suggests comparison with the species of *Schmidtiellus* from Baltica (see *Discussion* under *M. parallela*).

A trilobite specimen (UCLA 26821) originally identified as *Fallotaspis* cf. *tazemmourtensis* Hupé (Nelson and Hupé, 1964) was reported from the Andrews Mountain Member of the Campito Formation near the Waucoba Spring section in California in Inyo County, California (Fig. 2) (Scott, 1960). This trilobite occurs in siltstone, and the back side of the rock is subrounded and weathered, suggesting that the specimen may have been transported some distance. The cephalon and thorax have a combined length of about 50 mm. The cephalon is angled downward about 20° with the anterior border jammed backward. Weathering and breakage combined to obliterate most cephalic features. The thorax, though, has at least 12 segments and is more useful. The axial width is one-fourth the total width. The first segment has a triangular inner pleural region with a pointed tip laterally directed. The second segment is wider (exsag.) than the first with a distinct pleural furrow and slightly thornlike pleural tip. The third is wider (exsag.) than the adjacent segment. The pleural spine is slightly thornlike and directed outward at about 35° from the axis. This thoracic configuration best agrees with *Montezumaspis cometes*, therefore this repeatedly cited (Alpert, 1976; Nelson, 1978) specimen is from the middle of the Montenegro Member, not the earliest trilobite in the region from the upper third of the Andrews Mountain Member (Hollingsworth, 2005).

Genus ESMERALDINA Resser and Howell, 1938

Esmeraldina RESSER AND HOWELL, 1938, p. 228–229; SHIMER AND SHROCK, 1944, p. 611; HUPÉ, 1953b, p. 133; BERGSTRÖM, 1973, p. 285–286; AHLBERG ET AL., 1986, p. 40; FRITZ, 1995, p. 712–714; PALMER AND REPINA, 1997, p. 414–415; LIEBERMAN, 1998, p. 65–66, 71; 1999, p. 85–86.

Type species.—*Holmia rowei* Walcott, 1910.
Included species.—*E. elliptica* n. sp., *E.* sp. 1 Fritz, 1995.
Emended diagnosis.—Holmiid with genal angle slightly to strongly advanced, genal spine wide at base. Intergenal spine well developed, located proximal to midlength of posterior margin. Anterior and lateral borders well defined. Glabella slightly expanded anteriorly, slightly narrowed at S1, reaching or nearly reaching anterior border, L1 to L3 similar in shape, glabellar furrows not joined at axis. L0 with spine or node. Posterior tips of ocular lobes align with L1 or anterior of L0. Extraocular area between one and two times width of interocular area. Exoskeleton smooth to strongly granular. Thorax narrow, with 17 segments, inner pleural region narrower (tr.) than axis, pleural spines short, thornlike, each segment with an axial spine. Pygidium small, expanded posteriorly.

Occurrence.—Middle Montezuman Stage, in the Montezuma Range, elsewhere in Esmeralda County, Nevada, and in White-Inyo Mountains, Inyo County, California. *Esmeraldina* occurs in the Caborca region, Mexico (McMenamin, 1987, see *Discussion* under *E. rowei*), in the Cassiar Mountains of British Columbia (Fritz, 1995) and in the Mackenzie Mountains of northwestern Canada (Fritz, 1973, 1978a).

Discussion.—Many specimens appear to have complete S3 furrows due to compaction, but full-relief specimens confirm that none of the furrows cross the axis (Fig. 9.1). Lieberman (1999)

places *Holmia*? sp. Fritz, 1973 in *Esmeraldina*, noting the major departure to be that S2 is less prominently incised. However, the broad-based occipital spine and the presence of ocular ridges that are continuous into the LA are significant departures from this genus as conceived herein.

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ESMERALDINA ROWEI (Walcott, 1910)
Figures 9.1–9.9, 9.12, 10.1–10.3

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Holmia rowei WALCOTT, 1910 (in part), p. 292–296, pl. 29, figs. 2–4, 7–11, non figs. 1, 5, 6; NELSON AND DURHAM, 1966, pl. 2, fig. 6, non fig. 7.
Gen. undet. *rowei* (WALCOTT, 1910). KIAER, 1917, p. 56, 57.
Esmeraldina rowei (WALCOTT, 1910). RESSER AND HOWELL, 1938, p. 229 (reassignment only); SHIMER AND SHROCK, 1944, p. 611; TASCH, 1952, p. 487, fig. 1f; FRITZ, 1995, p. 714, figs. 5.1, 6.1–6.12, 7.1–7.3, 10.10, 10.11; PALMER AND REPINA, 1997, p. 414–415, fig 262–1a, 1b; LIEBERMAN, 1998, p. 62 (coded), 71, fig. 3.4; 1999, p. 76–77 (coded), 86.
Esmeraldina? *rowei* (WALCOTT, 1910). FRITZ, 1973, p. 12.
Holmia sp. NELSON, 1976, p. 31, pl. 3, center, figs. 1, 2.
cf. *Fallotaspis* sp. MCMENAMIN, 1987, p. 743, fig. 5.4.

Description.—Fritz (1995) has given a thorough description based on material from the type collection. Full-relief specimens preserved in limestone provide additional information here.

Interocular area level, with slight dorsal rise in the middle. Weak, sigmoidal intergenal ridge present. Weak S4 furrow ahead of ocular lobe (also see Fritz, 1995, fig. 10.6, 10.7). Glabellar furrows do not join axially (Fig. 9.1), although many compressed specimens give the appearance of a continuous S3 furrow. Glabella more elevated dorsally than ocular ridge. Maximum observed cephalic length about 35 mm.

Late meraspides (Fig. 9.6) differ from the holaspides in having the intergenal angle slightly more than one-fourth distance from axial furrow to genal angle, the base of the genal spine advanced to align with L0 or L1, the glabella evenly expanding, LA short, short preglabellar field questionably present, LA has distinct, shallow S4, the intergenal ridge is distinct, extending forward into interocular area as longitudinal ridge. Third thoracic segment slightly wider and pleural spines slightly thornlike, outward-directed resembling *Montezumaspis cometes*.

Material examined.—About 190 cephala, 19 with more or less complete thoraxes, two with pygidia, and two isolated pygidia. Forty-seven of these cephala are the narrow form averaging 21 mm in cephalic length (range 6–36 mm) and 13 are the wide form averaging 21.8 mm in cephalic length (range 7–45 mm) (all from field collections). Also a cephalon from Caborca, Mexico (IGM 3652).

Occurrence.—Montenegro Member of the Campito Formation in the northern Montezuma Range (sections MN-f 184, 188, 188–203, 194.5, 199, 248, and 284–294; MN-h 184, 194.5, 220–240, 245, 246.5, 249, and 266; MS 199, 255, 257, 262, 267, 278, and 288), in the Fish Lake Valley (section FLVS-N: 1), at Stewart's Mill (section RR 32), and at Slate Ridge (section GCM 370 and 425). Type material from Montenegro Member at Barrel Spring (Fig. 2.6), Walcott's 1f collection. Also from the Montenegro Member in the White-Inyo Mountains of California (Nelson and Durham, 1966; Nelson, 1976), and questionably from the Puerto Blanco Formation, Sonora, Mexico (McMenamin, 1987).

Discussion.—As discussed under *Montezumaspis parallela*, the lability of these early holmiid species combined with taphonomic variability makes specific assignment of individual cephala difficult. This problem is even more frustrating when dealing with *Esmeraldina*. Four end-members of cephalic variability (Fig. 10) are readily apparent in the available material. However, with the exception of the advanced-spine form, *E. elliptica* n. sp., they are treated herein as end-members of a highly labile species, *E. rowei*.
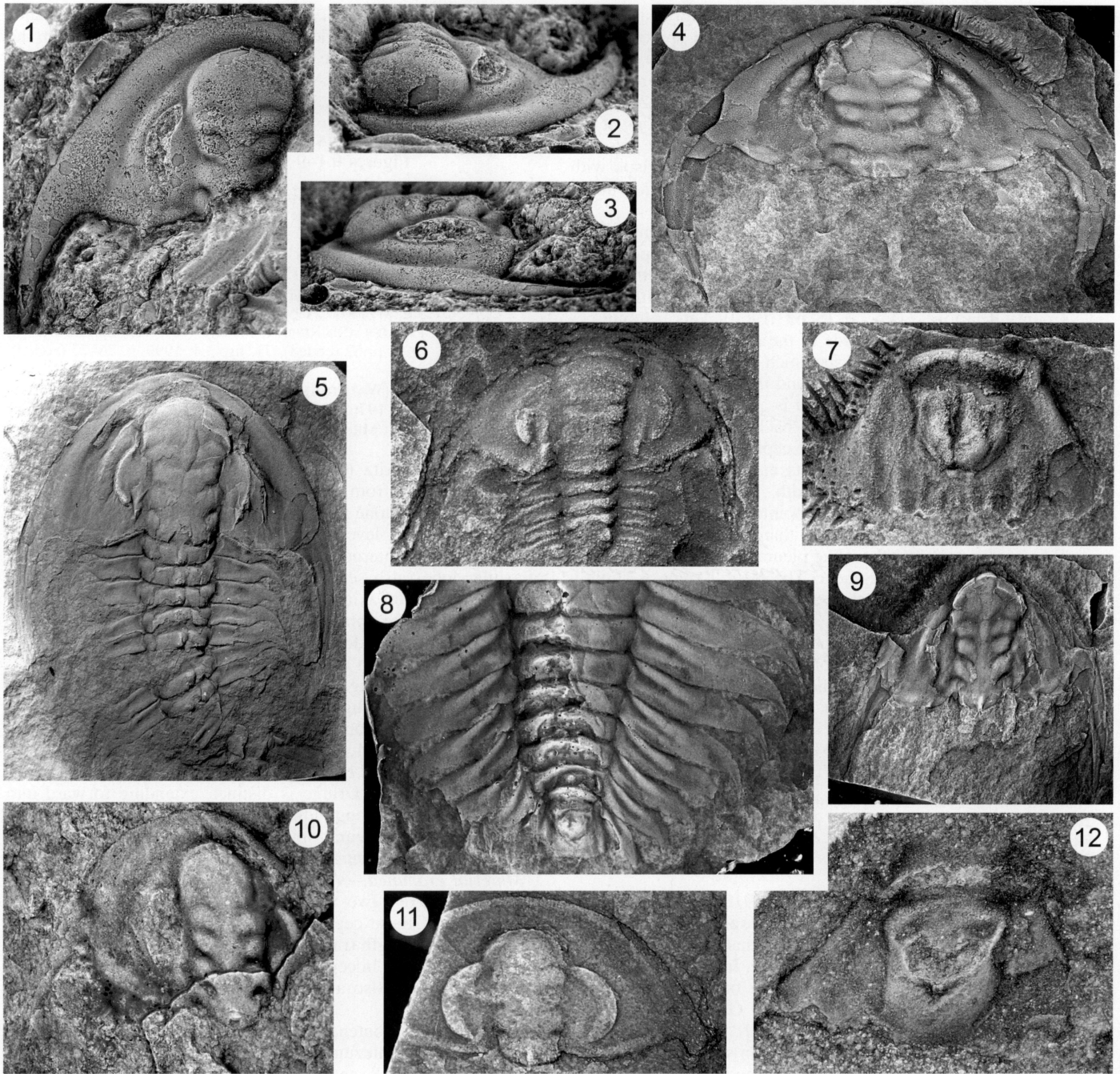
FIGURE 9—*1–9, 12, Esmeraldina rowei* (Walcott, 1910), Montenegro Member of the Campito Formation, *1–3,* Slate Ridge area; *4–9, 12,* Montezuma Range; *1–3,* cephalon, typical form, full-relief in limestone, USNM 520967, locality 1489, ×3, *1,* dorsal view, *2,* anterior view, *3,* lateral view; *4,* cephalon, wide form, USNM 520976, section MN-f 199, ×1; *5,* latex cast of cephalon and incomplete thorax, ICS 3756, MN-h 184, ×1; *6,* meraspid, anterior of LA exaggerated in preparation, USNM 520971, section MN-f 199, ×10; *7,* pygidium, ICS 3757, section MN-f 199, ×5; *8,* latex cast of pygidium and posterior of thorax, USNM 520974, original specimen in private collection of E. Fowler, section MN-h 220–240, ×2.2; *9,* cephalon of narrow form, USNM 520972, section MN-h 193, ×1; and *12,* internal mold of pygidium associated with narrow form, USNM 520970, section MN-h 184, ×6. *10, Palmettaspis consorta*? Fritz, 1995, cephalon, internal mold, USNM 520977, Montenegro Member, Montezuma Range, section MN-f 163, ×6. *11, Palmettaspis lidensis* Fritz, 1995, small cephalon, USNM 520978, Montenegro Member, Montezuma Range, section MN-h 214–216, ×8.

In addition to blurred distinctions of the cephalon, variations in sculpture, thoracic shape, and pygidia can be suggested, but reversals of these features among the various forms confuse the separations to the point that, provisionally, this range of forms is considered to be within a single, highly variable species. While the amount of available material is large, few have attached pygidia so the critical combination of cephalon with pygidium is not often available. The resolution of this variability into separate species or explanation of the variability by any of the mechanisms discussed below must await detailed statistical treatment in
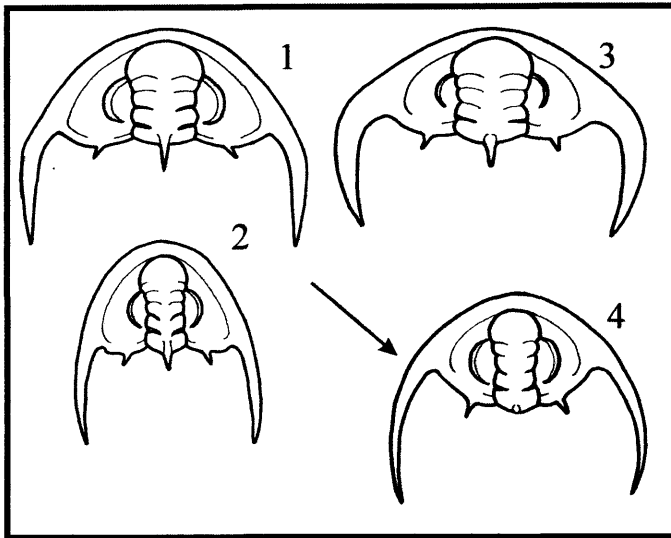
FIGURE *10*—Line drawings of cephala of *Esmeraldina* Resser and Howell, 1938, based on material from the Montezuma Range, *1,* typical *Esmeraldina rowei*; *2,* *E. rowei* narrow form; *3,* *E. rowei* wide form; and *4,* *E. elliptica* n. sp.

addition to the availability of even more complete material, bed-by-bed collecting, and single-bedding-plane variability studies.

The three cephalic forms of *E. rowei* are compared as follows:

1. The cephalon of the narrow form (Fig. 10.2) is parabolic in shape, width (measured outside the genal spines laterally from L0) is one-half greater than cephalic length. The width of the typical form (Fig. 10.1) is about twice the cephalic length, while on the wide form (Fig. 10.3) the cephalic width is nearly three times cephalic length due to the unusual genal spines.

2. On the typical form the genal angle aligns with the anterior part of L0; there is a notable change in curvature of the genal spine to more nearly parallel the axis which occurs just posterior to the posterior margin of the cephalon. Width at the base of the genal spine measured perpendicular to the spine axis is one-half greater than length (sag.) of L0. On the narrow form, the genal spines are long, approximately equal to cephalic length, curving uniformly from genal angle to approach thorax at tip, width near genal angle one-tenth more than length (sag.) of L0. On the wide form, genal spines very wide at base, four-fifths greater than length (sag.) of L0, somewhat advanced, genal angle aligns with S0. At base, spine slightly outward-directed then curving smoothly back as spine tips approach thorax; sagittal length only about one-sixth greater than cephalic length.

3. On some of the narrow forms, the posterior margin of the cephalon is transverse abaxially from the intergenal spine then curves distinctly forward near the genal angle (Fig. 9.5, 9.9).

4. On the wide form the intergenal spine is stout and triangular, shorter than on the other forms (Fig. 9.4).

5. On the narrow form, the occipital spine arises as narrow ridge on posterior two-thirds of L0 continuing to small spine seldom longer than one-half length (sag.) of L0; while on the wide form the occipital spine is slightly longer than L0 (sag.) originating at posterior third of L0; a pair of elevations lateral to occipital spine occur which become distinct nodes on larger cephala.

6. On the narrow form the ocular lobes are closer to the glabellar axial furrow (Fig. 9.5), while on the wide form the ocular lobes are somewhat outward-directed (Fig. 9.4).

7. Finally, on the wide form, the LA is wider and the axial furrow is shallower at L1 than on typical *E. rowei*.

The narrow form shows the greatest transition with the typical *E. rowei*, appears at the same stratigraphic position, and occurs through much of the range of typical *E. rowei*. The external sculpture of the narrow form has about 80 fine granules per mm^2 on a large cephalon, in the type suite of *E. rowei* three cephala have about 60 granules per mm^2, but some typical *E. rowei* and all the wide form cephala have as few as eight coarse granules per mm^2. This variation in external sculpture may be due to dimorphism or may be a response to subtle environmental changes (Palmer, 1965).

The thorax on medium to large typical *E. rowei* is parallel-sided through about T10 then rapidly tapered to the pygidium, while the thorax on the wide form is evenly tapered. The thorax of the narrow form is distinctly narrower than typical *E. rowei*.

The pygidium is even more confusing; on the lectotype it appears to have three pairs of short spines with the end of the axis close to the posterior margin (Fritz, 1995, fig. 6.12). An isolated example of a similar pygidium is shown in Figure 9.7. However a pygidium attached to a typical *E. rowei* thorax (Fig. 9.8) has a smooth posterior margin and a space of one-fourth the pygidial length behind end of the axis. Isolated pygidia in a collection dominated by the narrow form are small, trapezoidal, anterior width (tr.) three-fifths posterior width, length (sag.) two-thirds anterior width (Fig. 9.12). Axis wide, transverse width is approximately equal to pygidial length (sag.), one axial ring. Articulating half ring arcuate, wide and smooth centrally. Terminal piece parallel-sided, rounded posteriorly, reaching posterior margin, transversely elevated, two lateral pits define an anterior pseudo-ring, with a triangular, backward-pointing ridge in center of large bulbous area. Pleural areas triangular, posterior margin transverse, slightly indented at axis, apparently lacking spines, rounded at posterolateral corners. A low ridge, essentially a border, proceeds posteriorly to curve adaxially near posterior margin. Using the proportions known from the lectotype, these pygidia are from individuals with a cephalon about 38 mm long, about the size of the largest cephalon found in this collection. The assignment of pygidia will remain questionable until more articulated material is available.

The narrow form is often more common than the typical form in the early part of the range of *E. rowei*. The wide form is most common at MN-f 199 where it is two-thirds as frequent as the accompanying typical *E. rowei*. Otherwise it is rare in the upper part of the *E. rowei* range.

Hughes (1994, p. 59) cites two causes of size-independent intraspecific variation: "(1) genetic polymorphism among local populations, each of which are developmentally-canalized . . . and (2) a genetically flexible (i.e., poorly-canalized) genotype, producing ecophenotypic variation." The wide variation within *E. rowei* is not likely to be environmentally or ecologically related because there is minimal lithological variation in the rocks yielding these trilobites. The observed variation in *E. rowei* is likely genetic polymorphism as suggested by the continuation of the wide morphotype in a succeeding form, *Grandinasus patulus* n. gen. and sp.

McMenamin's (1987, fig. 5.4) specimen, IGM 3652 (Institute of Geology Museum, México, D. F.), from the upper part of Member 2, Puerto Blanco Formation, Cerro Rajòn, Sonora, Mexico, is a parabolic cephalon with dorsally elevated border and no preglabellar field. Based on these features, this poor specimen is questionably assigned to *E. rowei*, probably the narrow morphotype, rather than to *Fallotaspis* Hupé, 1953a.
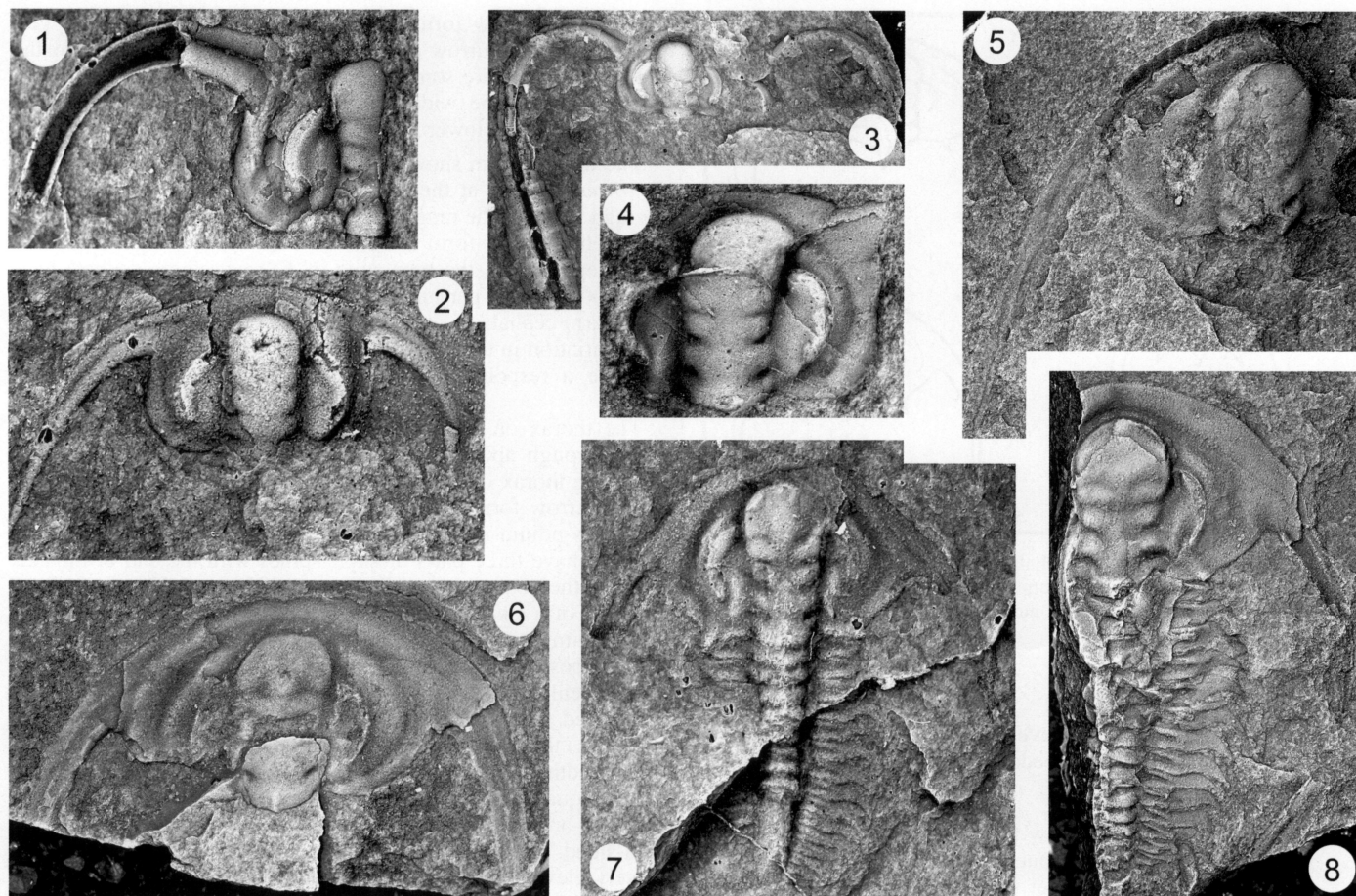
FIGURE *11—1–4, Holmiella falx* n. sp., from the shale unit in the lower member of the Poleta Formation, east of Mount Jackson, locality 1721; *1,* latex cast of cephalon, left part with arched genal spine, USNM 520998, ×4; *2,* latex cast of late-stage meraspid cephalon, USNM 521000, ×7; *3,* latex cast of holotype cephalon with right genal spine displaced, USNM 521001, ×1; and *4,* latex cast of cephalon, USNM 520999, ×4. *5–8, Esmeraldina elliptica* n. sp., Montenegro Member of the Campito Formation, Montezuma Range; *5,* partial cephalon, USNM 520980, section MN-h 246.5, ×2; *6,* cephalon showing small occipital node, USNM 520979, section MN-h 246.5, ×3; *7,* latex cast of small, external mold, ICS 3758, section MN-f 199, ×5; and *8,* holotype, relatively complete exoskeleton, thorax somewhat jumbled, USNM 520981, section MN-h 193, ×2.

ESMERALDINA ELLIPTICA new species
Figures 10.4, 11.5–11.8

Diagnosis.—Cephalon with strongly advanced genal spines, and a small node on L0. Thorax narrow, widest at T5.

Description.—Cephalon broadly elliptical, width varies from 1.5 to over 2.0 times cephalic length. Genal spines long, broad-based, advanced, lateral margin smoothly following the alignment of the lateral border, gently curving adaxially near posterior tip; length 1.0 to more than 1.5 times cephalic length. Posterior cephalic margin transverse to intergenal angle then strongly directed forward. Intergenal angle located slightly distal to exsagittal margin of ocular lobe, about one-third length of posterior margin from L0 to genal angle; marked by node or small spine angled outward. Genal angle approximately opposite L2. Anterior border cross section convex (sag.); length (sag.) about equal to length (sag.) of L0; becomes broad and flat toward genal angle. Posterior border narrower by half than anterior border. Border furrow broad, continuous to L0, strongly curved, deepest parallel to anterior margin. Glabella extended to anterior border furrow, width at LA approximately two-thirds length of glabella and wider (tr.) than L0 by one-sixth, sides slightly concave. Preglabellar field absent. Axial furrow well defined adjacent to L0 and lateral margins of LA to S2; weakly developed or absent adjacent to L1. LA no more elevated dorsally than rest of glabella, length (sag.) about

one-third length of glabella. S1, S2, S3 distinct distally, not connected across glabella; S1 and S2 nearly straight, S3 distinctly arced forward. S0 deepest distally, shallow to barely apparent across axis. L0 longest on axial line, bears distinct axial node at posterior margin; node largest on smaller cephala. Ocular lobes distinctly separated from LA by axial furrow, uniformly curved, slightly divergent posteriorly; posterior tip opposite L1, distance (tr.) from posterior tip to axial furrow about one-fourth glabellar width at L0; inner margin weakly differentiated from interocular cheek. Width of cephalon between distal margins of ocular lobes approximately the same as glabellar length. Extraocular area slightly more than twice width (tr.) of interocular area, with distinct rolled elevation close to and paralleling margin of ocular lobe. External surface finely and irregularly granular. Thorax known from 17 segments observed on holotype, narrow, widest at T5 then tapering rapidly toward posterior. Axis narrow, about one-quarter thoracic width (tr.) at T5. Pleural spines thornlike with anterior margin about 50° to sagittal axis. Pygidium and hypostome unknown.

Etymology.—Greek, *elleiptikos,* elliptical, for the elliptical shape of the cephalon.

Types.—Holotype, half of nearly complete exoskeleton USNM 520981, and paratypes from Montenegro Member of the Campito Formation in the northern Montezuma Range, Nevada.

Other material examined.—Nine cephala (in field collections).

Occurrence.—Montenegro Member of the Campito Formation in the northern Montezuma Range (section MN-f 199; section MN-h 193, 246.5; section MS 288).

Discussion.—This is a small species of *Esmeraldina*, average cephalic length for 12 specimens is 9.5 mm, range 5–15 mm, easily distinguished from all other species of *Esmeraldina* by the lack of an occipital spine and a thorax that is widest at T5. This species is rare (about 3% of the holmiid cephala) in collections from MS 211 to MS 278 (see Fig. 5). Furthermore, this species differs from *Esmeraldina rowei* in having a strongly rounded posterolateral margin, narrower glabella, and strongly advanced genal spines. It is distinguished from *Palmettaspis lidensis* (Fritz, 1995), in lacking the preglabellar field of the latter. Fritz's specimens of *P. lidensis* have about the same cephalic length, 7–12 mm, as the key specimens of this form, thus the absence of a preglabellar field is not ontogenetic. The advanced genal spines of this species are similar to *Palmettaspis consorta*, but the glabella is wider, there is no preglabellar field, the genal spines are wider and often more advanced, and the cephalon is finely granular.

Genus PALMETTASPIS Fritz, 1995

Palmettaspis FRITZ, 1995, p. 718, 720; PALMER AND REPINA, 1997, p. 416; LIEBERMAN, 1998, p. 65; 1999, p. 83–84.

Type species.—*Palmettaspis consorta* Fritz, 1995.

Included species.—*Esmeraldina lidensis* Fritz, 1995, not *Palmettaspis parallela* Fritz, 1995.

Occurrence.—Middle Montezuman in Esmeralda County, Nevada.

Discussion.—The notable differences between *Palmettaspis* and *Esmeraldina* are the presence of a preglabellar field and genal spines with a relatively narrow base on *Palmettaspis*. The thoraxes of the two species assigned by Fritz (1995) to *Palmettaspis*, *P. consorta*, and *P. parallela*, are substantially different. *Palmettaspis consorta* has distinctly thornlike pleural spines which are similar to those on the thorax of *Esmeraldina*. The thorax tentatively assigned to *P. parallela* by Fritz (1995) has sentate pleural spines, and new articulated material of this species confirms that assignment. These thoracic differences are the major reason to assign *P. parallela* to the new genus *Montezumaspis* (see *Discussion* of *Montezumaspis parallela* n. sp. for additional differences). Considering most of the features of the two species assigned to or retained in *Palmettaspis* herein, both could comfortably be placed within *Esmeraldina* (Lieberman, 1999). The strongest justification to maintain *Palmettaspis* separate from *Esmeraldina* is the presence of the preglabellar field. Ontogenetic studies (Palmer, 1957; Webster, 2003) show that with increased age, the glabella becomes relatively longer, thus the preglabellar field becomes progressively shorter. The preglabellar field is absent on small (about 10 mm cephalic length) specimens of *Esmeraldina*, so this criterion is valid even for small cephala.

PALMETTASPIS CONSORTA Fritz, 1995

Palmettaspis consorta FRITZ, 1995, p. 720, figs. 5.4, 8.1–8.6, 10.1, 10.2; PALMER AND REPINA, 1997, p. 416, fig. 262.5; LIEBERMAN, 1999, p. 76–77 (coded), 83–84, fig. 15.2.

Material examined.—Three cephala ranging in length from 7 to 16 mm in a collection from the Montenegro Member at Stewart's Mill (section RR 32), not illustrated.

Discussion.—New material of this species is limited and nothing useful can be added to the original diagnosis and description. This species is not particularly common in the original 1f collection with only 23 specimens (7% of trilobite cephala) (Fritz, 1995). That large collection was made by F. B. Weeks from the lowest unit of the Barrel Spring section located three miles (4.8 km) northeast of Barrel Spring, 16 miles (26 km) south of the town of Silver Peak (Walcott, 1908, 1910, 1912b). Unfortunately the exact source of this early collection has not been found, nor has any other locality been found that contains the same mix of species (Fritz, 1995).

A single 5.9 mm long cephalon (Fig. 9.10) of *Palmettaspis consorta*? was found in a large collection (section MN-f 163) in the Montezuma Range. It differs from the *P. consorta* of the 1f collection in having a nearly circular cephalon with genal spine outward-directed, initially at an angle of 55° to the sagittal axis, compared with 30° on the holotype. The glabella expands slightly forward, and is not parallel-sided. The anterior border and border furrows are subtle, and the preglabellar field is practically absent. The extraocular area is about equal to the interocular area, compared with nearly twice as wide on the holotype. The occipital spine is broken but does not appear to emanate from a ridge on the occipital ring as stated for the type material. This cephalon may represent an earlier species but, lacking adequate material, it is now questionably assigned to *P. consorta*.

PALMETTASPIS LIDENSIS (Fritz, 1995)
Figure 9.11

Esmeraldina lidensis FRITZ, 1995, p. 716, figs. 5.2, 7.4?, 7.5–7.9. *Palmettaspis lidensis* (FRITZ, 1995). LIEBERMAN, 1999, p. 76–77 (coded), 84–85.

Material examined.—One cephalon, 3.6 mm in length, from the Montenegro Member in the Montezuma Range (section MN-h 214–216).

Discussion.—This species is relatively common in Walcott's 1f collection (Fritz, 1995), where it comprises 16% of trilobite cephala. Lieberman (1999) transferred this species to *Palmettaspis*, citing the short preglabellar field; his other criterion refers to the advancement of the genal spines which in this study is found to vary widely within *Esmeraldina*. The genal spines are narrow, but the glabellar configuration more closely resembles that of *Esmeraldina*.

Genus GRANDINASUS new genus

Type species.—*Olenellus*? *argentus* Walcott, 1910.

Included species.—*Grandinasus auricampus* n. sp., *G. patulus* n. sp., *G.* sp. A.

Diagnosis.—Holmiid with LA impinging on the anterior border. Lateral cephalic border wide, one-third to over two-thirds width (tr.) of L0. S3 furrow faint or obsolete, and L3 incorporated in dorsally inflated LA. Glabella wider at LA than at L0 and constricted at S1. L0 expands posteriorly into stout spine. Ocular lobes short with posterior tips opposite anterior of L1 or posterior of L2. Extraocular area one to one and one-half times width (tr.) of interocular area. Intergenal spine located closer to axial furrow than to genal angle. Dorsal surface granular. Thorax of 17 segments, pygidium unknown.

Etymology.—Latin, *grandis*, great, large; *nasus*, nose, noting the bulbous LA of the glabella.

Occurrence.—Uppermost middle through middle upper Montezuman Stage. Known occurrences are from Esmeralda County, Nevada, and Inyo County, California, and a single specimen from Stevens County, Washington.

Discussion.—In this genus, the S3 furrow is virtually obsolete, although it may be present on the ventral surface, and the L3 lobe is drastically modified by incorporation into the dorsally inflated LA. In most other respects it is similar to *Esmeraldina*. The curvature of the S3 furrow and modifications of L3 are important

characters of the Holmiidae (Ahlberg et al., 1986), thus the distinctive modifications on this form are considered to be diagnostic generic features.

GRANDINASUS ARGENTUS (Walcott, 1910)
Figure 12.1–12.9

Olenellus? argentus WALCOTT, 1910, p. 314–315, pl. 40, figs. 12, 13, 15, 16, non fig. 14.
Mesonacis argentus (WALCOTT, 1910). BELL, 1931, p. 12, 18, 20.
Olenellus argentus WALCOTT, 1910. HARRINGTON, 1956, p. 56.
Esmeraldina? argentus (WALCOTT, 1910). RAW, 1957, p. 170.
Esmeraldina argenta (WALCOTT, 1910). SHAW, 1962, p. 333.
Holmia? argenta (WALCOTT, 1910). FRITZ, 1972, p.12, 13, 25; 1991, p. 15.
Holmia argenta (WALCOTT, 1910). POULSEN, 1974, p. 87.

Description.—Cephalon semicircular, width about twice length. Genal spines slightly outward-directed at base becoming parallel to the sagittal axis distally. Posterior margin transverse to genal angle. Intergenal spine long, distinct, two-fifths to one-half the distance from axial furrow to genal angle. Lateral border (tr.) somewhat less than half width (tr.) of L0; anterior border reduced to one-third width of lateral border due to expanded LA; posterior border two-thirds maximum width of lateral border. Border furrow becomes more distinct anteriorly. Glabella constricted at S1, expanding rapidly anteriorly to middle of LA which is about one-third wider (tr.) than L0 (tr.). LA width (tr.) and length (sag., including incorporated L3) both about two-thirds sagittal length of glabella. Preglabellar field absent. Axial furrow deep, distinct anteriorly, shallower adjacent to L0 and L1. S0 short deep, transverse, absent at glabellar axis, S1 similar but inclined slightly back; S2 shallower, nearly transverse; S3 very faint or absent. L3 incorporated in expanded LA. L2 slightly wider (tr.) than L1. L0 longer (sag.) medially by half than at axial furrow with narrow, upward-directed occipital spine from posterior margin. Ocular lobe narrow, slightly curved, clearly separated from LA by deep axial furrow; posterior tip opposite middle of L1, laterally spaced from axial furrow by interocular area one-fourth width (tr.) L0. Width of cephalon between distal margins of ocular lobes equal to length of glabella. Interocular area marked by longitudinal swelling or ridge. Extraocular area about equal to or slightly wider (tr.) than interocular area, with swelling parallel to border furrow. Dorsal surface of larger cephala granular.

Thorax of 17 segments, expanding in width from T1 to T4, tapering rapidly behind T8. At T4, thoracic axis slightly less than one-third thoracic width (tr.), each inner portion of pleurae one-fourth thoracic width. Axial rings of at least T1 through T4 have prominent dorsally directed spines; spine length shown by isolated segments to be two-fifths width (tr.) of axial ring (USNM 520958). Pleural segments with sharp anterior band and short triangular pleural furrows; length of furrows (tr.) decreases uniformly from T1 to T17. Pleural spines sentate (although unclear for T1 through T3), outward-directed to backward-directed posteriorly; pleural spines of T12 through T17 are thornlike and backward-directed. Hypostome and pygidium unknown.

Late meraspid cephala (Fig. 12.4–12.6) with cephalic lengths of 2.4 and 2.2 mm have a glabella which expands steadily forward to an enlarged LA that incorporates L3 as in holaspides. LA reaches border furrow but border width (sag.) is not diminished ahead of LA. Intergenal spine about as thick as genal spine but somewhat shorter. Genal spines are advanced to align with L1; posterior margin beyond intergenal spine angled forward, not transverse as on holaspides of *G. argentus* nor curved forward near genal angle as on holaspides of *G. auricampus* n. gen. and sp.

Type.—Lectotype cephalon (USNM 56812d) figured by Walcott (1910, pl. 40, fig. 15) as designated by Harrington (1956, p.

56). The specimen was collected by F. B. Weeks at locality 1v, three miles (4.8 km) north of Valcalda Spring, and four miles (6.4 km) west-northwest of the Drinkwater Mine, Silver Peak Quadrangle, Esmeralda County (Walcott, 1910, p. 415; 1912b, p. 161). Walcott's statement (1910, p. 315) attributing this material to "Lower Cambrian: (1v) shales of No. 3 of the Silver Peak Group, Barrel Spring section" was presumably intended to define the stratigraphic position of the collection, not the locality. The writer recollected this locality from the middle shale unit of the lower member of the Poleta Formation on the crest of Mineral Ridge 11.4 km northwest of the town of Silver Peak.

Other material examined.—Thirty more or less complete adult cephala, one with attached thorax, and five meraspid cephala, from field collections. Replica of lectotype cephalon (ICS 3255).

Occurrence.—From the shale unit in the middle of the lower member of the Poleta Formation at the Montezuma Range (section MS 386–411, 390–410; section IS 45, 134; IS-W 15), at Mineral Ridge (locality 1574, 1672, topotypes?), at the Fish Lake Valley (sections FLVS 183–188, 186–196, 193, 209; FLVS-N 231, 251), and east of Mount Jackson (locality 1721). An incomplete cephalon was found by M. B. McCollum from the Addy Quartzite at the type locality of *Nevadia addyensis* Okulich, 1951, on the southern end of the hill west of Addy, Washington.

Discussion.—This is a relatively small species; 29 cephala from various collections average 9.3 mm in cephalic length and range from 3.3 to 21.3 mm, but one fragmentary specimen suggests a cephalic length of 40 mm. The features that combine to differentiate this species from other *Grandinasus* species are: the LA reduces the anterior border to a third the lateral border width, the glabella is constricted at S1, the posterior border is transverse, and the genal spine is not advanced. It is readily distinguished from *Esmeraldina rowei* by the general shape of the cephalon and glabella, the bulbous LA, and the absence of S3 with L3 incorporated in the LA. The bulbous LA and the severely reduced anterior border ahead of the LA are features that resemble '*Holmia*' *zimmermanni* (Schwarzbach, 1939), but that species has a normal L3 and prominent S3 furrow (see Ahlberg et al., 1986, fig. 4; and see Geyer and Elicki, 1995, for an extended discussion of this species). The shape of the thorax of *G. argentus*, widest at T4, resembles the thorax of *Esmeraldina elliptica* n. sp.

GRANDINASUS AURICAMPUS new species
Figure 12.10–12.14, ?12.15–12.17

Diagnosis.—Glabella parallel-sided from L0 through L2. Posterior margin angled back from axial furrow to intergenal spine, then distinctly curved forward to genal angle. Genal spine moderately advanced, aligning with mid-L0 to S0, and initially slightly outward-directed curving to straight back.

Description.—Cephalon parabolic, width nearly twice length, wider in larger specimens. Genal spines initially directed outward at 30° from sagittal axis, curving nearly parallel sagittal axis, behind posterior margin of cephalon. Posterior margin angled slightly back from axial furrow to intergenal spine; from intergenal spine, posterior margin curves gently forward with a sharper curve at proximal margin of genal spine. Genal angle aligns with middle of L0 to S0. Intergenal spine is nearly as long as L0 (sag), and located distal of lateral margins of ocular lobes; on small cephala intergenal spine aligns with lateral margins of ocular lobes. Lateral border width (tr.) about equal to sagittal length of L0. Anterior border ahead of LA reduced to less than half lateral border. Border convex in cross section near border furrow becoming nearly flat toward outer margins, posterior border one-half width (tr.) of lateral border. Border furrow broad, shallow except from middle of genal spine forward to LA. Glabella narrow and parallel-sided to S2 then expanded forward to middle of LA. LA incorporates L3. LA about two-fifths wider (tr.) than L0; length

(sag.) half length of glabella. Preglabellar field absent. Axial furrow broad, shallow, deeper adjacent to LA. S0 short, transverse, S1 similar; S2 shallower and longer, S3 absent or very faint and convex forward. L0 and L1 slightly longer (exsag.) than L2. Posterior margin of L0 slightly curved posteriorly, and distinctly elevated dorsally with stout occipital spine arising from posterior half; spine is angled upward. Ocular lobe narrow (tr.), one-sixth width (tr.) of L0, broadly curved, separated from LA by furrow; line from anterior to posterior tip of ocular lobe nearly parallels sagittal axis; posterior tip of ocular lobe aligns with L1. Width of cephalon between distal margins of ocular lobes slightly less than length (sag.) of glabella. Interocular area essentially flat. Extraocular area varies in width (tr.) from less than interocular area to about one-fifth greater, with a slight swelling parallel to border furrow. Dorsal surface granular. Thorax, pygidium, and hypostome unknown.

Etymology.—Latin, *aurium*, gold, and *campus*, field, reflecting the proximity of the type locality to the Goldfield mining district.

Types.—Holotype cephalon, slightly distorted external mold, USNM 520990, and two paratypes from the uppermost beds of the Montenegro Member of the Campito Formation in the northern Montezuma Range. Additional paratype cephalon, USNM 520989, from the lower member of the Poleta Formation in the Gold Point area, Esmeralda County, Nevada.

Other material examined.—Thirty-eight cephala and cephalic fragments (in field collections).

Occurrence.—Near the top of the Montenegro Member of the Campito Formation in the northern Montezuma Range (section MN-h 323, 326, 330–331, 332, and 337–338; section MS 326.5, 330.5, 337.5, and 338), in a nodular limestone bed near the top of the Montenegro Member in the Gold Point area (section GP-N 0), and in the basal, ribbon limestone of the Poleta Formation in the Gold Point area (locality 1473).

Cephala collected by A. R. Palmer from limestone at the top of the lower member of the Poleta in the Gold Point area (locality ICS 1053) (Fig. 12.15–12.17) have a sharp ridge in the interocular area, but otherwise fall within the concept of *Grandinasus auricampus*.

Discussion.—The specimens of this species from the Montenegro Member are compacted with some distortion. These cephala range in length from 5.6 to 28.8 mm averaging 12.2 mm and lack a distinct longitudinal ridge in the interocular area. Weakly silicified cephala were found on limestone surfaces in the basal Poleta Formation near Gold Point; 10 cephala range in length from 3.3 to 8.6 mm, averaging 5.9 mm and have a longitudinal swelling in the interocular area. There are questionably assigned, poorly preserved, late-stage meraspid cephala occurring in the same interval. Many of these fragile sclerites were lost during bulk acid digestion.

GRANDINASUS PATULUS new species
Figure 13.4–13.7, 13.9, 13.10

Diagnosis.—Cephalon unusually wide. Lateral border widens and merges with widening posterior border to form wide flat area at base of genal spine which is outward directed. Ocular lobes somewhat outward-directed.

Description.—Cephalon broadly curved at front, width well over twice cephalic length (sag.). Genal spine broad, outward-directed. Posterior margin transverse to intergenal spine then angled moderately forward. Intergenal spine distinct, located distal of exsagittal margin of ocular lobe, and slightly less than halfway on posterior margin from axial furrow to genal angle. Genal angle approximately opposite S0 to L1. Anterior border narrowed ahead of LA, width (exsag.) at point aligned ahead of distal lateral margin of ocular lobe about one-third width (tr.) L0, cross section slightly convex. Posterior border furrow very shallow laterally.

Border furrow broad, shallow, deepest ahead of glabella. LA width (tr.) three-fourths length (sag.) of glabella and wider than L0 by one-fifth, glabella constricted at S1. Axial furrow, shallow; practically obsolete adjacent to L1 and L0. LA elevated dorsally above rest of glabella, length (sag.) about two-thirds length of glabella. S0, S1, and S2 similar, shallow but distinct, angled posteriorly, not connected across glabellar axis. S3 furrow virtually obsolete, L3 incorporated in dorsally inflated LA. L0 expands posteriorly into broad-based spine at least one-fifth the glabellar length. Ocular lobes narrow, one-tenth width (tr.) L0, separated from LA by broad axial furrow, angle of line from posterior tip of ocular lobe to posterior point where ocular lobe meets LA averages about 20° from sagittal axis. Width of cephalon between distal margins of ocular lobes one-eighth more than length of glabella. Interocular area slightly convex dorsally. Extraocular area 1.4 times width (tr.) of interocular area, with convex elevation close to and paralleling margin of eye and extending forward to axial furrow at LA. Dorsal surface uniformly granular. One specimen, USNM 520965, shows that thoracic axial rings of segments T1 and T2 have stout medial spines similar to occipital spine, which are elevated at base, free portion of these spines parallels dorsal surface. Pygidium and hypostome unknown.

Etymology.—Latin, *patulus*, spreading, referring to the wide arrangement of the genal spines.

Types.—Holotype cephalon, USNM 520991, and one paratype cephalon from the Montezuma Range; one paratype cephalon from the Gold Point area, and a paratype cephalon, ICS 3760, from Stewart's Mill, all from the upper beds of the Montenegro Member of the Campito Formation.

Other material examined.—Sixteen cephala and cephalic fragments (in field collections).

Occurrence.—Upper beds of the Montenegro Member of the Campito Formation in the northern Montezuma Range (section MN-h 326, 330–331, 332, and 334; section MS 330.5 and 338), in the Gold Point area (section GP-N 0), in Fish Lake Valley (section FLVS 97–113), at Alcatraz Island (locality 1223), and Stewart's Mill (ISC 1045).

Discussion.—This is a large, wide trilobite; available cephala range from 10 to 40 mm in length. It is distinguished from *Grandinasus argentus* by the anterior border which is not completely eliminated by the advancement of the LA. It resembles *Esmeraldina rowei*, especially the wide variant, but L3 is incorporated in the dorsally inflated LA. It also resembles *Kjerulfia*? *palpebra* Ahlberg (1984, fig. 6a, b) in having a wide, relatively flat border but the ocular lobes are much narrower and the genal spines are outward-directed.

GRANDINASUS species A
Figure 13.1–13.3

Description.—Cephalon subtriangular, width one-half greater than length. Genal spines directed slightly outward then straight backward, length about three-fifths cephalic length. Posterior margin straight, distal point at genal angle slightly behind L0. Intergenal spine long, approximately equal to length of L0 (sag.), located slightly distal of lateral margin of ocular lobe. Lateral border convex dorsally near anterior, becoming flat and outward-sloping laterally, widens from anterior to genal angle where it is twice exsagittal length of L0. Anterior border severely reduced ahead of LA. Lateral border furrow distinct, rounded in cross section with nearly vertical outer margin, deeper near genal angle. Posterior border furrow shallow. Glabella constricted at S1, expanding anteriorly to middle of LA which is about one-fifth wider (tr.) than L0 (tr.); LA width one-half sagittal length of glabella. S3 very faint at axial furrow; L3 incorporated into LA which is over one-half total length (sag.) of glabella. Axial furrow shallower adjacent to L1 and L2. L2 slightly shorter (exsag.) than L1.
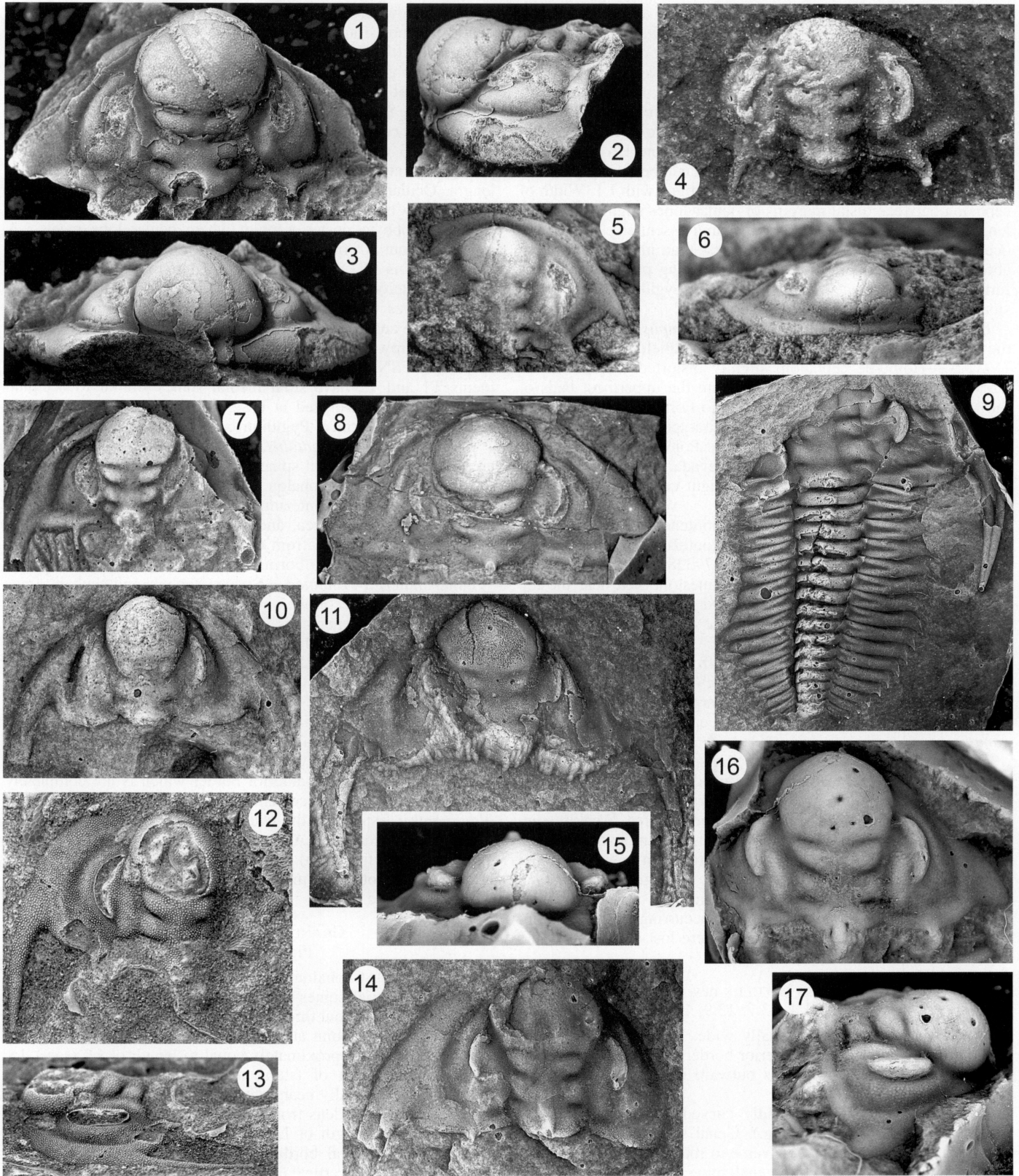
FIGURE *12—1–9, Grandinasus argentus* (Walcott, 1910) n. gen., from the lower member of the Poleta Formation; *1–6,* Fish Lake Valley area; *7, 8,* Mineral Ridge (Walcott's locality 1v); and *9,* east of Mount Jackson; *1–3,* cephalon, USNM 520983, section FLVS-N 351 ×3, *1,* dorsal view, *2,* lateral view, *3,* anterior view; *4,* latex cast of meraspid cephalon, USNM 520984, section FLVS 186–196, ×12; *5, 6,* meraspid cephalon, USNM 520985, section FLVS 209, ×12, *5,* dorsal view, *6,* anterior view; *7,* replica of topotype cephalon, ICS 3758, Walcott's locality 1v, ×3; *8,* replica, ICS 3256, of lectotype cephalon, USNM 56812d, Walcott, 1910, pl. 40, fig. 15, 15a, Walcott's locality 1v, "3 miles north of Valcalda Spring, and 4 miles northwest of the Drinkwater Mine, Silver Peak Quadrangle," ×3; and *9,* latex cast of ventral surface of exoskeleton, USNM 520986,
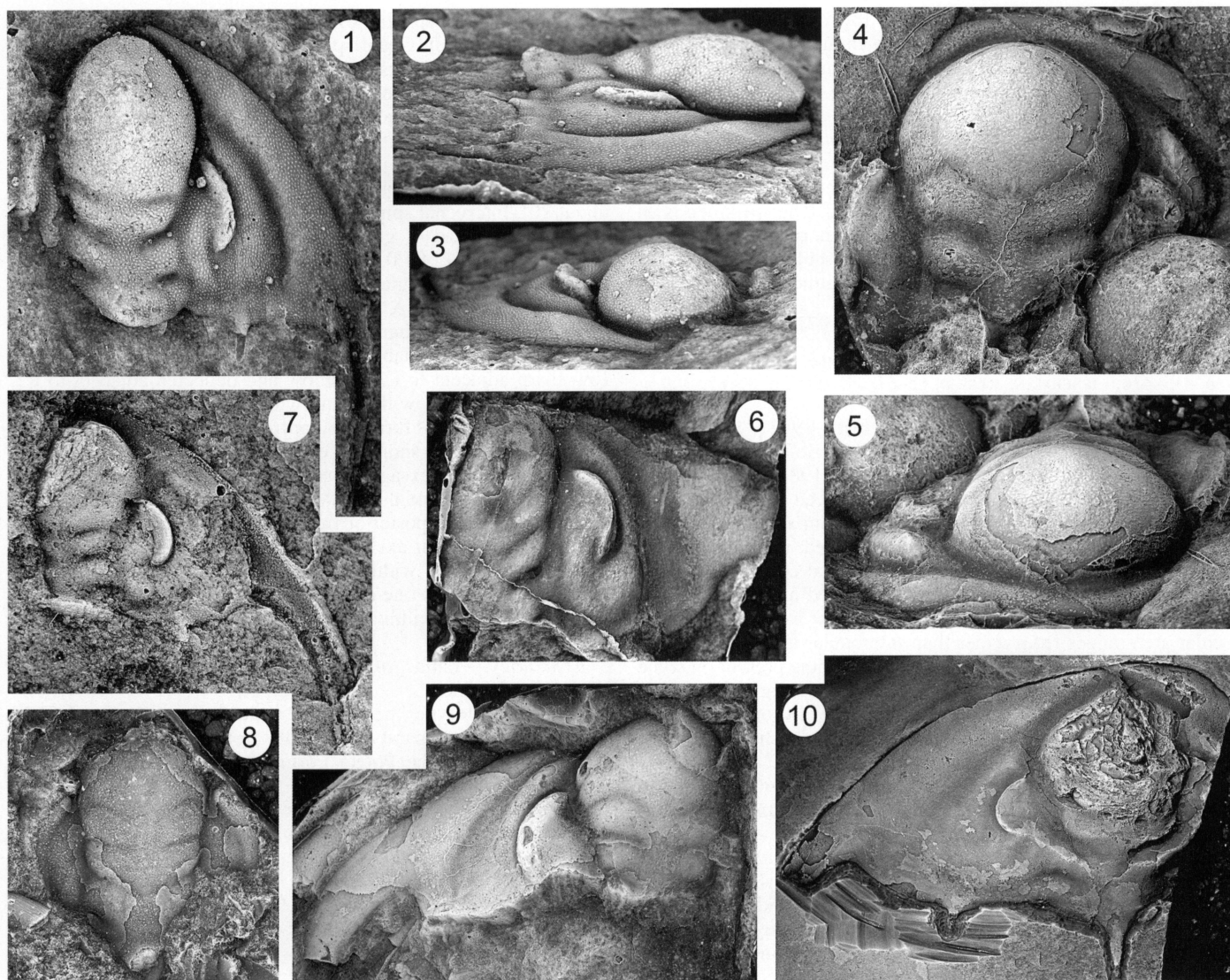
FIGURE 13—1–3, *Grandinasus* sp. A n. gen., latex cast of cephalon, USNM 520997, lower member of Poleta Formation, Montezuma Range, locality 1316, ×3; *1*, dorsal view, *2*, lateral view, and *3*, anterior view. *4–7, 9, 10, Grandinasus patulus* n. gen. and sp., Montenegro Member of the Campito Formation; *4, 5*, latex cast of glabellar region, USNM 520992, Gold Point area, section GP 0, ×1, *4*, dorsal view, *5*, anterior view; *6*, latex cast of a large cephalon, ICS 3760, Stewart's Mill area, near top of Montenegro Member, locality ICS 1045, ×1.5; *7*, latex cast of partial cephalon, USNM 520994, Montezuma Range, section MS 337.5, ×3; *9*, latex cast of partial cephalon USNM 520995, Gold Point area, section GP 0, ×1.5; and *10*, holotype, large incomplete cephalon, USNM 520991, Montezuma Range, section MN-h 332, ×1. *8*, Holmiid?, genus and species undetermined, latex cast of glabellar region, USNM 520996, lower middle member of Poleta Formation, Montezuma Range, section IS 224, ×2.3.

L0 broadens (sag.) medially by half the width (exsag.) at lateral margin. Prominent upward-angled node or spine at posterior margin. Ocular lobe narrow, one-sixth width (tr.) of L0, slightly curved, separated from LA by distinct axial furrow, posterior tip opposite S1. Width of cephalon between distal margins of ocular lobes three-quarters length of glabella. Interocular area has longitudinal ridge or swelling extending to posterior border furrow. Extraocular area about equal in width (tr.) to interocular area with swelling parallel to border furrow. Cephalon uniformly covered with coarse granules.

←

Occurrence.—The single cephalon, 15.8 mm long, occurs in the shale unit in the middle of the lower member of the Poleta Formation in a collection not on a measured section (locality 1316, Fig. 3), northern Montezuma Range, Esmeralda County, Nevada.

Discussion.—This form differs from *Grandinasus argentus* in having a long narrow LA, flat lateral border, and coarse granular sculpture. Also the posterior margin from the intergenal spine to the genal angle is slightly backward-directed. The specimen is an external mold preserving full relief in metamorphically indurated mudstone. The notably increased granular sculpture may reflect some unidentified environmental change (Palmer, 1965).

Genus HOLMIELLA Fritz, 1972

Holmiella FRITZ, 1972, p. 25; PALMER AND REPINA, 1993, p. 25; 1997, p. 415–416; LIEBERMAN, 1998, p. 65–67, 71; 1999, p. 85–87.

Type species.—*Holmiella preancora* Fritz, 1972.

Included species.—*Holmiella falcuta* Fritz, 1972, *H. falx* n. sp., *H. millerensis* n. sp., ?*H.* sp. Ahlberg et al., 1986.

Emended diagnosis.—Holmiid with advanced genal spines initially directed outward to slightly forward from anterolateral margin of cephalon, posterolateral margin rounded, intergenal spines or node a short distance in from posterolateral corner, or may be absent. Glabellar sides concave, LA expanded and front broadly curved against anterior border furrow. Ocular lobes long. Extraocular area ranges from wider than interocular area to much less than interocular area width. Small occipital spine present on some species. Thorax of 17 segments, pleural regions slightly narrower than axis. Pygidium large for a holmiid, wide, one axial ring clearly defined and a second defined by pits and a shallow furrow. Posterior margin transverse, bearing short spines.

Occurrence.—Upper middle and upper Montezuman Stage, in Esmeralda County, Nevada, and Mackenzie Mountains, Northwest Territories, Canada; ?Sweden.

Discussion.—The addition of *Holmiella millerensis* to this genus requires the above amendments to the diagnosis. This assignment is made with some hesitation because the wide extraocular area of *H. millerensis* is a major departure from the type species. Also the relatively narrow axial lobe of the pygidium suggests an overall thoracic shape quite different from the type species (see discussion in Lieberman, 1999, p. 87). The fact that the single specimen of *H. millerensis* is so large raises some concern that these differences may be ontogenetic in the adult stage.

Ahlberg et al. (1986, p. 53–54, figs. 13,14) describe a pygidium that is about two-thirds the size of the pygidium of *Holmiella millerensis*, but differs markedly from the pygidia of all other *Holmiella* species in that the axis makes up two-thirds of the anterior pygidial width. Lieberman (1999) suggests that this pygidium belongs to an indeterminate holmiid but it is much closer to *H. preancora* and *H. falcuta* than to *H. millerensis*. The Swedish pygidium does display the two pairs of spines as observed on other *Holmiella* species.

HOLMIELLA FALX new species
Figure 11.1–11.4

Olenellus? *argentus* WALCOTT, 1910, pl. 40, fig. 14, non figs. 12, 13, 15, 16.
Holmiella? FRITZ, 1972, p. 25.

Diagnosis.—Cephalon slightly subtrapezoidal, narrowing forward, with rounded posterolateral margins, intergenal spine or node absent. Genal spine, long, advanced to align with anterior quarter of LA, slightly forward-directed at base, then curved backward. Ocular lobes long. Extraocular area narrower than interocular area.

Description.—Cephalic width about one-half greater that cephalic length (sag.). Genal spines slightly forward-directed from anterolateral angles, base aligned with anterior quarter of LA, curve smoothly back to approach thoracic margin, length over twice cephalic length, generally round in cross section. Posterior margin transverse, slightly posteriorly inclined from axial furrow where posterior margin is indented, rounded at posterolateral corners, lateral margin forward-directed, inclined toward axis at about 20°. Intergenal spine or node absent. Anterior border slightly narrowed ahead of glabella, lateral border width (tr.) greater than length (sag.) of L0. Posterior border narrow, subtle. Border furrow deep ahead of glabella, shallow otherwise. Glabella slightly narrowed at S2. LA 1.6 times wider (tr.) than length (sag.), width slightly more than width (tr.) of L0, length of lobe (sag.) two-fifths length of glabella, slightly inflated dorsally. Axial furrow sharp adjacent to LA, shallow and deflected adjacent to L2, L1, and L0. S0 furrow deep and wide at axial furrow, shallow at axis. S1 deep at axial furrow, S2 narrow, straight, adjacent to axial furrow. S3 shallow, short. L0 expanded posteriorly, length (sag.) up to twice length (exsag.) at axial furrow. Ocular lobes separated from LA by deep axial furrow, outward-directed from LA then backward-directed, posterior tip opposite S0 to posterior third of L1, at distance from axial furrow three-tenths width (tr.) at L0, lobe width one-fifth width (tr.) at L0. Width between distal margins of ocular lobes one-eighth greater than glabellar length. Interocular area flat; width (tr.) of extraocular area two-thirds width of interocular area.

Etymology.—Latin, *falx*, sickle-shaped weapon, for the shape of the genal spines.

Types.—Holotype cephalon, ventrally exposed, USNM 521001, and three paratype cephala from the shale unit in the lower member of the Poleta Formation east of Mount Jackson (locality 1721).

Other material examined.—One cephalon in field collection and replica, ICS 3257, of one of Walcott's (1910) paratype, USNM 56812c, of *Holmia?* *argenta*.

Occurrence.—Shale unit in the lower member of the Poleta Formation east of Mount Jackson (locality 1721), Walcott's material from same interval at locality 1v, Mineral Ridge (see *Discussion* of *Grandinasus argentus*).

Discussion.—This species differs from *Holmiella preancora* and *H. falcuta* in having the genal spine distinctly more advanced. The genal spine of *H. millerensis* n. sp. is even more advanced and forward-directed, and the ocular lobes are smaller and located close to the glabella. These cephala average about 7 mm in length. A late-stage meraspid cephalon of *H. falx* (3.0 mm cephalic length) has genal spines aligned with the anterior part of LA, but initially directed outward and slightly backward (Fig. 11.2).

HOLMIELLA MILLERENSIS new species
Figure 14

Holmiella sp. NELSON, 1976, pl. 3; LIEBERMAN, 1999, p. 87.

Diagnosis.—Cephalon subtrapezoidal with rounded posterolateral margins. Genal spine advanced to anterior portion of cephalon, initially forward-directed then curving outward to straight backward to a length greater than length of entire carapace. Glabella slightly expanded anteriorly with shallow S3 furrow. Ocular lobes very close to glabella; extraocular area is about 2.5 times width (tr.) of interocular area. Pygidium wide (tr.), more than twice pygidial length, pygidial axis narrow, about one-fourth pygidial width.

Description.—Cephalon subtrapezoidal, narrowing forward, maximum width 1.8 times cephalic length, lateral margins rounded. Posterior margin transverse, regularly curved at posterolateral

FIGURE *14—Holmiella millerensis* n. sp. Montenegro Member, Miller Mountain, holotype, UCLA 38541, locality 23993, entire specimen, photograph courtesey of C. A. Nelson, ×0.5. *LACMIP 26933*

corners. No intergenal spine or node observed. Genal spine spectacular, originating with a broad base on anterior margin of cephalon just abaxial of outside axial furrow. Midpoint of genal spine base aligns with anterior portion of LA being advanced seven-eighths of cephalic length. Initially, spine subtends 120° angle with posteriorly directed axis. Spine rapidly curves posteriorly, anterior margin of spine slightly ahead of anterior margin of cephalon. Spine curves backward to parallel posterior taper of thoracic pleural spines, total length at least one-fifth greater than combined length (sag.) of cephalon, thorax, and pygidium. Adjacent to posterior portion of cephalon, spine is triangular in cross section with a broad base, dorsal surfaces sculpted with fine, nodular ribs directed outward and forward on both lateral surfaces; posterior portion of spine cylindrical.

Glabella slightly expanding forward, LA one-tenth wider (tr.) than L0. LA impinges upon anterior border, preglabellar field absent. LA just over two-fifths length (sag.) of glabella, defined laterally by deep axial furrows and posteriorly by a broad, shallow, backward-directed S3 that crosses glabellar axis but does not reach axial furrow. L3 equal in width (tr.) to L2. Axial furrow shallow and indistinct at L1 which is wider (tr.) than L2 or L0. S1 and S2 do not reach the glabellar midline. L0 defined by S0 furrow, shallow at the glabellar axis and deepening to pits at lateral margin. Lateral lobes on L0 defined by shallow furrows. Posterior margin of L0 even, without any indication of occipital node or spine. Ocular lobes narrow, one-sixth glabellar width (tr.), angled outward from LA then backward-directed, situated close to glabella, anterior portion aligned with posterolateral margin of

LA, separated from LA by deep axial furrow, posterior tips align with the middle of L1. Width (tr.) between distal margins of ocular lobes seven-eighths length of glabella. Interocular area flat with longitudinal interocular swelling separating ocular tip from axial furrow. Dorsal character of extraocular area and lateral border not available. Lateral margin displays wide doublure, one-twelfth width of cephalon, with sculpture of longitudinal ridges. Posterior border low and rounded. Anterior border (sag.) is three-eighths width (tr.) of lateral border as suggested by doublure. Extraocular area may be flat or broadly elevated, width (tr.) about 2.5 times width of interocular area. Hypostome unknown.

Thorax of 17 segments, tapering gently and uniformly. At T4, thoracic axis three-tenths of thoracic width (tr.), each inner portion of pleurae about one-fourth thoracic width and each pleural spine over one-tenth thoracic width. Axial rings of T1 through T5 have discernable lateral lobes marked by shallow furrows with prominent anterolateral furrows; T3 through T17 have medial nodes, or possibly spines, at back of ring. Axial furrows of thorax distinct. Inner portion of pleurae marked by strong anterior and posterior bands separated by flat, triangular pleural furrow which is wide at the axis and narrows to a point at lateral margin. Pleural furrow of anterior segments more than half sagittal width of segments; posteriorly, pleural furrow narrows (exsag.) while anterior and posterior bands maintain width through length of thorax. T3 not enlarged. Pleural spines on anterior thoracic segments are thornlike and divergent (laterally directed); posterior pleural spines are sentate and slightly pendent.

Pygidium large for a holmiid, length (sag.) is about one-tenth total exoskeletal length, ovoid in shape, width (tr.) slightly over twice pygidial length. Axis narrow, width (tr.) at anterior is one-quarter of pygidial width, with two? axial rings, a terminal piece, and low postaxial medial ridge. Ring furrows poorly defined on this specimen. Axial furrow shallow but anterolateral corners of second ring and terminal piece marked by circular pits. Terminal piece wide and triangular with strongly elevated and rounded posterior, and a pair of shallow, laterally directed pits. Three pleural ribs slightly curved, outward-directed at about 40° from sagittal axis, then angled gently posteriorly, pleural furrows deep, continuous to margin. Border wide, over one-fifth pygidial length, gently convex, and marked by subtle ridge that may be doublure. Posterior margin gently curved, cuspate behind the axis and marked by three pairs of blunt spines as extensions of pleural ribs. Exoskeletal sculpture cannot be observed.

Etymology.—For the source of the type specimen at Miller Mountain.

Type.—Holotype complete internal mold, UCLA 38541, UCLA Loc. 26993, only specimen known. *LACMIP LOC. 26933*

Occurrence.—Upper part of the Montenegro Member, Miller Mountain, Esmeralda Co., Nevada (details of this locality in *Discussion*).

Discussion.—This species is based on a single specimen which is complete but poorly preserved due to compaction, metamorphism, tectonic distortion, and weathering. It is an internal mold, thus the description does not accurately treat the external features, particularly the glabellar furrows. The thoracic axis of the specimen is depressed below the level of the pleural regions of the thorax, probably due to compaction. The pygidium is the most weathered portion of the specimen, so the pygidial features are suspect.

The 15.8 cm long trilobite specimen occurs on a 9–10 cm thick block of very dusky red purple, laminated, granoblastic argillite. It was found in the early 1970s by R. P. Bowen, an exploration engineer for a mining company. He submitted the specimen to C. A. Nelson for study. Bowen reported that the specimen was found, presumably as float, at coordinates 396,180 m east by 4,208,600 m north in the NW¼, NE¼, NW¼ sec. 22, T.2N.,

R.34E. on the U.S. Geological Survey topographic map, Miller Mountain Quadrangle, 7.5′ series. During this study, over two days were spent searching the vicinity, finding only one barely recognizable nevadiid cephalon. The lithology, argillite, and the exfoliated weathering pattern certainly agree with the rocks at the site, so there is virtually no question in my mind that this specimen came from the reported location. Measurements suggest that the specimen came from somewhere in the interval 100–160 m below the top of the Montenegro Member of the Campito Formation.

The large size, cephalic length of 54 mm, raises concerns that ontogenetic changes in the late holaspid stage may be incorporated in the description. To address this, a latex cast of a large specimen of *Holmiella preancora* from the Sekwi Formation, Mackenzie Mountains, Canada, provided by T. P. Fletcher, with cephalic length of 42.4 mm, was compared with illustrations of paratype cephala ranging from 5.0 to 18.4 mm in cephalic length. The most notable difference is lateral expansion near the posterolateral corners of the cephalon resulting in a somewhat wider extraocular area (at least in the posterior part) and a slight change in cephalic shape from subpentagonal to subtrapezoidal on the larger specimen. The base of the genal spine is slightly more forward and the initial angle of the genal spine from the sagittal axis is slightly larger. Since no smaller material of *Holmiella millerensis* is available, these observations suggest some differences to be expected on smaller cephala of this species.

This species differs from *Holmiella preancora* and *H. falcuta* in the dramatically advanced genal spine and significantly wider extraocular area; the genal spine is somewhat more advanced than in *Holmiella falx* n. sp. The ocular lobes are much closer to the glabella, the width between the distal margins of the ocular lobes is 12% less than the length of the glabella plus L0, while this width is about 25% greater on *H. preancora* and *H. falcuta* and 13% greater on *H. falx*. The pygidium of *H. millerensis* is wider, but the axis is only about one-fourth the transverse pygidial width compared to an axis one-third and one-half the width on *H. preancora* and *H. falcuta*.

The pleural spines of this species, particularly in the posterior part of the thorax, are sentate and resemble those of *Kjerulfia* and *Grandinasus* n. gen.

A single 5 cm spine possibly attributable to this species, USNM 521004, was found about 35 m below the top of the Montenegro Member at MS 316 in the Montezuma Range. The spine is triangular in cross section and the ventral surface has a sculpture of fine transverse ridges.

HOLMIID? genus and species undetermined
Figure 13.8

Description.—Fragmentary cephalon preserving glabella and parts of ocular lobes. Glabella straight-sided, slightly expanding forward. LA one-fifth length of glabella. S0, S1, and S2 distinct at axial furrow, absent across glabella axis, S0 shorter than S1. S3 shallow, arched forward. L0 expanded posteriorly to broad spine with diameter one-third width (tr.) L0. Ocular lobes one-fifth width (tr.) L0, separated from LA by deep axial furrow. Cephalic width between distal margins of ocular lobes one-sixth greater than glabellar length. Interocular area inclined slightly upward to ocular lobe. Small fragments of exoskeleton on specimen show no granules or surface sculpture.

Occurrence and material examined.—Single partial cephalon, cephalic length estimated as 13 mm, about 30 m above the base of the middle member of the Poleta Formation, northern Montezuma Range (section IS 224).

Discussion.—This specimen is too incomplete to allow even generic assignment. It is included, however, because it is the youngest holmiid in the Montezuman rocks of Nevada. The massive occipital spine of this form differentiates it from *Holmiella*. This feature does occur on *Holmia*? sp. (Fritz, 1973) which has deeper glabellar furrows, a more pointed LA, and the ocular lobes meet the LA with a small connecting ridge and weak preocular furrow.

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APPENDIX

Localities Cited

All localities in Esmeralda County, Nevada. Numbers preceded by "ICS" are localities recorded at the Institute for Cambrian Studies, Boulder, Colorado. Four-digit numbers are JSH localities.

Alcatraz Island.—Locality 1223, 37°44.03'N, 117°37.01'W on the northwestern part of the Alcatraz Island 7.5-minute quadrangle map (U.S. Geological Survey, 1987), near top of Montenegro Member.

East of Mount Jackson.—Locality 1721, stream bank at 37°28.86'N, 117°19.71'W, Mount Jackson 7.5-minute quadrangle map (U.S. Geological Survey, 1968), shale in the lower member, Poleta Formation.

Fish Lake Valley.—Section FLVS, 0 point at 37°51.79'N, 117°52.24'W in the northwestern part of Rhyolite Ridge 7.5-minute quadrangle map (U.S. Geological Survey, 1987), measured east-southeasterly; section FLVS-N, 0 point at 37°52.17'N, 117°52.01'W on the same map, measured southeasterly. These sections measured by W. H. Fritz with JSH assisting.

Gold Point.—Locality ICS 1053, 37°22.56'N, 117°16.62'W on the Mount Jackson 7.5-minute quadrangle map (U.S. Geological Survey, 1968), top of lower member, Poleta Formation, collected by A. R. Palmer; section GP-N, 0 point at 37°21.96'N, 117°17.17.33'W on the Gold Point 7.5-minute quadrangle map (U.S. Geological Survey, 1968) measured southeasterly; locality 1473, 37°21.87'N, 117°17.33'W on the Gold Point quadrangle map, from lower 10 m of Poleta Formation.

Mineral Ridge.—Localities 1574 and 1672, 37°48.40'N and 117°44.81'W, Silver Peak 7.5-minute quadrangle map (U.S. Geological Survey, 1987), shale unit of lower member, Poleta Formation, probably the same locality as 1v (Walcott, 1910).

Montezuma Range.—All pertinent sections and localities shown on Figure 3.

Slate Ridge.—Section SR, 0 point at 37°20.11'N, 117°15.56'W, Gold Point 7.5-minute quadrangle map (U.S. Geological Survey, 1968) measured easterly; section SRN, 0 point at 37°20.11'N, 117°15.57'W, same map; locality 1489 at 37°20.27, 117°15.36'W, same map; section GCM, 0 point at 37°21.29'N, 117°14.19'W, Scotty's Junction SW 7.5-minute quadrangle map (U.S. Geological Survey, 1968), measured southeasterly.

Stewart's Mill.—Section RR, 0 point in a bulldozer trench at southwest corner NW¼, SE¼, section 8, T6S., R41E, Lida 7.5-minute quadrangle map (U.S. Geological Survey, 1968) measured north-northwesterly; locality ICS 1045, center westside line of NW¼, SW¼, section 8, near top of Montenegro Member, collected by A. R. Palmer.

Subject: Re: trilobite and reprint
From: STEWHOLL@aol.com
Date: Thu, 30 Mar 2006 23:08:55 EST
To: hfilkorn@nhm.org

Dear Harry Filkorn:

I borrowed the holotype specimen of Holmiella millerensis from Clem Nelson with three other specimens. These were all returned to Clem personally on October 3, 2001, in Bishop. We had a delightful dinner with Clem at the Whisky River Restaurant and returned the specimens at that time.

I will get a reprint of my article in the mail in the next day or so.

Sincerely,

Stew

In a message dated 3/29/2006 12:36:54 P.M. Mountain Standard Time, hfilkorn@nhm.org writes:

> Dear J. Stewart Hollingsworth,
>
> I am attempting to locate one of the trilobite specimens that was figured in your article in the March issue of the Journal of Paleontology: the holotype of *Holmiella millerensis* Hollingsworth, 2006 (fig. 14 on p. 329). Did you return the specimen to the White Mountain Research Station in Bishop, California? If so, when was it sent back? About 20 years ago, the UCLA fossil collection was incorporated into the holdings of the Natural History Museum of Los Angeles County, Department of Invertebrate Paleontology (LACMIP), so the trilobite specimen should be placed in the type collection at the LACMIP.
> I would greatly appreciate your help in tracking down this specimen.
> Also, if you get reprints of your article, please send one to us for the type specimen file at the LACMIP.
> Thank you.
>
> Best regards,
> Harry Filkorn, Collections Manager
> Department of Invertebrate Paleontology
> Natural History Museum of Los Angeles County
> 900 Exposition Blvd.
> Los Angeles, CA 90007
> ph. (213) 744-3485
> fax (213) 746-7646
> hfilkorn@nhm.org

J. Stewart Hollingsworth
Institute for Cambrian Studies
729 25 Road
Grand Junction, CO 81505
(970) 241-6484
stewholl@aol.com