Trilobite biostratigraphy of the Stairsian Stage (upper Tremadocian) of the Ibexian Series, Lower Ordovician, western United States

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New field collections from sections in western Utah and southeastern Idaho permit the development of a high resolution trilobite biostratigraphy for the northern Laurentian Lower Ordovician (upper Tremadocian) Stairsian Stage similar to that proposed previously for the overlying Tulean and Blackhillsian stages. Four zones recognised previously are replaced with 11 formally proposed zones, most of which are new in concept. The new zonal scheme in ascending order includes the *Paraplethopeltis genacurva* Zone (replaces "*Paraplethopeltis* Zone"/"Zone C"), *Paraplethopeltis helli* Zone (new), *Hystricurus zanderi* Zone (new), *Rossaspis leboni* Zone (new), Unnamed Zone 1 (new), *Bearriverops loganensis* Zone (new; contains much of the diversity previously assigned to "*Tesselacauda* Zone"/"Zone E"), *Bearriverops deltaensis* Zone (new), *Bearriverops alsacharovi* Zone (new), *Pseudoclelandia weymouthae* Zone (new), *Pseudoclelandia cornupsittaca* Zone (new) and *Pseudohystricurus obesus* Zone (new). The latter two zones were previously lumped as the "*Rossaspis superciliosa* Zone"/"Zone F". Four of the name bearers of the new zones, *Paraplethopeltis helli* sp. nov., *Hystricurus zanderi* sp. nov., *Rossaspis leboni* sp. nov. and *Pseudoclelandia weymouthae* sp. nov., are formally described.

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LOWER AND Middle Ordovician trilobite faunas from the western part of northern Laurentia (in Ordovician palaeogeographic terms) are remarkable in that they feature very common preservation via secondary silicification across a broad region. This permits recovery of exceptionally preserved material via acid digestion. These faunas were originally treated by Ross (1949, 1951, 1953; Garden City Formation, southeastern Idaho and northern Utah) and Hintze (1951, 1953; Pogonip Group, western Utah and eastern Nevada). The faunas received very little attention for a half century following these classic studies, but a modern field based revision founded on extensive new collections is now in progress (Adrain *et al*. 2003, 2009, 2011a, b, 2012; Adrain & Westrop 2006a, b, 2007a, b; McAdams & Adrain 2009a, b, 2010, 2011a, b, c). A revised, high resolution zonation for most of the Floian was given by Adrain *et al*. (2009), a preliminary scheme for the upper Floian by Adrain & McAdams (2012), and for the Dapingian and lower Darriwilian by Adrain *et al.* (2012). The history of study of the faunas and previous attempts at biostratigraphy were reviewed by Adrain *et al.* (2009). The goal of the present work is to extend the new zonation to cover the upper Tremadocian Stairsian Stage of northern Laurentia, based mainly on faunas sampled from the lower Fillmore Formation in the Ibex area, western Utah (original work by Hintze [1951, 1953, 1973]), and the Garden City Formation, southeastern Idaho (original work by Ross [1949, 1951]).

The Stairsian Stage was defined by Ross *et al*. (1997) on the basis of trilobites, with its base drawn at the base of the now-obsolete "Zone D" of Ross (1949, 1951) and Hintze (1953), which was termed the "*Leiostegium-Kainella* Zone" by Ross *et al*. (1997) and the "*Leiostegium* Zone" by Taylor *et al*. (2012). The base of the stage was moved by Taylor *et al*. (2012) to the base of the old "Zone C"/"*Paraplethopeltis* Zone", an action with which we agree. The top of the stage is the base of the (revised) lowest Tulean *Litzicurus shawi* Zone of Adrain *et al*. (2009). As now defined, the Stairsian is bracketed by significant mass extinctions, and its trilobite faunal content consists in large part of clades restricted in distribution to the interval.

LOCALITIES

A general overview of the history of study and the main field regions in western Utah and southeastern Idaho was given by Adrain *et al*. (2009, p. 544-548) and will not be repeated. Parts of the Stairsian portions of the sections were treated

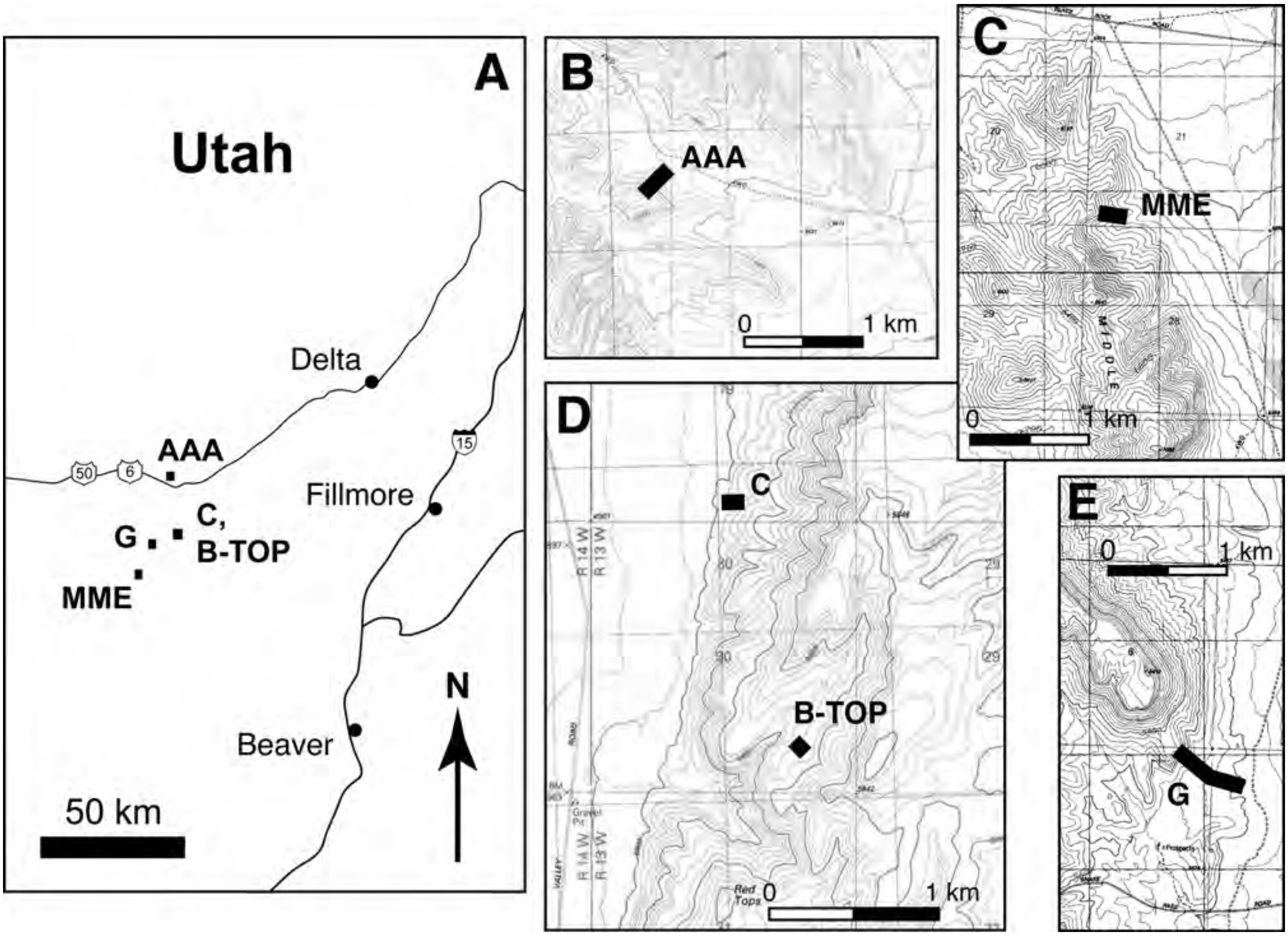


Figure 1. Maps showing lines of sections through the lower Fillmore Formation in the Ibex area, western Utah. **A**, index map. **B**, northern House Range, showing line of Section AAA. **C**, Middle Mountain, showing line of Section MME. **D**, southern House Range, showing line of base of Section C and Section B-TOP. **E**, southern Confusion Range, showing line of Section G.

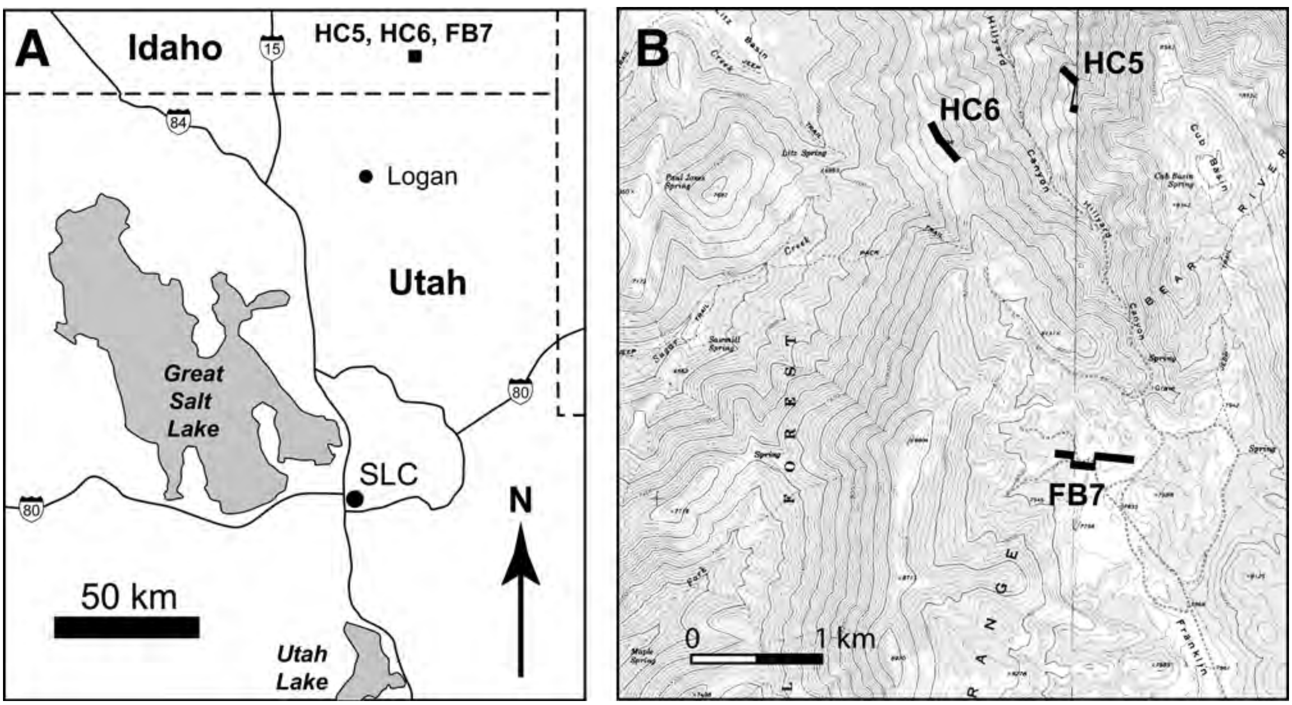


Figure 2. Maps showing lines of sections through the Garden City Formation in the Bear River Range, southeastern Idaho. **A**, index map showing location of sections. **B**, lines of sections of sections HC5 and HC6, Hillyard Canyon, and Section FB7, Franklin Basin.

Global Stage	Laurentian Series	Laurentian Stage	Ross (1951) Zones	Ross *et al.* (1997) Zones	This Paper
↑ TREMADOCIAN ↓	↑ IBEXIAN ↓	TULEAN (PART)	G(1)	*Hintzeia celsaora*	↑ see Adrain *et al.* (2009) ↑
					Litzicurus shawi Zone
		STAIRSIAN	F	*Rossaspis superciliosa*	*Pseudohystricurus obesus* Zone
					Pseudoclelandia cornupsittaca Zone
			E	*Tesselacauda*	*Pseudoclelandia weymouthae* Zone
					Bearriverops alsacharovi Zone
					Bearriverops deltaensis Zone
					Bearriverops loganensis Zone
			D	*Leiostegium - Kainella*	Unnamed Zone 1
					Rossaspis leboni Zone
					Hystricurus zanderi Zone
					Paraplethopeltis helli Zone
			C	*Paraplethopeltis*	*Paraplethopeltis genacurva* Zone
		SKULL-ROCKIAN (PART)	B	*Bellefontia - Xenostegium*	↓ under study (see Adrain *et al.* [2003]) ↓

Figure 3. Trilobite zonation of the Stairsian Stage proposed herein, compared with previous schemes.

previously by Adrain & Westrop (2007a, b), but herein we provide complete graphical logs for all sections that we have sampled.

Ibex area, western Utah

The Stairsian Stage comprises rocks mainly of Hintze's (1953, 1973) "basal ledge-forming limestone member" of the Fillmore Formation. We sampled the unit at our Section MME (Fig. 1C; Appendix 1), Middle Mountain, and parts of Hintze's Section G (Fig. 1E; log given by Adrain *et al*. [2009, appendix 1]), southern Confusion Range, our Section B-TOP (equivalent to the high part of Hintze's [1953, 1973] Section B) and Hintze's Section C (Fig. 1D; Appendix 2), southern House Range, and our Section AAA (Fig. 1B, Appendix 3; approximately equivalent to Section AA of Terrell [1973]), northern House Range. Hintze (1973, p. 10) considered that "Except for abundant silicified asaphid trilobites in the brown-weathering beds of the upper 100 feet of this member, it is the least fossiliferous portion of the Fillmore Formation." Terrell (1973) attempted to correlate the Stairisan faunas of Sections AA (probably the same as our AAA) and E (just to the south of our MME), also remarking (Terrell 1973, p. 67) that "identifiable specimens are sparse" and concluding that "Paleontologic work completed on these two sections is perhaps more detailed that has been done on any of the other sections in the area, yet refinement in correlation has not been proportionally improved."

While it is certainly true that other parts of the Pogonip Group contain more regularly spaced silicified faunas, many lower Fillmore Formation horizons with prolific faunas, apparently previously overlooked, were encountered in the present study, and a biostratigraphic zonation comparable in resolution to that published earlier for the Floian (Adrain *et al*. 2009) is possible.

Section MME contains the most complete sequence of Stairsian faunas, lacking only evidence of the *Pseudoclelandia weymouthae* Zone. Section G is mainly Floian, but approximately 40-50 m at the bottom of the section represent the upper part of the Stairsian. The richest collections of the *Bearriverops alsacharovi* Zone were obtained from G 26.6 m and G 27.0 m, and of the *Pseudohystricurus obesus* Zone at G 48.5 m. Section B-TOP yielded the most prolific samples of the lowest Stairsian *Paraplethopeltis genacurva* Zone, and it and Section C contain important *Paraplethopeltis helli* Zone horizons. Section AAA is likely the same as Terrell's (1973) AA. His difficulty in correlating it with the succession at Middle Mountain (his Section EE) is understandable, as Section AAA is mostly covered. Nevertheless, it yielded important material of the relatively poorly known *Bearriverops deltaensis* and *Pseudoclelandia weymouthae* zones.

Bear River Range, southeastern Idaho

We sampled Stairsian faunas from three sections of the Garden City Formation in the Bear River Range (Fig. 2). Section HC5, on the east side of Hillyard Canyon (Appendix 4) is Ross's (1949, 1951) Locality 5, Section HC6, on the west crest of Hillyard Canyon (Appendix 5), is his Locality

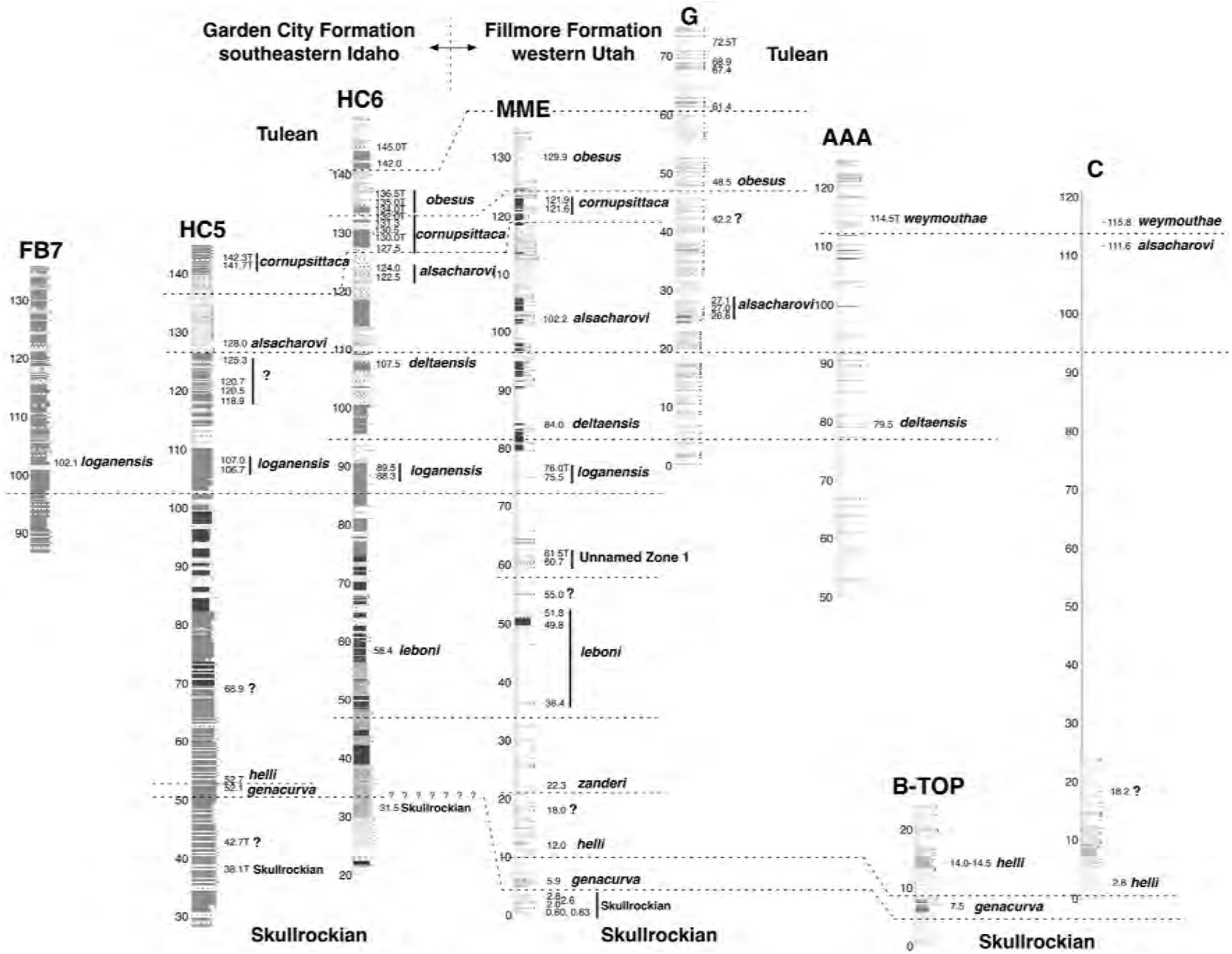


Figure 4. Sections and sampling horizons used in this study, with new trilobite zonation indicated. Section designations are as in Figures 1 and 2. Dashed lines between zones are placed at arbitrary levels to show groupings of horizons, not at exact positions of zonal bases. A question mark indicates the zonal assignment of the horizon has yet to be determined. Stratigraphic logs of each of the sections at full size are given in the appendices, with the exception of Section G, which is contained in Adrain *et al*. (2009, appendix 1). The portion of Section C lacking a graphical log was not relogged by us, and the measurements reflect those of Hintze (1973). *genacurva* = *Paraplethopeltis genacurva* Zone; *helli* = *Paraplethopeltis helli* Zone; *zanderi* = *Hystricurus zanderi* Zone; *leboni* = *Rossaspis leboni* Zone; *loganensis* = *Bearriverops loganensis* Zone; *deltaensis* = *Bearriverops deltaensis* Zone; *alsacharovi* = *Bearriverops alsacharovi* Zone; *weymouthae* = *Pseudoclelandia weymouthae* Zone; *cornupsittaca* = *Pseudoclelandia cornupsittaca* Zone; *obesus* = *Pseudohystricurus obesus* Zone.

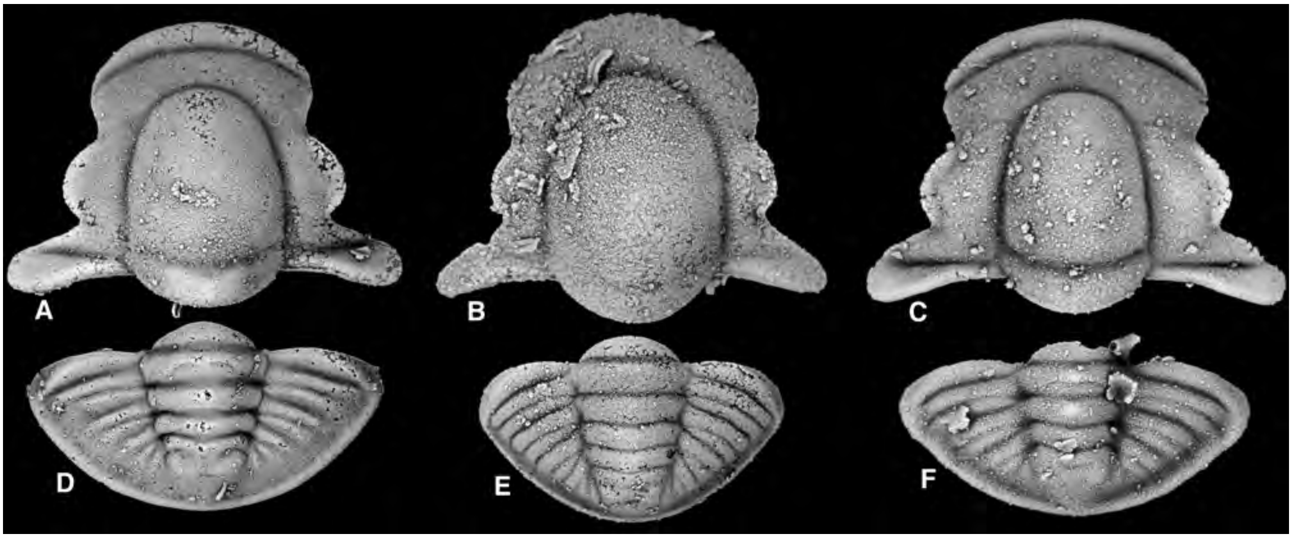


Figure 5. Trilobites of the *Paraplethopeltis genacurva* Zone. All views are dorsal, and all specimens are from B-TOP 7.5 m. **A**, **D**, ***Paraplethopeltis genacurva*** Hintze 1953. A, cranidium, SUI 134037, x6. D, pygidium, SUI 134038, x3. **B**, **E**, ***Paraplethopeltis generecta*** Hintze 1953. B, cranidium, SUI 134039, x6. E, pygidium, SUI 134040, x6. **C**, **F**, ***Paraplethopeltis* sp. nov. 1**. C, cranidium, SUI 134041, x10. F, pygidium, SUI 134042, x10.

6, and Section FB7, at Franklin Basin (Appendix 6), is his Locality 7. The lower part of the Stairsian seems genuinely poorly fossiliferous at these localities, with the exception of small but well preserved samples from HC6 58.4 m representing the *Rossaspis leboni* Zone. Rich horizons representing the *Bearriverops loganensis* Zone occur at all three sections, and from this point upward, good samples of all of the zones occurring at Ibex were found, with the exception of the *Pseudoclelandia weymouthae* Zone.

ZONATION

The results of new field sampling for the Stairsian are very similar to those for the Floian (Adrain *et al*. 2009) in that they indicate large portions of the available trilobite diversity have not previously been noticed and traditional zones have had huge stratigraphic thicknesses that are not justified by actual data. There are many more stratigraphically successive, almost entirely distinct, faunas than previously realised, and as a result a more highly resolved zonal biostratigraphy is both possible and required. In the case of the Floian (Adrain *et al*. 2009), five traditionally recognised zones were replaced by a new 15 zone scheme (and more work remains to be carried out, see Adrain & McAdams [2012]). Here, the traditional upper Skullrockian and Stairsian scheme of four zones (Ross 1951; Hintze 1953; Ross *et al*. 1997) is replaced by a new 11 zone scheme (Fig. 3).

As argued by Adrain *et al*. (2009, p. 542-544), this increased resolution is not achieved through differing taxonomic approaches but simply by the discovery of more data. Species ranges given by Ross *et al*. (1997) in defense of the now obsolete zones were mostly undocumented. When these undocumented intervals have been sampled and the faunas investigated in detail, they have proven to contain entirely new, undescribed assemblages.

The approximate correlation of the sections, along with an indication of which fossiliferous horizons are assigned to each zone, is given in Figure 4. Once again, it bears emphasis that while many of the new species encountered are illustrated, details of their taxonomy and comparisons with similar species from other zones is far beyond the scope of this work. In some cases species distinctions are subtle and not easily conveyed by a single dorsal view of a cranidium and/or pygidium. Many systematic studies are in preparation in which the morphology of the species listed will be documented in detail.

Conventions used in the following lists follow those of Adrain *et al*. (2009). Horizon designations followed by the letter "T" indicate talus or float samples, generally considered to be weathering in place but not from definite outcrop. Nameable new species awaiting description are identified as "sp. nov." with a number following. Species which are definitely new but for which material adequate for formal naming has yet to be obtained are identified as "sp. nov." with a capital letter following. Species which are likely new and distinct but for which this judgement cannot be made with absolute certainty are identified as "sp." with a number following if there were more than one encountered belonging to the same genus. Most systematic work on the faunas remains to be carried out, and genus (and even family, in some cases) assignments should be regarded as provisional.

1. *Paraplethopeltis genacurva* Zone (replaces "*Paraplethopeltis* Zone"/"Zone C") (Fig. 5)

Horizons. B-TOP 7.5, HC5 52.1 m. The interval is present at sections LDN, approximately 150 m, and MME 5.9 m, but trilobites are generally not silicified at these localities.

Species (5):
Asaphidae
Symphysurina sp.
Dimeropygidae
Dimeropygidae gen. nov. 2 sp. 1
Hystricuridae
Paraplethopeltis genacurva Hintze 1953 (Fig. 5A, D)
Paraplethopeltis generecta Hintze 1953 (Fig. 5B, E)
Paraplethopeltis sp. nov. 1 (Fig. 5C, F)

Remarks. In the Ibex area, the *Paraplethopeltis genacurva* Zone occurs in a well known interval of brachiopod coquina in the upper House Formation. Silicification of trilobites in the coquina is locally sporadic. At Section Lava Dam North,

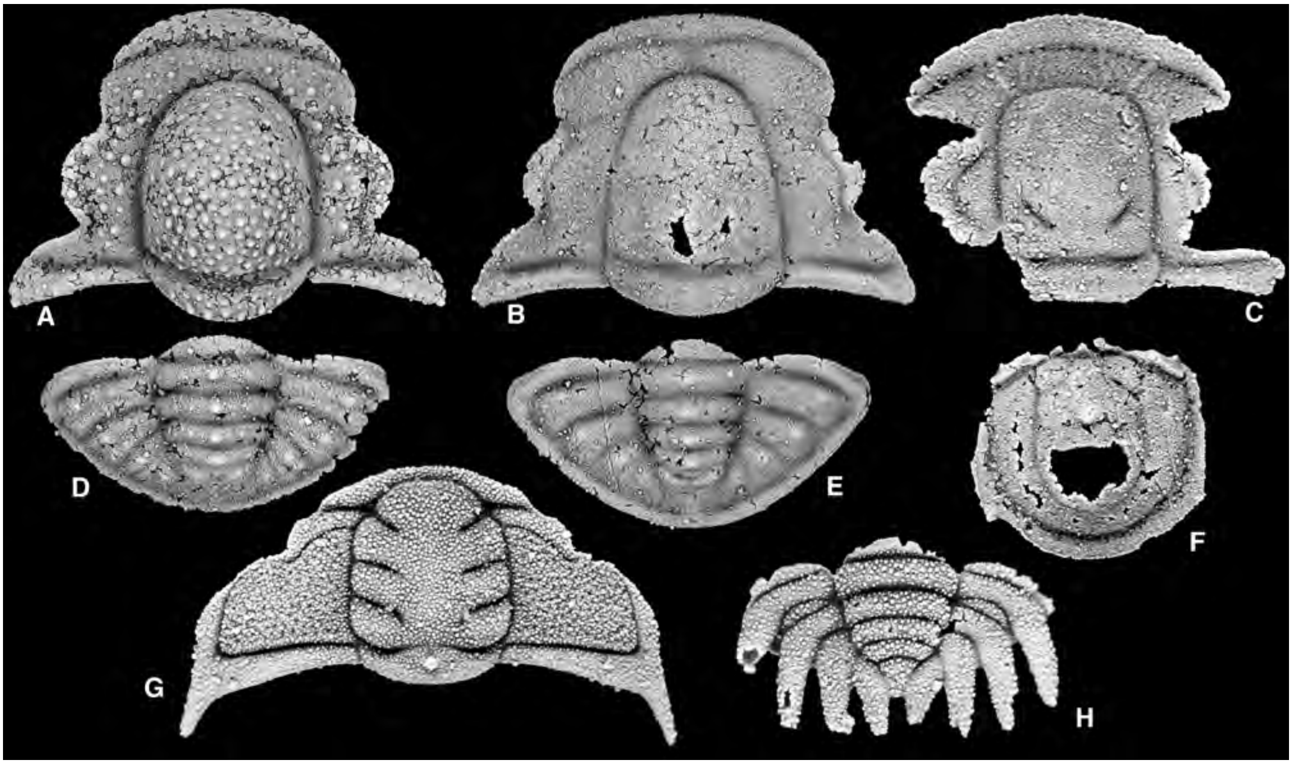


Figure 6. Trilobites and agnostoid arthropod of the *Paraplethopeltis helli* Zone. All views are dorsal, and all specimens are from C 2.6T m. **A**, **D**, ***Paraplethopeltis helli*** sp. nov. A, cranidium, SUI 134273, x7.5. D, pygidium, SUI 134278, x10. **B**, **E**, ***Paenebeltella* sp. nov. 1**. B, cranidium, SUI 134043, x9. E, pygidium, SUI 134044, x9. **C**, ***Kainella* sp. nov. 1**, cranidium, SUI 134045, x12. **F**, ***Geragnostus* sp. 1**, pygidium, SUI 134046, x10. **G**, **H**, **Pilekiinae gen. nov. 2 *pliomeris*** (Demeter 1973). G, cranidium, SUI 134047, x12. H, pygidium, SUI 134048, x15.

for example, there is only sparse and partial silicification, whereas a short distance to the north at Section B-Top silicification is pervasive and preservation excellent. At Ibex, the fauna is overwhelmingly dominated by three species of *Paraplethopeltis* Bridge & Cloud 1947. Hintze (1953, pl. 7, figs 1–9) illustrated sclerites belonging to all three, but assigned them to only two species. The material he assigned to *P. genacurva* (Hintze 1953, pl. 7, figs 1–5) is correctly associated. However, the material assigned to *P. generecta* represents two species. The two librigenae (one of which is the holotype of *P. generecta*) belong together with the illustrated pygidium (i.e., Hintze 1953, pl. 7, figs 6, 7, 9). The cranidium (Hintze 1953, pl. 7, fig. 8) represents a third (new) species. The correct cranidium of *P. generecta* is illustrated herein for the first time (Fig. 5B). All three species will be dealt with in detail in a forthcoming work.

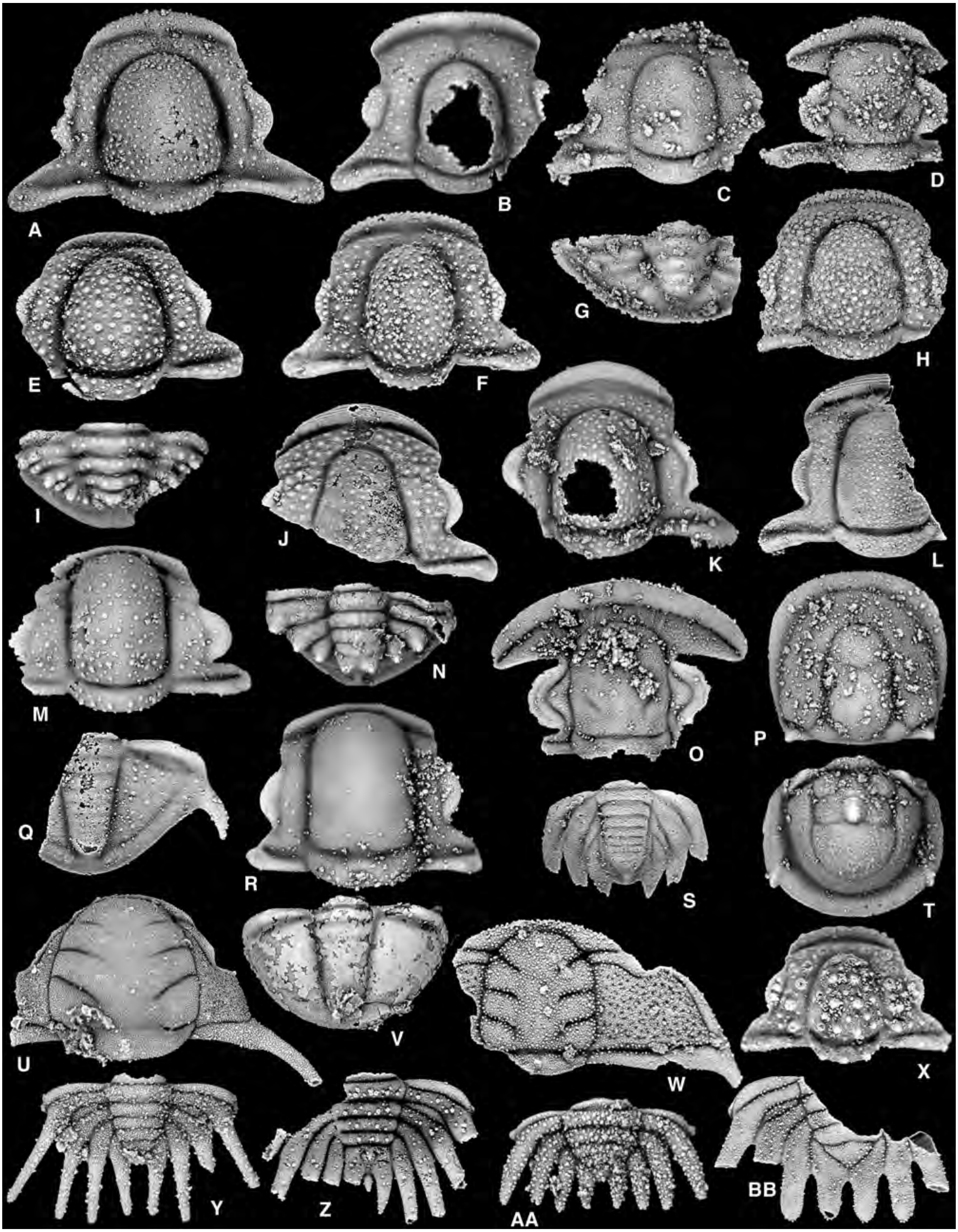
A fauna also dominated by *Paraplethopeltis* occurs in a similar stratigraphic position in the Garden City Formation at Section HC5 52.1 m. The trilobites are not silicified, but well preserved crackout material has been sampled. While it may be a function of a much smaller sample size owing to calcareous preservation requiring mechanical preparation, thus far the only species recovered is *P. genacurva*.

Taylor *et al*. (2012) characterised the content of the zone as "dominated by a survivor of the stage-boundary extinction that decimated the diverse fauna of the underlying *Bellefontia* trilobite Zone...." In the present state of knowledge, however, the sister group of *Paraplethopeltis* is obscure. The diverse pre-extinction faunas feature common species belonging to Hintzecurinae (see Adrain *et al*. 2003) and there is no obvious close phylogenetic relationship between them and *Paraplethopeltis*. A few taxa certainly did cross the extinction horizon. A very rare species of *Symphysurina* Ulrich in Walcott 1924, occurs in the zone, the youngest known. A rare dimeropygid has clear phylogenetic connections to Skullrockian and later Stairsian species. And although absent from the lower two Stairsian zones, *Hystricurus* s.s. Raymond 1913, is known with certainty from the upper Skullrockian (work in progress) and reappears as a common faunal element in the *Hystricurus zanderi* Zone.

2. *Paraplethopeltis helli* Zone (new) (Fig. 6)

Horizons. B-TOP 14.0–14.5, C 2.6T m. The zone is also present at MME 12.0 m, but the trilobites are not silicified.

Figure 7 (opposite). Trilobites and agnostoid arthropod of the *Hystricurus zanderi* Zone. All views are dorsal, and all specimens are from MME 22.3 m. **A**, ***Amblycranium* sp. nov. 1**, SUI 134049, x12. **B**, **Hystricuridae? gen. nov. 1 sp. nov. 2**, cranidium, SUI 134050, x10. **C**, **G**, ***Paenebeltella* sp. nov. 2**. C, cranidium, SUI 134051, x12. G, pygidium, SUI 134052, x7.5. **D**, ***Apatokephalus* sp. nov. 1**, cranidium, SUI 134053, x10. **E**, **I**, **Dimeropygidae gen. nov. 2 sp. nov. 2**. E, cranidium, SUI 134054, x9. I, pygidium, SUI 134055, x10. **F**, ***Parahystricurus* sp. nov. 1**, cranidium, SUI 134056, x9. **H**, **Hillyardininae gen. nov. 1 sp. nov. A**, cranidium, SUI 134057, x8. **J**, **N**, ***Hystricurus zanderi*** sp. nov. J, cranidium, SUI 99742, x6. N, pygidium, SUI 134285, x10. **K**, **Hystricuridae gen. nov. 2 sp. nov. 1**, cranidium, SUI 134058, x5. **L**, **Hystricuridae gen. nov. 2 sp. nov. 2**, cranidium, SUI 134059, x6. (*continued opposite*)



M, **Q**, ***Perischodory* sp. nov. 1**. M, cranidium, SUI 134060, x10. Q, pygidium, SUI 134061, x7.5. **O**, **S**, ***Kainella* sp. nov. 2**. O, cranidium, SUI 134062, x10. S, pygidium, SUI 134063, x8. **P**, **T**, ***Geragnostus* sp. nov. 1**. P, cephalon, SUI 134064, x12. T, pygidium, SUI 134065, x12. **R**, **V**, ***Leiostegium* sp. nov. 1**. R, cranidium, SUI 134066, x10. V, pygidium, SUI 134067, x5. **U**, **Y**, ***Pilekia* sp. nov. 1**. U, cranidium, SUI 134068, x7.5. Y, pygidium, SUI 134069, x7.5. **W**, **AA**, ***Rossaspis* sp. nov. 1**. W, cranidium, SUI 134070, x9. AA, pygidium, SUI 134071, x12. **X**, **Dimeropygidae gen. nov. 2 sp. nov. 1**, cranidium, SUI 134072, x12. **Z**, **Pilekiinae sp. 1**, pygidium, SUI 134073, x7.5. **BB**, **Pilekiinae gen. nov. 3 sp. nov. A**, pygidium, SUI 134074, x4.5.

Species (6):
Agnostoid Arthropods
Geragnostus sp. 1 (Fig. 6F)
Cheiruridae
Pilekiinae gen. nov. 2 *pliomeris* (Demeter 1973) (Fig. 6G, H)
Hystricuridae
Paenebeltella sp. nov. 1 (Fig. 6B, E)
Paraplethopeltis helli sp. nov. (Figs 6A, D, 18)
Leiostegiidae
Leiostegium sp. nov. A
Remopleurididae
Kainella sp. nov. 1 (Fig. 6C)

Remarks. Well preserved silicified trilobites occur in very thin bedded lime mudstone in a recessive interval near the base of the Fillmore Formation. The most prolific samples occur near the base of Section C, from which Demeter (1973) described his new "*Rossaspis*" *pliomeris*. The fauna has also been located with slightly poorer silicification at B-TOP 14.0–14.5 m and in calcareous preservation at MME 12.0 m. Apart from "*R.*" *pliomeris*, the two most common species are *Paraplethopeltis helli*, described below, and an apparently phylogenetically basal species of *Paenebeltella* Ross 1951 (=*Glabretina* Lochman 1965). This zone represents the basal part of the obsolete "*Leiostegium* Zone" and equivalents of previous authors. None of its species range into the overlying zone. Leiostegiid trilobites are present sporadically at many horizons of the "*Leiostegium* Zone", but they also occur as rare elements throughout the Stairsian and into the Tulean at Ibex.

3. *Hystricurus zanderi* Zone (new) (Fig. 7)

Horizon. MME 23.3 m.

Species (20):
Agnostoid Arthropods
Geragnostus sp. nov. 1 (Fig. 7P, T)
Cheiruridae
Pilekia sp. nov. 1 (Fig. 7U, Y)
Pilekiinae gen. nov. 3 sp. nov. A (Fig. 7BB)
Pilekiinae sp. 1 (Fig. 7Z)
Rossaspis sp. nov. 1 (Fig. 7W, AA)
Rossaspis sp.
Dimeropygidae
Amblycranium sp. nov. 1 (Fig. 7A)
Dimeropygidae gen. nov. 2 sp. nov. 2 (Fig. 7E, I)
Dimeropygidae gen. nov. 2 sp. nov. 1 (Fig. 7X)
Parahystricurus sp. nov. 1 (Fig. 7F)
Hystricuridae
Hillyardininae gen. nov. 1 sp. nov. A (Fig. 7H)
Hystricuridae? gen. nov. 1 sp. nov. 2 (Fig. 7B)
Hystricuridae gen. nov. 2 sp. nov. 2 (Fig. 7L)
Hystricuridae gen. nov. 2 sp. nov. 1 (Fig. 7K)
Hystricurus zanderi sp. nov. (Figs 7J, N, 19)
Paenebeltella sp. nov. 2 (Fig. 7C, G)
Leiostegiidae
Leiostegium sp. nov. 1 (Fig. 7R, V)
Perischodory sp. nov. 1 (Fig. 7M, Q)
Remopleurididae
Apatokephalus sp. nov. 1 (Fig. 7D)
Kainella sp. nov. 2 (Fig. 7O, S)

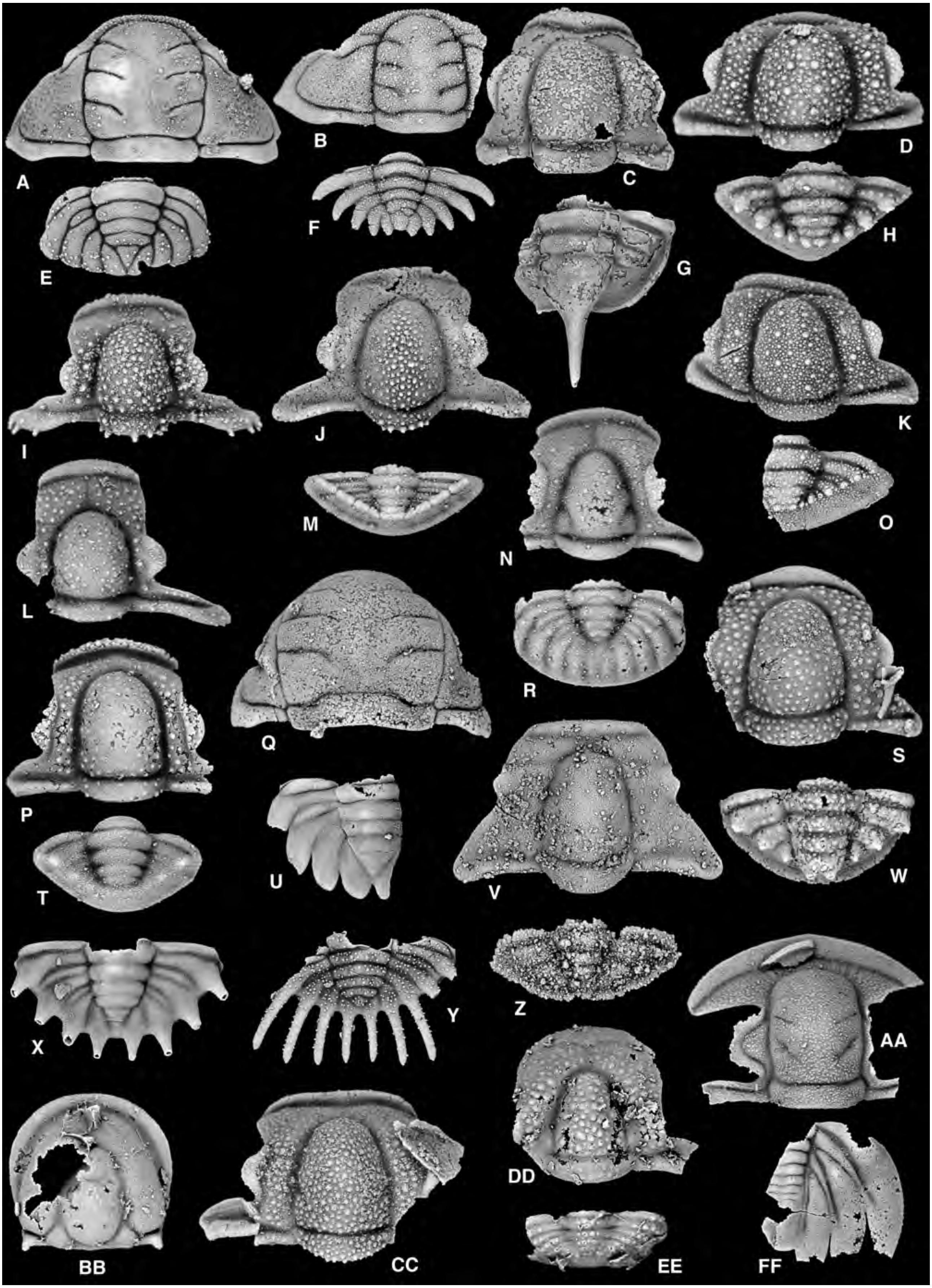
Remarks. A sample from Section MME 22.3 m at Middle Mountain features the stratigraphically lowest of the high diversity (20–24 species) faunas typical of the remainder of the Stairsian (lower diversity exceptions below are almost certainly due to small sample sizes). These faunas tend to have common species of *Hystricurus* s.s., and are dominated by species presently assigned to Cheiruridae, Hystricuridae and Dimeropygidae. The fauna of the *Hystricurus zanderi* Zone was apparently overlooked during earlier sampling. All of its species are new and unique to the zone, which has yet to be sampled in any other locality or section. The selected name bearer is a large and distinctive member of *Hystricurus* s.s., described below.

4. *Rossaspis leboni* Zone (new) (Fig. 8)

Horizons. MME 36.4, 49.8, 51.8, HC6 58.4 m.

Species (22):
Agnostoid Arthropods
Geragnostus sp. 2 (Fig. 8BB)
Cheiruridae
Pilekia sp. nov. A
Pilekia sp. nov. B (Fig. 8X)
Pilekiinae gen. nov. 3 sp. nov. 1 (Fig. 8Q, U)
Pilekiinae sp. 2 (Fig. 8Y)
Rossaspis leboni sp. nov. (Figs 8B, F, 20)
Tesselacauda sp. nov. 1 (Fig. 8A, E)
Dimeropygidae
Amblycranium sp. nov. 3 (Fig. 8L)

Figure 8. Trilobites and agnostoid arthropod of the *Rossaspis leboni* Zone. All views are dorsal. **A**, **E**, ***Tesselacauda* sp. nov. 1**. A, cranidium, SUI 134075, x7.5 (MME 49.8 m). E, pygidium, SUI 134076, x7.5 (MME 49.8 m). **B**, **F**, ***Rossaspis leboni*** sp. nov. B, cranidium, SUI 134077, x7.5 (MME 49.8 m). F, pygidium, SUI 134290, x7.5 (MME 49.8 m). **C**, **G**, ***Gonioteloides* sp. nov. 1**. C, cranidium, SUI 134078, x5 (MME 49.8 m). G, pygidium, SUI 134079, x3 (MME 49.8 m). **D**, **H**, **Dimeropygidae gen. nov. 2 sp. nov. 4**. D, cranidium, SUI 134080, x12 (MME 49.8 m). H, pygidium, SUI 134081, x10 (MME 49.8 m). **I**, ***Amblycranium* sp. nov. 2**, cranidium, SUI 134082, x10 (MME 49.8 m). **J**, **M**, **Hillyardininae gen. nov. 1 sp. nov. 1**. J, cranidium, SUI 134083, x6 (MME 49.8 m). M, pygidium, SUI 134084, x10 (MME 49.8 m). **K**, **O**, **Dimeropygidae gen. nov. 2 sp. nov. 3**. K, cranidium, SUI 134085, x10 (MME 49.8 m). O, pygidium, SUI 134086, x10 (MME 49.8 m). **L**, ***Amblycranium* sp. nov. 3**, cranidium, SUI 134087, x11 (HC6 58.4 m). **N**, **R**, **Hystricuridae? gen. nov. 1 sp. nov. 1**. N, cranidium, SUI 134088, x12 (MME 49.8 m). R, pygidium, SUI 134089, x12 (MME 49.8 m). **P**, **T**, **Hillyardininae gen. nov. 3 sp. nov. 1**. P, cranidium, SUI 134090, x9 (MME 49.8 m). T, pygidium, SUI 134091, x10 (MME 49.8 m). **Q**, **U**, **Pilekiinae gen. nov. 3 sp. nov. 1**. Q, cranidium, SUI 134092, x6 (MME 49.8 m). U, pygidium, SUI 134093, x3 (MME 49.8 m). **S**, **W**, ***Hystricurus* sp. nov. 1**. S, cranidium, SUI 134094, x4 (MME 49.8 m). W, pygidium, SUI 134095, x6 (MME 49.8 m). **V**, **Z**, ***Paenebeltella* sp. nov. 3**. V, cranidium, SUI 134096, x10 (HC6 58.4 m). Z, pygidium, SUI 134097, x15 (MME 51.8 m). **X**, ***Pilekia* sp. nov. B**, pygidium, SUI 134098, x3 (MME 49.8 m). **Y**, **Pilekiinae sp. 2**, pygidium, SUI 134099, x3 (MME 49.8 m). **AA**, **FF**, ***Kainella* sp. nov. 3**. AA, cranidium, SUI 134100, x7.5 (HC6 58.4 m). FF, pygidium, SUI 134101, x4 (MME 49.8 m). **BB**, ***Geragnostus* sp. 2**, cephalon, SUI 134102, x10 (MME 36.4 m). **CC**, **Hillyardininae gen. nov. 1 sp. nov. B**, cranidium, SUI 134103, x6 (MME 49.8 m). **DD**, **EE**, ***Pseudoclelandia* sp. nov. 1**. DD, cranidium, SUI 134104, x9 (MME 36.4 m). EE, pygidium, SUI 134105, x12 (MME 36.4 m).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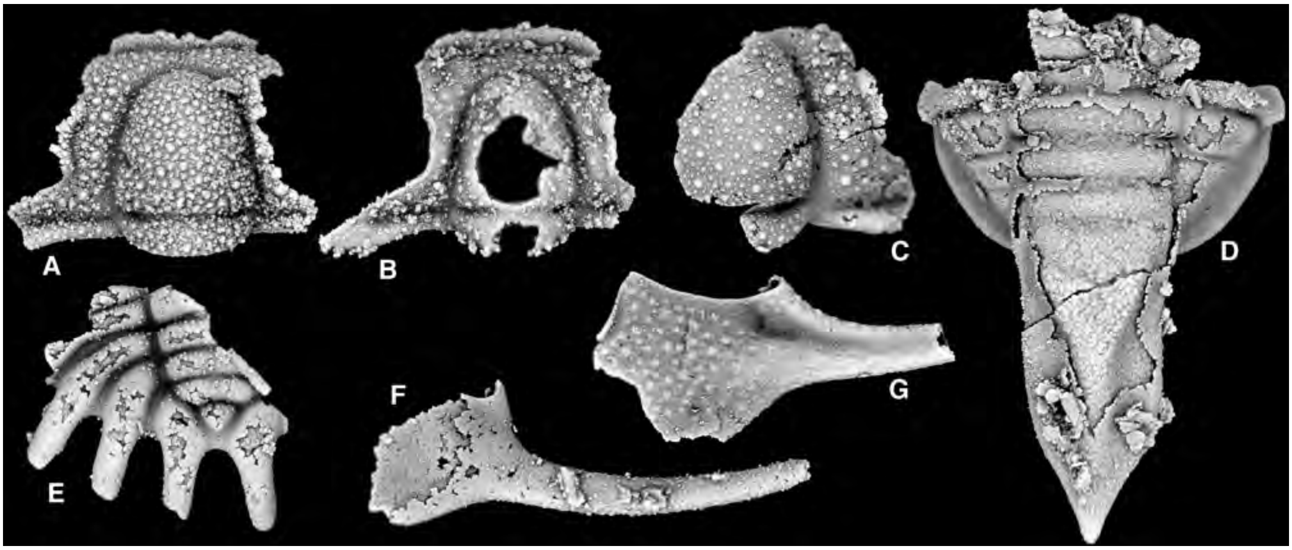


Figure 9. Trilobites of Unnamed Zone 1. All views are dorsal, and all specimens are from MME 60.7 m. **A**, **Hillyardininae gen. nov. 1 sp. nov. C**, cranidium, SUI 134106, x12. **B**, ***Amblycranium* sp.**, cranidium, SUI 134107, x12. **C**, **Dimeropygidae gen. nov. 2 sp. 2**, cranidium, SUI 134108, x7.5. **D**, ***Gonioteloides* sp. nov. A**, pygidium, SUI 134109, x6. **E**, **Pliomeridae gen. nov. A sp. nov. A**, pygidium, SUI 134110, x10. **F**. ***Paenebeltella* sp.**, left librigena, SUI 134111, x10. **G**. **Hystricuridae gen. nov. 3 sp.**, left librigena, SUI 134112, x7.5.

Amblycranium sp. nov. 2 (Fig. 8I)
Dimeropygidae gen. nov. 2 sp. nov. 4 (Fig. 8D, H)
Dimeropygidae gen. nov. 2 sp. nov. 3 (Fig. 8K, O)
Gonioteloides sp. nov. 1 (Fig. 8C, G)

Hystricuridae
Hillyardininae gen. nov. 1 sp. nov. 1 (Fig. 8J, M)
Hillyardininae gen. nov. 1 sp. nov. B (Fig. 8CC)
Hillyardininae gen. nov. 3 sp. nov. 1 (Fig. 8P, T)
Hystricuridae? gen. nov. 1 sp. nov. 1 (Fig. 8N, R)
Hystricurus sp. nov. 1 (Fig. 8S, W)
Paenebeltella sp. nov. 3 (Fig. 8V, Z)

Leiostegiidae
Leiostegium sp. nov. B

Remopleurididae
Apatokephalus sp.
Kainella sp. nov. 3 (Fig. 8AA, FF)

Uncertain
Pseudoclelandia sp. nov. 1 (Fig. 8DD, EE)

Remarks. This zone is named for a common species of the cheirurid *Rossaspis* Harrington 1957, *R. leboni*, described below. It is notable in that it is the lowest Stairsian zone which can be unambiguously located in the Garden City Formation, as all species occurring in a limited but well preserved sample at HC6 58.4 m are shared with MME 49.8 m. The zone would occupy the middle part of the obsolete "*Leiostegium* Zone", but does not appear to have been detected in previous sampling. All of its species are new, and all are unique to the zone.

5. Unnamed Zone 1 (Fig. 9)

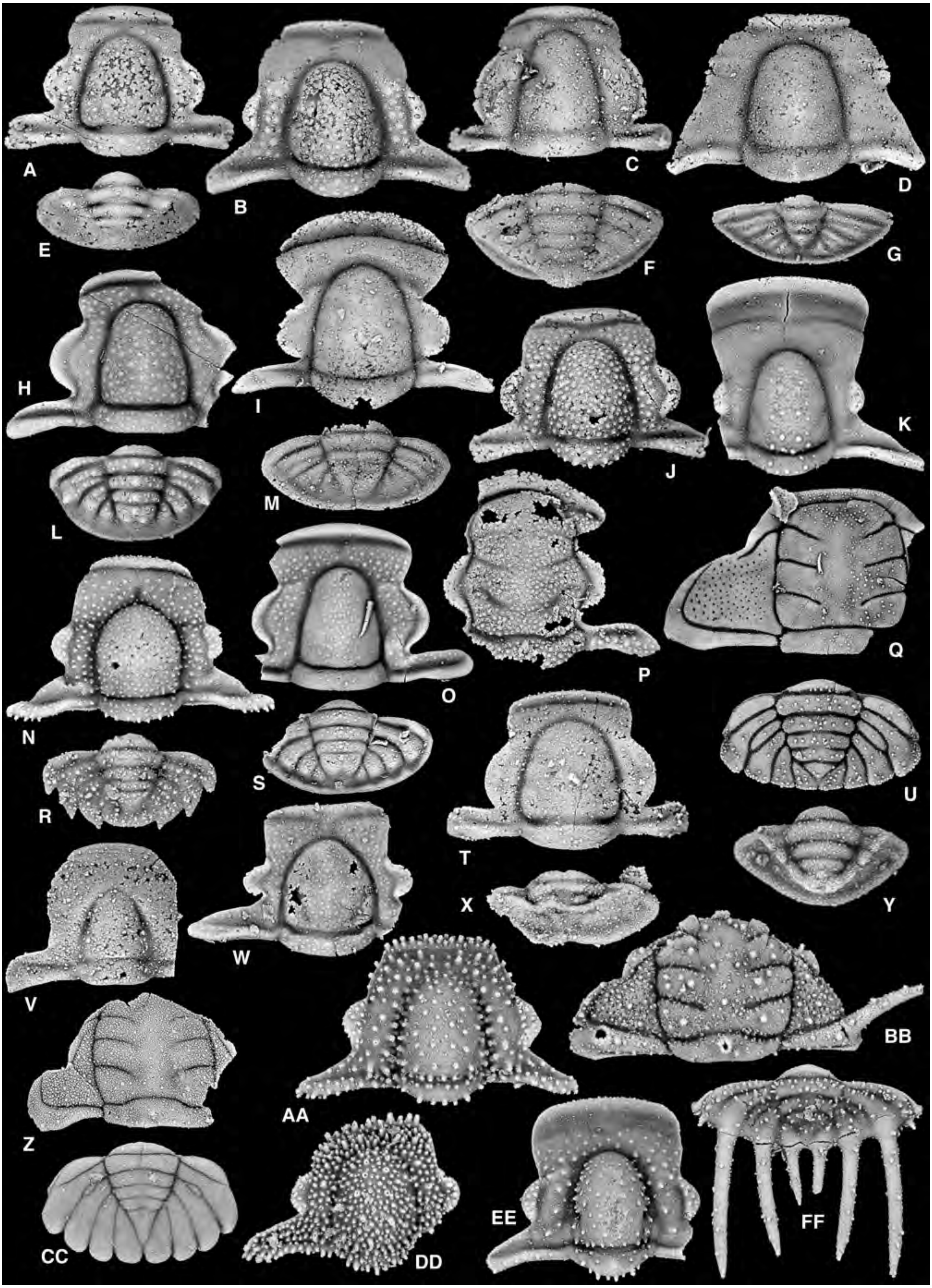
Horizon. MME 60.7 m.

Species (7):

Dimeropygidae
Amblycranium sp. (Fig. 9B)
Dimeropygidae gen. nov. 2 sp. 2 (Fig. 9C)
Gonioteloides sp. nov. A (Fig. 9D)

Hystricuridae
Hillyardininae gen. nov. 1 sp. nov. C (Fig. 9A)
Hystricuridae gen. nov. 3 sp. (Fig. 9G)

Figure 10. Trilobites of the *Bearriverops loganensis* Zone. All views are dorsal. **A**, **E**, ***Bearriverops loganensis*** Adrain & Westrop 2007a. A, cranidium, SUI 99887, x7.5 (MME 75.5 m). E, pygidium, SUI 99901, x7.5 (MME 75.5 m). **B**, **Hillyardininae gen. nov. 1 *carinata*** (Ross 1951), cranidium, SUI 134113, x9 (MME 75.5 m). **C**, **F**, ***Gonioteloides* sp. nov. 2**. C, cranidium, SUI 134114, x7.5 (MME 75.5 m). F, pygidium, SUI 134115, x10 (MME 75.5 m). **D**, **G**, ***Paenebeltella vultulata*** Ross 1951. D, cranidium, SUI 134116, x7.5 (MME 75.5 m). G, pygidium, SUI 134117, x7.5 (MME 75.5 m). **H**, **L**, ***Hystricurus eos*** Kobayashi 1955. H, cranidium, SUI 134118, x6 (MME 75.5 m). L, pygidium, SUI 134119, x6 (MME 75.5 m). **I**, **M**, **Hystricuridae gen. nov. 4 sp. nov. 1**. I, cranidium, SUI 134120, x7.5 (MME 75.5 m). M, pygidium, SUI 134121, x7.5 (MME 75.5 m). **J**, **Hillyardininae gen. nov. 1 *robusta*** (Ross 1951), cranidium, SUI 134122, x7.5 (MME 75.5 m). **K**, ***Hyperbolochilus* sp. nov. 1**, cranidium, SUI 134123, x6 (MME 75.5 m). **N**, **R**, ***Amblycranium variabile*** Ross 1951. N, cranidium, SUI 134124, x7.5 (MME 75.5 m). R, pygidium, SUI 134125, x12 (MME 75.5 m). **O**, **S**, **Hystricuridae gen. nov. 2 sp. nov. 3**. O, cranidium, SUI 134126, x6 (HC5 106.7 m). S, pygidium, SUI 134127, x6 (HC5 106.7 m). **P**, ***Apatokephalus* sp. nov. 2**, cranidium, SUI 134128, x7.5 (MME 75.5 m). **Q**, **U**, ***Tesselacauda depressa*** Ross 1951. Q, cranidium, SUI 134129, x5 (MME 75.5 m). U, pygidium, SUI 134130, x6 (MME 75.5 m). **T**, **X**, ***Bearriverops borderinnensis*** Adrain & Westrop 2007a. T, cranidium, SUI 99927, x10 (MME 75.5 m). X, pygidium, SUI 99935, x10 (MME 75.5 m). **V**, ***Pseudoclelandia* sp. 1**, cranidium, SUI 134131, x12 (MME 75.5 m). **W**, **Hystricuridae gen. nov. 3 *populus*** (Ross 1951), cranidium, SUI 134132, x5 (MME 75.5 m). **Y**, **Dimeropygidae gen. nov. 1 sp. nov. A**, pygidium, SUI 134133, x15 (HC5 106.7 m). **Z**, **CC**, **Pilekiinae gen. nov. 3 sp. nov. 2**. Z, cranidium, SUI 134134, x10 (FB7 102.1 m). CC, pygidium, SUI 134135, x8 (HC5 106.7 m). **AA**, ***Parahystricurus* sp. nov. 2**, cranidium, SUI 134136, x12 (HC5 106.7 m). **BB**, **FF**, **Pilekiinae gen. nov. 4 *trio*** (Hintze 1953). BB, cranidium, SUI 134137, x15 (FB7 102.1 m). FF, pygidium, SUI 134138, x10 (HC5 106.7 m). **DD**, **Hillyardininae gen. nov. 1 sp. nov. 2**, cranidium, SUI 134139, x12 (HC5 106.7 m). **EE**, ***Hillyardina* sp. nov. 1**, cranidium, SUI 134140, x9 (HC5 106.7 m).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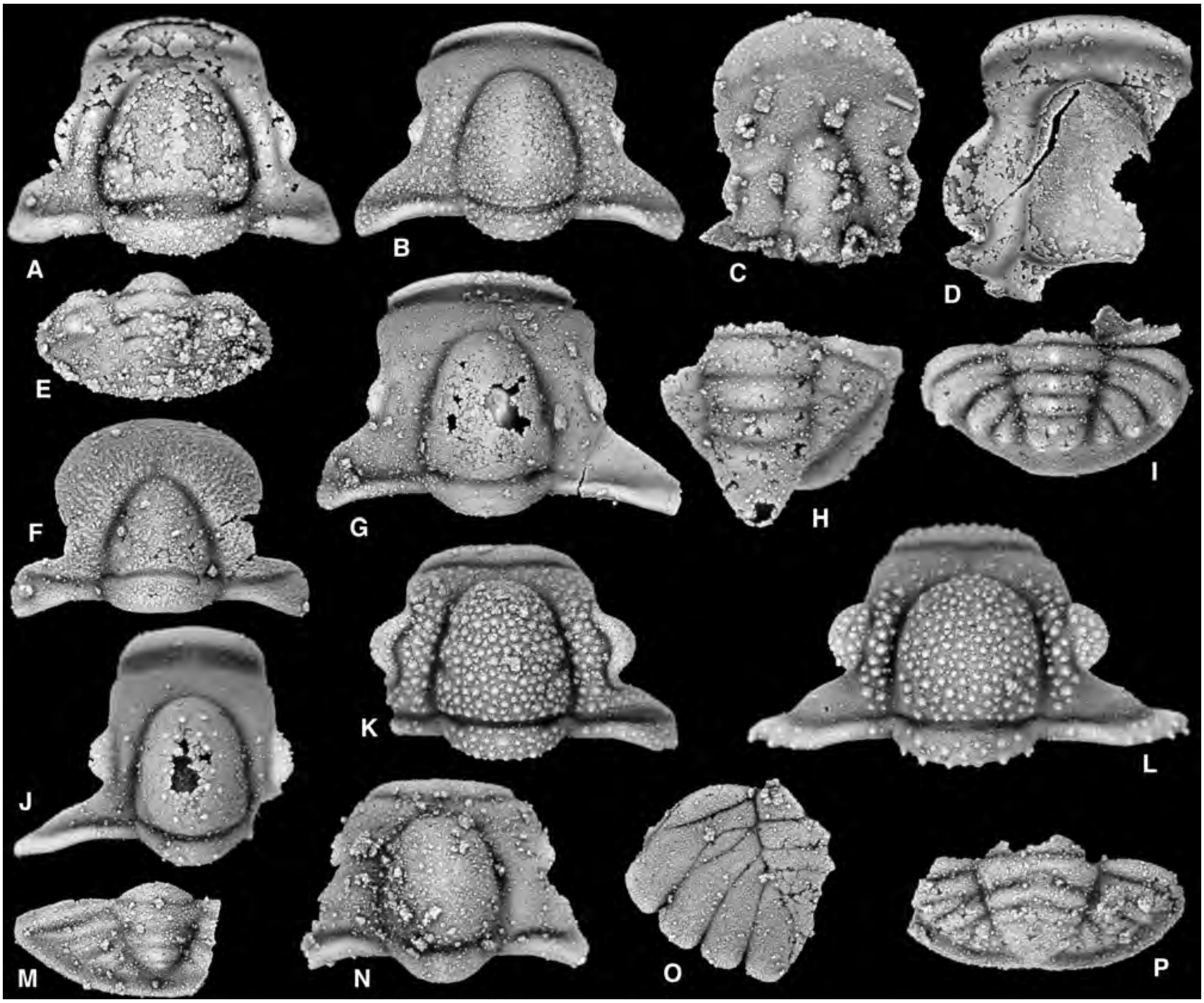


Figure 11. Trilobites of the *Bearriverops deltaensis* Zone. All views are dorsal, and all specimens are from MME 84.0 m. **A**, **E**, ***Bearriverops deltaensis*** Adrain & Westrop 2007a. A, cranidium, SUI 99908, x10. E, pygidium, SUI 99920, x10. **B**, **Hillyardininae gen. nov. 1 sp. nov. 4**, cranidium, SUI 134141, x6. **C**, ***Amechilus*** **sp**., cranidium, SUI 134142, x15. **D**, **I**, ***Hystricurus*** **sp. nov. A**. D, cranidium, SUI 134143, x5. I, pygidium, SUI 134144, x12. **F**, ***Pseudoclelandia*** **sp. nov. 2**, cranidium, SUI 134145, x12. **G**, **Hillyardininae gen. nov. 1 sp. nov. D**, cranidium, SUI 134146, x7.5. **H**, ***Gonioteloides*** **sp. nov. B**, pygidium, SUI 134147, x12. **J**, ***Hyperbolochilus*** **sp. nov. 2**, cranidium, SUI 134148, x12. **K**, **Hillyardininae gen. nov. 1 sp. nov. 3**, cranidium, SUI 134149, x10. **L**, ***Amblycranium*** **sp. nov. 4**, cranidium, SUI 134150, x12. **M**, **N**, ***Paenebeltella vultulata*** Ross 1951. M, pygidium, SUI 134151, x10. N, cranidium, SUI 134152, x12. **O**, **Pilekiinae gen. nov. 3 sp. nov. 2?**, pygidium, SUI 134153, x12. **P**, **Hystricuridae gen. nov. 4 sp**., pygidium, SUI 134154, x15.

Paenebeltella sp. (Fig. 9F)

Pliomeridae

Pliomeridae gen. nov. A sp. nov. A (Fig. 9E)

Remarks. A very limited sample from MME 60.7 contains overall diversity similar to that of the underlying and overyling zones. However, for all comparisons that can be made, the species occurring appear to be distinct and unique to the horizon. For example, the species of *Gonioteloides* present (Fig. 9D) has a huge terminal pygidial spine much larger than that of any other known species. Unfortunately, none of the species are currently well enough known to formally name, and hence the zone itself is left unnamed. Preservation is reasonably good, but trilobite sclerites are rare in the sample. Very large field samples were made recently in the hope that material adequate to name some of the species present can eventually be accumulated. This zone represents the highest horizon that would previously have been assigned to the obsolete "*Leiostegium* Zone".

6. *Bearriverops loganensis* Zone (new) (Fig. 10)

Horizons. MME 75.5, 76.0T, HC5 106.7, HC6 88.3, 89.5, FB7 102.1 m.

Species (24):

Cheiruridae

Pilekiinae gen. nov. 3 sp. nov. 2 (Fig. 10Z, CC)

Pilekiinae n gen. 4 *trio* (Hintze 1953) (Fig. 10BB, FF)

Tesselacauda depressa Ross 1951 (Fig. 10Q, U)

Dimeropygidae

Amblycranium variabile Ross 1951 (Fig. 10N, R)

Bearriverops borderinnensis Adrain & Westrop 2007a (Fig. 10T, X)

Bearriverops loganensis Adrain & Westrop 2007a (Fig. 10A, E)
Dimeropygidae gen. nov. 1 sp. nov. A (Fig. 10Y)
Gonioteloides sp. nov. 2 (Fig. 10C, F)
Parahystricurus sp. nov. 2 (Fig. 10AA)

Hystricuridae
Hillyardina sp. nov. 1 (Fig. 10EE)
Hillyardininae gen. nov. 1 *carinata* (Ross 1951) (Fig. 10B)
Hillyardininae gen. nov. 1 *robusta* (Ross 1951) (Fig. 10J)
Hillyardininae gen. nov. 1 sp. nov. 2 (Fig. 10DD)
Hyperbolochilus sp. nov. 1 (Fig. 10K)
Hyperbolochilus sp. nov. A
Hystricuridae gen. nov. 2 sp. nov. 3 (Fig. 10O, S)
Hystricurus eos Kobayashi 1955 (Fig. 10H, L)
Hystricuridae gen. nov. 3 *populus* (Ross 1951) (Fig. 10W)
Hystricuridae gen. nov. 4 sp. nov. 1 (Fig. 10I, M)
Paenebeltella vultulata Ross 1951 (Fig. 10D, G)

Remopleurididae
Apatokephalus sp. nov. 2 (Fig. 10P)

Uncertain
Amechilus palaora Ross 1951
Pseudoclelandia lenisora Ross 1951
Pseudoclelandia sp. 1 (Fig. 10V)

Remarks. This zone is represented as a single prolifically yielding horizon (or two, very closely spaced) at all relevant sections. A single horizon, HC5 106.7 m, likely yielded most of the species previously assigned to the obsolete "Zone E"/"*Tesselacauda* Zone" by Ross (1951). Based on taphonomic evidence, the same horizon may be represented by HC6 89.5 m and FB7 102.1 m, which feature the same taxon-abundances, very similar styles of silicified preservation, and the unusual prevalence of articulated specimens of the same handful of species.

7. *Bearriverops deltaensis* Zone (new) (Fig. 11)

Horizons. MME 84.0, AAA 79.5, HC6 107.5 m.

Species (14):

Cheiruridae
Pilekiinae gen. nov. 3 sp. nov. 2? (Fig. 11O)

Dimeropygidae
Amblycranium sp. nov. 4 (Fig. 11L)
Bearriverops deltaensis Adrain & Westrop 2007a (Fig. 11A, E)
Bearriverops sp. cf. *B. ibexensis* of Adrain & Westrop (2007a)
Gonioteloides sp. nov. B (Fig. 11H)

Hystricuridae
Hillyardininae gen. nov. 1 sp. nov. 4 (Fig. 11B)
Hillyardininae gen. nov. 1 sp. nov. 3 (Fig. 11K)
Hillyardininae gen. nov. 1 sp. nov. D (Fig. 11G)
Hyperbolochilus sp. nov. 2 (Fig. 11J)
Hystricuridae gen. nov. 4 sp. (Fig. 11P)
Hystricurus sp. nov. A (Fig. 11D, I)
Paenebeltella vultulata Ross 1951 (Fig. 11M, N)

Uncertain
Amechilus sp. (Fig. 11C)
Pseudoclelandia sp. nov. 2 (Fig. 11F)

Remarks. Species from this zone are typically very similar to, yet clearly differentiated from, congenerics in the underlying *Bearriverops loganensis* Zone. This was first demonstrated by Adrain & Westrop (2007a) who noted the subtle distinctions between *B. deltaensis* and *B. loganensis*. As photography has advanced, similar distinctions have become apparent for almost all of the species present. Only *Paenebeltella vultulata* Ross 1951, appears to be shared between the zones. Lower diversity of this zone is likely a result of the limited sample sizes thus far available.

8. *Bearriverops alsacharovi* Zone (new) (Fig. 12)

Horizons. G 26.6, 27.0, 27.1, C 111.6, MME 102.2, HC5 128.0, HC6 122.5, 124.0 m.

Species (21):

Cheiruridae
Pilekia loella Demeter 1973 (Fig. 12AA, FF)
Pilekiinae gen. nov. 3 sp. nov. B (Fig. 12EE)
Pilekiinae n gen. 4 sp. nov. 2 (Fig. 12O, T)
Pilekiinae n gen. 4 sp. nov. 1 (Fig. 12CC, GG)
Tesselacauda sp. nov. 2 (Fig. 12Y, DD)

Dimeropygidae
Amblycranium sp. nov. 5 (Fig. 12K)
Bearriverops alsacharovi Adrain & Westrop 2007a (Fig. 12A, E)
Bearriverops ibexensis Adrain & Westrop 2007a (Fig. 12B, F)
Dimeropygidae gen. nov. 1 sp. nov. 1 (Fig. 12D, H)
Gonioteloides monoceras Kobayashi 1955 (Fig. 12C, G)

Hystricuridae
Hillyardininae gen. nov. 2 sp. nov. 1 (Fig. 12J, N)
Hyperbolochilus sp. nov. 4 (Fig. 12L)
Hyperbolochilus sp. nov. 3 (Fig. 12R, W)
Hystricuridae gen. nov. 2 sp. nov. 4 (Fig. 12V)
Hystricurus sp. nov. 2 (Fig. 12I, M)
Metabowmania braggi Adrain & Westrop 2007b (Fig. 12S, X)
Pachycranium sp. nov. 1 (Fig. 12P)

Leiostegiidae
Perischodory sp. nov. A (Fig. 12Q)

Pliomeridae
Pliomeridae gen. nov. A sp. nov. B (Fig. 12BB)

Uncertain
Pseudoclelandia sp. nov. 3 (Fig. 12U, Z)
Shumardiidae sp. indet.

Remarks. Rich collections from G 26.6 m and G 27.0 m yielded the only previously named species belonging to this zone, *Pilekia loella* Demeter 1973. New sampling has shown that almost all of the associated species are new (the exception is *Hystricurus eos*, which appears to be the same species described by Kobayashi (1955) and Dean (1989) from further to the (Ordovician) east along the northern Laurentian margin. Samples representing the zone have also been discovered at Sections HC5 and HC6 in the Garden City Formation.

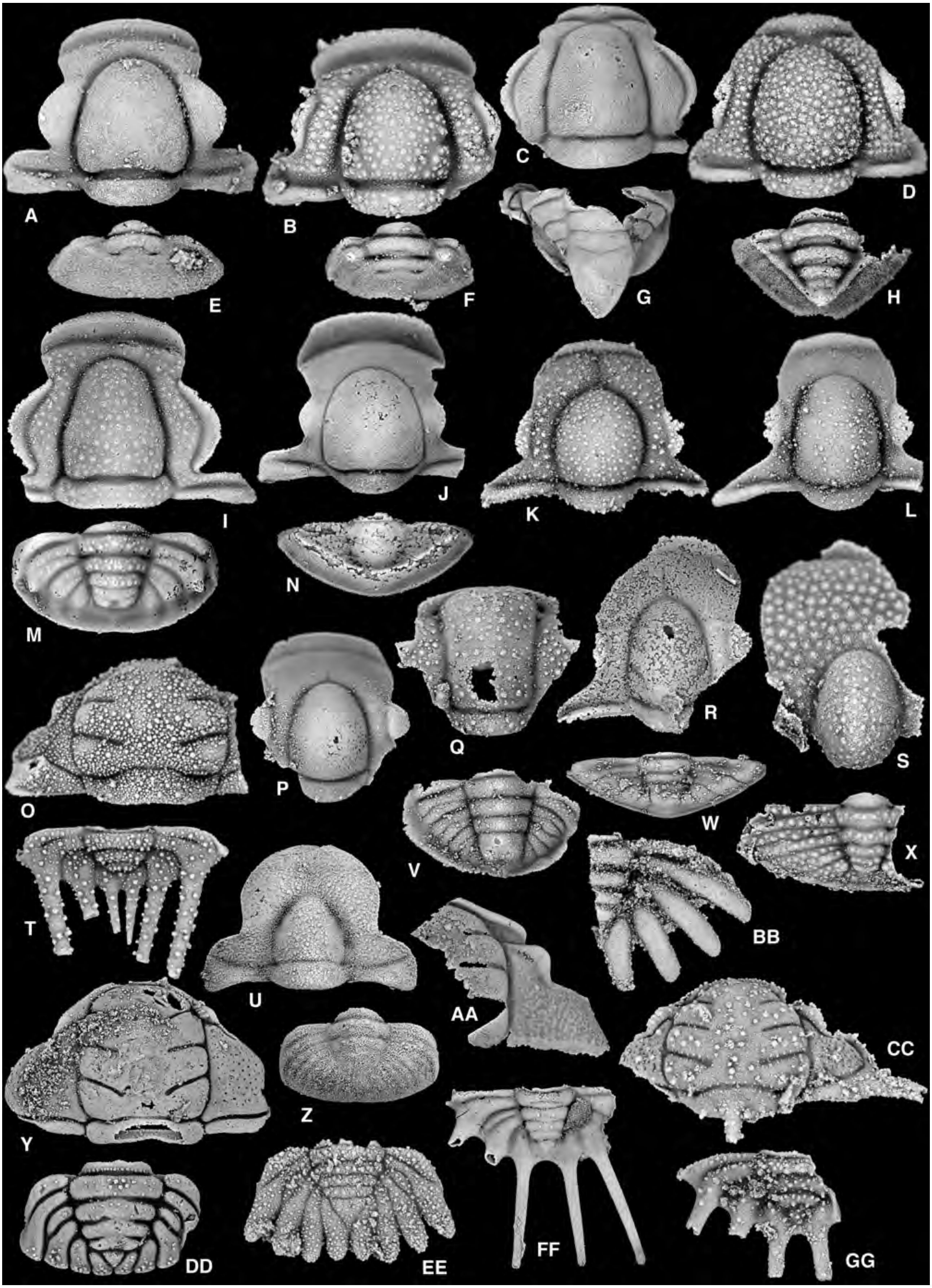
9. *Pseudoclelandia weymouthae* Zone (new) (Fig. 13)

Horizons. AAA 114.5T, C 115.8 m.

Species (6):

Cheiruridae
Rossaspis sp. nov. 2 (Fig. 13J, K)

Hystricuridae
Flectihystricurus sp. nov. 2 (Fig. 13B, F)
Flectihystricurus sp. nov. 1 (Fig. 13A)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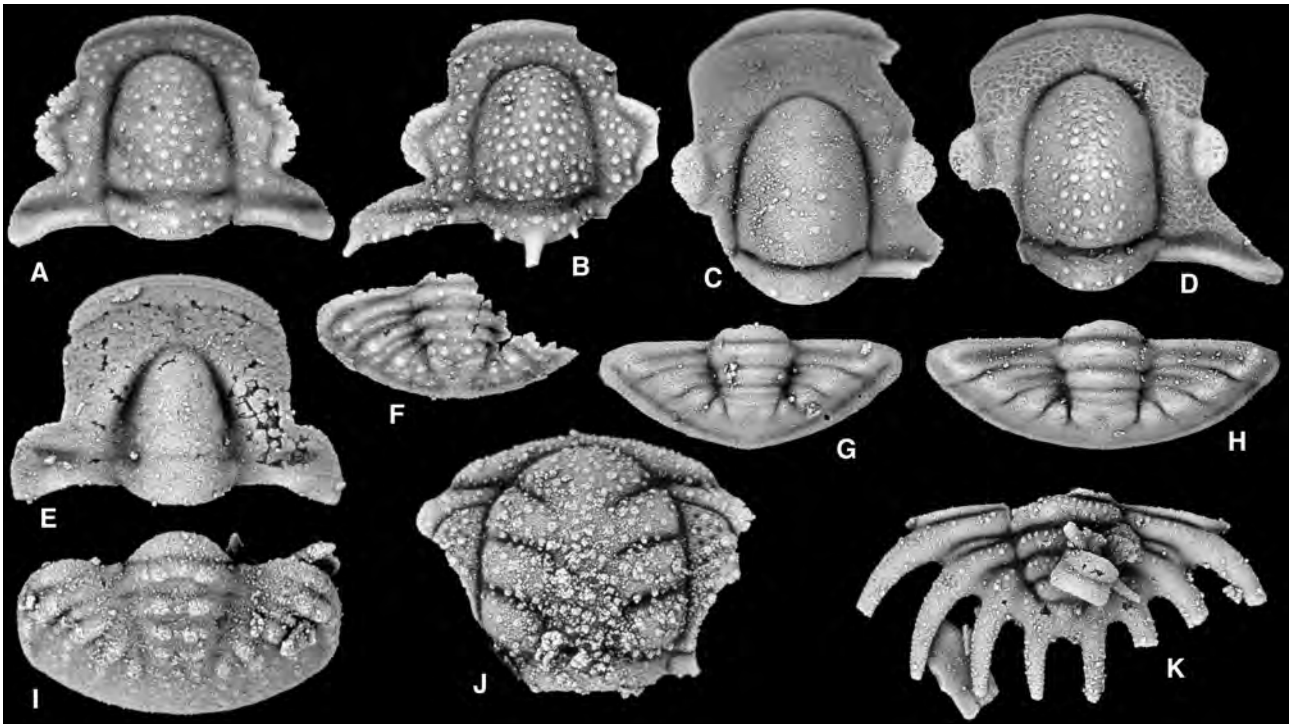


Figure 13. Trilobites of the *Pseudoclelandia weymouthae* Zone. All views are dorsal, and all specimens are from AAA 114.5T m. **A**, ***Flectihystricurus* sp. nov. 1**, cranidium, SUI 134181, x15. **B**, **F**, ***Flectihystricurus* sp. nov. 2**. B, cranidium, SUI 134182, x8. F, pygidium, SUI 134183, x12. **C**, **G**, ***Hyperbolochilus* sp. nov. 6**. C, cranidium, SUI 134184, x10. G, pygidium, SUI 134185, x10. **D**, **H**, ***Hyperbolochilus* sp. nov. 5**. D, cranidium, SUI 134186, x7.5. H, pygidium, SUI 134187, x5. **E**, **I**, ***Pseudoclelandia weymouthae*** sp. nov. E, cranidium, SUI 134188, x15. I, pygidium, SUI 134298, x15. **J**, **K**, ***Rossaspis* sp. nov. 2**. J, cranidium, SUI 134189, x12. K, pygidium, SUI 134190, x10.

Hyperbolochilus sp. nov. 6 (Fig. 13C, G)
Hyperbolochilus sp. nov. 5 (Fig. 13D, H)

Uncertain

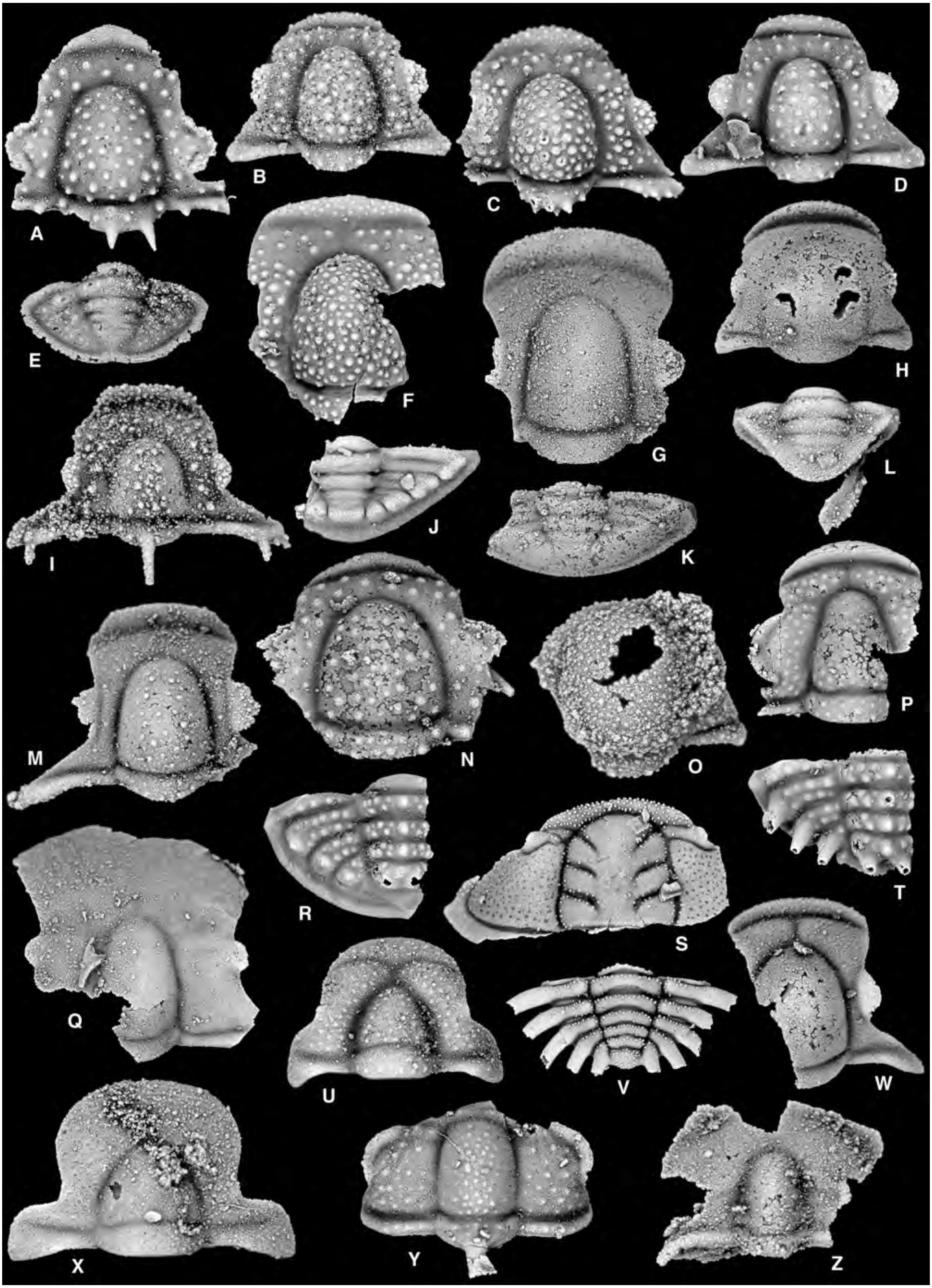
Pseudoclelandia weymouthae sp. nov. (Figs 13E, I, 21)

Remarks. When initially sampled, the stratigraphic position of the *Pseudoclelandia weymouthae* Zone was uncertain. It was collected from talus blocks strewn along strike at Section AAA 114.5T m. All of the species contained in the relatively small available sample were clearly new, but none had been found in any other section. Reconnaisance collections in Hintze's Section C (most of which we have yet to log ourselves), however, yielded the same fauna at C 115.8 m (380' in Hintze's measurement) and revealed that it immediately overlies the *Bearriverops alsacharovi* Zone, which occurs at C 111.6 m (366' in Hintze's measurement). While the fauna of the zone is not well known due to the small available samples, and despite the fact that it has been found in only two sections, it makes no sense to assign these horizons to any other zone as they contain a completely unique fauna with no species shared. As the Stairsian zonal scheme becomes better understood, it will likely be possible to locate underrepresented zones like this via targeted collecting at other sections.

10. *Pseudoclelandia cornupsittaca* Zone (new) (Figs 14, 15)

Horizons. MME 121.6, 121.9, HC6 127.5, 130.0T, 130.5,

Figure 12. Trilobites of the *Bearriverops alsacharovi* Zone. All views are dorsal. **A**, **E**, ***Bearriverops alsacharovi*** Adrain & Westrop 2007a. A, cranidium, SUI 99936, x10 (G 27.0 m). E, pygidum, SUI 99951, x12 (G 27.0 m). **B**, **F**, ***Bearriverops ibexensis*** Adrain & Westrop 2007a. B, cranidium, SUI 99970, x10 (G 26.6 m). F, pygidium, SUI 99980, x10 (G 26.6 m). **C**, **G**, ***Gonioteloides monoceras*** Kobayashi 1955. C, cranidium, SUI 134155, x10 (G 26.6 m). G, pygidium, SUI 134156, x4 (G 27.0 m). **D**, **H**, **Dimeropygidae gen. nov. 1 sp. nov. 1**. D, cranidium, SUI 134157, x12 (G 26.6 m). H, pygidium, SUI 134158, x10 (G 26.6 m). **I**, **M**, ***Hystricurus* sp. nov. 2**. I, cranidium, SUI 99740, x7.5 (G 26.6 m). M, pygidium, SUI 134159, x5 (G 27.0 m). **J**, **N**, **Hillyardininae gen. nov. 2 sp. nov. 1**. J, cranidium, SUI 134160, x10 (G 27.0 m). N, pygidium, SUI 134161, x7.5 (G 26.6 m). **K**, ***Amblycranium* sp. nov. 5**, cranidium, SUI 134162, x15 (G 26.6 m). **L**, ***Hyperbolochilus* sp. nov. 4**, cranidium, SUI 134163, x10 (G 26.6 m). **O**, **T**, **Pilekiinae gen. nov. 4 sp. nov. 2**. O, cranidium, SUI 134164, x10 (G 27.0 m). T, pygidium, SUI 134165, x15 (HC6 124.0 m). **P**, ***Pachycranium* sp. nov. 1**, cranidium, SUI 134166, x7.5 (G 26.6 m). **Q**, ***Perischodory* sp. nov. A**, cranidium, SUI 134167, x12 (G 27.0 m). **R**, **W**, ***Hyperbolochilus* sp. nov. 3**. R, cranidium, SUI 134168, x5 (G 26.6 m). W, pygidium, SUI 134169, x4 (G 26.6 m). **S**, **X**, ***Metabowmania braggi*** Adrain & Westrop 2007b. S, cranidium, SUI 102936, x12 (G 26.6 m). X, pygidium, SUI 102946, x6 (G 27.0 m). **U**, **Z**, ***Pseudoclelandia* sp. nov. 3**. U, cranidium, SUI 134170, x12 (G 27.0 m). Z, pygidium, SUI 134171, x10 (G 27.0 m). **V**, **Hystricuridae gen. nov. 2 sp. nov. 4**, pygidium, SUI 134172, x7.5 (G 26.6 m). **Y**, **DD**, ***Tesselacauda* sp. nov. 2**. Y, cranidium, SUI 134173, x6 (G 26.6 m). DD, pygidium, SUI 134174, x7.5 (G 26.6 m). **AA**, **FF**, ***Pilekia loella*** Demeter 1973. AA, cranidium, SUI 134175, x4 (HC6 124.0 m). FF, pygidium, SUI 134176, x6 (HC6 122.5 m). **BB**, **Pliomeridae gen. nov. A sp. nov. B**, pygidium, SUI 134177, x7.5 (G 26.6 m). **CC**, **GG**, **Pilekiinae gen. nov. 4 sp. nov. 1**. CC, cranidium, SUI 134178, x10 (G 26.6 m). GG, pygidium, SUI 134179, x7.5 (G 26.6 m). **EE**, **Pilekiinae gen. nov. 3 sp. nov. B**, pygidium, SUI 134180, x12 (G 26.6 m).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131.0T, 131.3, 132.0T m.

Species (29):

Cheiruridae

Rossaspis superciliosa (Ross 1951) (Fig. 15B, E)
Rossaspis sp. nov. 3 (Fig. 14S, V)

Dimeropygidae

Parahystricurus fraudator Ross 1951 (Figs 14B, 15Q)
Parahystricurus oculirotundus Ross 1951 (Fig. 14D)
Parahystricurus pustulosus Ross 1951 (Figs 14C, 15R)
Pseudohystricurus sp. (Fig. 14O)

Harpetidae

Hypothetica rawi Ross 1951 (Fig. 14Z)

Hystricuridae

Flectihystricurus flectimembrus (Ross 1951) (Fig. 15A, D)
Flectihystricurus sp. nov. 3 (Fig. 14A, E)
Flectihystricurus sp. nov. B (Fig. 14N)
Flectihystricurus sp. nov. A (Fig. 15G, J)
Hillyardina semicylindrica Ross 1951 (Fig. 15F, I)
Hillyardina sp. nov. 2 (Fig. 14I)
Hillyardininae gen. nov. 1 sp. nov. E (Fig. 14F, J)
Hyperbolochilus marginauctum Ross 1951 (Figs 14G, K, 15O, S)
Hyperbolochilus sp. nov. 8 (Fig. 15H, K)
Hyperbolochilus sp. nov. 7 (Fig. 14M)
Hystricurus sp. nov. C (Fig. 14R)
Hystricurus sp. nov. B (Figs 14P, T, 15P)
Metabowmania morgani Adrain & Westrop 2007b
Metabowmania sp. nov. A of Adrain & Westrop (2007b) (Fig. 14Q)
Metabowmania cf. *M. latilimbata* of Adrain & Westrop (2007b) (Fig. 15T)
Pachycranium faciclunis Ross 1951 (Figs 14W, 15N)

Telephinidae

Pyraustocranium orbatum Ross 1951 (Fig. 15C)
Pyraustocranium sp. nov. A (Fig. 14Y)

Uncertain

Affinities uncertain gen. nov. 2 sp. nov. 1 (Fig. 14H, L)
Pseudoclelandia cornupsittaca Ross 1951 (Figs 14U, 15M)
Pseudoclelandia fluxafissura Ross 1951 (Figs 14X, 15L)
Pseudoclelandia sp. 2

Remarks. Where they are represented by large collections in either region, the zones beneath the *Pseudoclelandia cornupsittaca* Zone contain virtually identical faunas in the Fillmore and the Garden City formations. Species present are the same, and relative abundance is in most cases directly comparable. For reasons not yet clear, this is not true of the uppermost two Stairsian zones, in which there are considerable differences between the two regions. Enough species are clearly shared that correlation is possible and the same zonal nomenclature can be applied to either succession. Within each zone, however, there is far more differentiation encountered than is the case lower in the sections. Species of *Pyraustocranium* Ross 1951, are clearly different between the regions, as are species of *Metabowmania* Kobayashi 1955, *Hystricurus*, *Hyperbolochilus* Ross 1951, *Hillyardina* Ross 1951, *Flectihystricurus* Adrain, Lee, Westrop, Chatterton & Landing 2003, and *Rossaspis* Harrington 1957. On the other hand, species of *Pseudoclelandia* (including the zonal name bearer), *Parahystricurus* Ross 1951 and *Pachycranium* Ross 1951, seem definitely to be shared. The inter-regional differences could perhaps be stratigraphic in nature, with collections from either region sampling different time intervals, and the species distinctions recording taxonomic turnover. The zone is not very thick, however, and it is difficult to explain why such distinctions are not encountered lower in the Stairsian (nor in the Floian zones documented by Adrain *et al.* [2009]). Alternatively, the differences may record geographic diversification in response to as yet unknown extrinsic factors.

11. *Pseudohystricurus obesus* Zone (new) (Figs 16, 17)

Horizons. G 48.5, MME 129.9, HC6 134.0T, 135.0T m.

Species (24):

Cheiruridae

Pilekiinae gen. nov. 1 sp. nov. 1 (Fig. 16Q, U)

Dimeropygidae

Parahystricurus bispicatus Hintze 1953 (Fig. 16X)
Parahystricurus sp. nov. 6 (Fig. 17E)
Parahystricurus sp. nov. 5 (Fig. 16W)
Parahystricurus sp. nov. 4 (Fig. 16Z)
Parahystricurus sp. nov. 3 (Fig. 16Y)
Pseudohystricurus obesus Ross 1951 (Fig. 16A, E)

Harpetidae

Hypothetica sp. nov. 1 (Fig. 17M)

Hystricuridae

Flectihystricurus acumennasus (Ross 1951) (Fig. 17F, I)
Flectihystricurus sp. nov. 4 (Fig. 16K, N)
Hillyardina sp. nov. 3 (Fig. 17A)
Hyperbolochilus marginauctum Ross 1951 (Figs 16O, S, 17G, J)

Figure 14. Trilobites of the *Pseudoclelandia cornupsittaca* Zone from the Ibex area, western Utah. All views are dorsal. **A**, **E**, ***Flectihystricurus* sp. nov. 3**. A, cranidium, SUI 134191, x10 (MME 121.6 m). E, pygidium, SUI 134192, x10 (MME 121.6 m). **B**, ***Parahystricurus fraudator*** Ross 1951, cranidium, SUI 134193, x10 (MME 121.6 m). **C**, ***Parahystricurus pustulosus*** Ross 1951, cranidium, SUI 134194, x10 (MME 121.6 m). **D**, ***Parahystricurus oculirotundus*** Ross 1951, cranidium, SUI 134195, x12 (MME 121.9 m). **F**, **J**, **Hillyardininae gen. nov. 1 sp. nov. E**. F, cranidium, SUI 134196, x7.5 (MME 121.9 m). J, pygidium, SUI 134197, x15 (MME 121.9 m). **G**, **K**, ***Hyperbolochilius marginauctum*** Ross 1951. G, cranidium, SUI 134198, x7.5 (MME 121.6). K, pygidium, SUI 134199, x6 (MME 121.6 m). **H**, **L**, **Affinities uncertain gen. nov. 2 sp. nov. 1**. H, cranidium, SUI 134200, x10 (MME 121.6 m). L, pygidium, SUI 134201, x15 (MME 121.6 m). **I**, ***Hillyardina* sp. nov. 2**, cranidium, SUI 134202, x12 (MME 121.6 m). **M**, ***Hyperbolochilus* sp. nov. 7**, cranidium, SUI 134203, x15 (MME 121.6 m). **N**, ***Flectihystricurus* sp. nov. B**, cranidium, SUI 134204, x9 (MME 121.6 m). **O**, ***Pseudohystricurus* sp.**, cranidium, SUI 134205, x16 (MME 121.6 m). **P**, **T**, ***Hystricurus* sp. nov. B**. P, cranidium, SUI 134206, x10 (MME 121.6 m). T, pygidium, SUI 134207, x5 (MME 121.9 m). **Q**, ***Metabowmania* sp. nov. A** of Adrain & Westrop (2007b), cranidium, SUI 102950, x10 (MME 121.6 m). **R**, ***Hystricurus* sp. nov. C**, pygidium, SUI 134208, x4 (MME 121.9 m). **S**, **V**, ***Rossaspis* sp. nov. 3**. S, cranidium, SUI 134209, x7.5 (MME 121.9 m). V, pygidium, SUI 134210, x7.5 (MME 121.9 m). **U**, ***Pseudoclelandia cornupsittaca*** Ross 1951, cranidium, SUI 134211, x15 (MME 121.9 m). **W**, ***Pachycranium faciclunis*** Ross 1951, cranidium, SUI 134212, x12 (MME 121.6 m). **X**, ***Pseudoclelandia fluxafissura*** Ross 1951, cranidium, SUI 134213, x15 (MME 121.9 m). **Y**, ***Pyraustocranium* sp. nov. A**, cranidium, SUI 134214, x12 (MME 121.9 m). **Z**, ***Hypothetica rawi*** Ross 1951, cranidium, SUI 134215, x15 (MME 121.6 m).

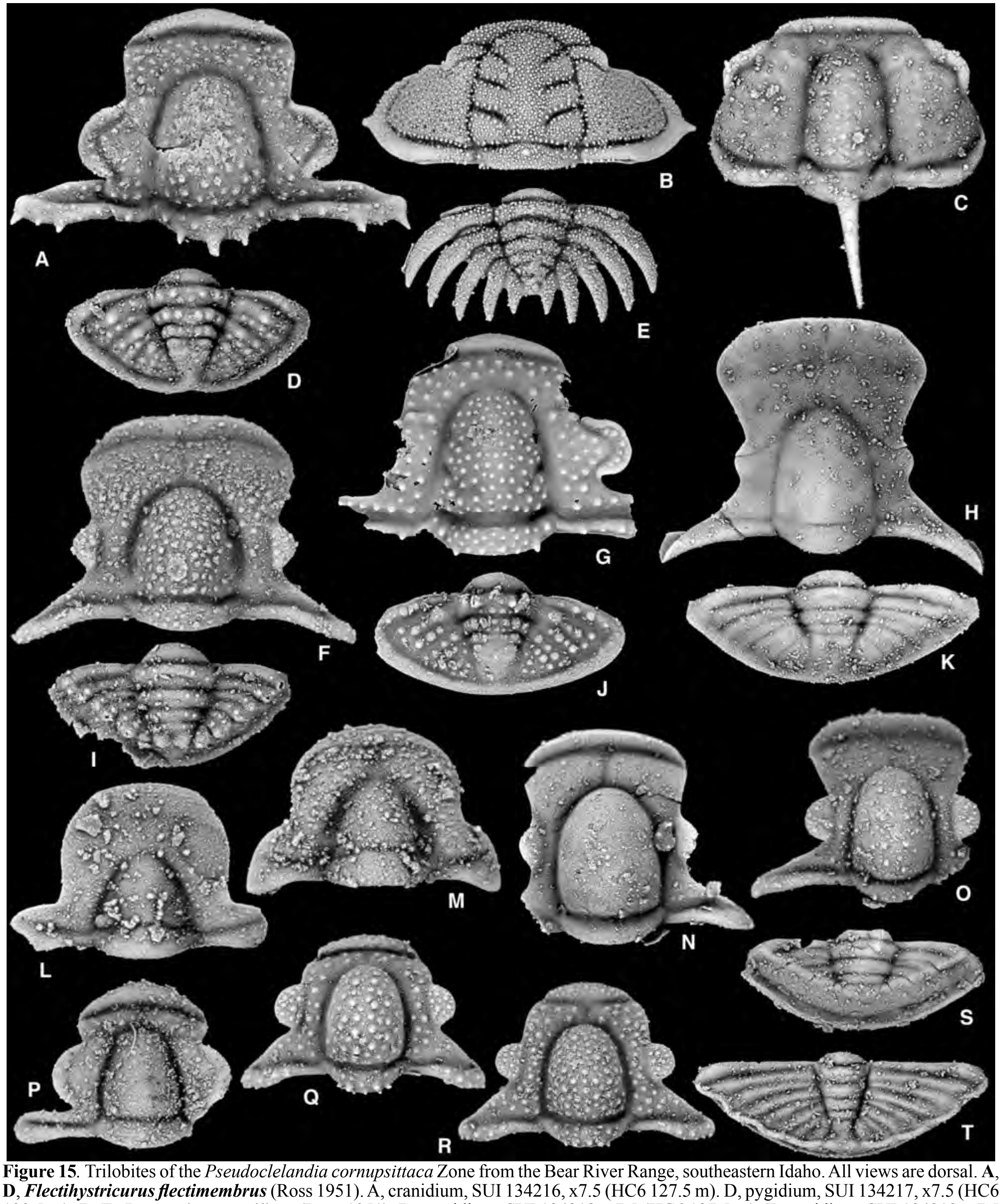


Figure 15. Trilobites of the *Pseudoclelandia cornupsittaca* Zone from the Bear River Range, southeastern Idaho. All views are dorsal. **A**, **D**, ***Flectihystricurus flectimembrus*** (Ross 1951). A, cranidium, SUI 134216, x7.5 (HC6 127.5 m). D, pygidium, SUI 134217, x7.5 (HC6 130.5 m). **B**, **E**, ***Rossaspis superciliosa*** (Ross 1951). B, cranidium, SUI 134218, x7.5 (HC6 127.5 m). E, pygidium, SUI 134219, x7.5 (HC6 127.5 m). **C**, ***Pyraustocranium orbatum*** Ross 1951, cranidium, SUI 134220, x10 (HC6 131.3 m). **F**, **I**, ***Hillyardina semicylindrica*** Ross 1951. F, cranidium, SUI 134221, 12 (HC6 130.5 m). I, pygidium, SUI 134222, x12 (HC6 130.5 m). **G**, **J**, ***Flectihystricurus* sp. nov. A**. G, cranidium, SUI 134223, x5 (HC6 132.0T m). J, pygidium, SUI 134224, x7.5 (HC6 132.0T m). **H**, **K**, ***Hyperbolochilus* sp. nov. 8**. H, cranidium, SUI 134225, x7.5 (HC6 127.5 m). K, pygidium, SUI 134226, x7.5 (HC6 131.3 m). **L**, ***Pseudoclelandia fluxafissura*** Ross 1951, cranidium, SUI 134227, x17 (HC6 127.5 m). **M**, ***Pseudoclelandia cornupsittaca*** Ross 1951, cranidium, SUI 134228, x15 (HC6 127.5 m). **N**, ***Pachycranium faciclunis*** Ross 1951, cranidium, SUI 134229, x10 (HC6 132.0T m). **O**, **S**, ***Hyperbolochilus marginauctum*** Ross 1951. O, cranidium, SUI 134230, x12 (HC6 127.5 m). S, pygidium, SUI 134231, x8 (HC6 127.5 m). **P**, ***Hystricurus* sp. nov. B**, cranidium, SUI 134232, x12 (HC6 127.5 m). **Q**, ***Parahystricurus fraudator*** Ross 1951, cranidium, SUI 134233, x10 (HC6 127.5 m). **R**, ***Parahystricurus pustulosus*** Ross 1951, cranidium, SUI 134234, x8 (HC6 127.5 m). **T**, ***Metabowmania* cf. *M. latilimbata*** of Adrain & Westrop (2007b), cranidium, SUI 134235, x7.5 (HC6 130.5 m).

Hyperbolochilus sp. nov. 9 (Fig. 16P, T)
Hystricuridae gen. nov. 2 sp. nov. A (Fig. 16V)
Hystricurus oculilunatus Ross 1951 (Fig. 16J, M)
Hystricurus sp. nov. 3 (Fig. 16I, L)
Metabowmania morgani Adrain & Westrop 2007b (Fig. 16R)
Metabowmania sp. nov. B (Fig. 17K, L)

Telephinidae
Goniophrys prima Ross 1951 (Fig. 17H)
Goniophrys sp. nov. 1 (Fig. 16D, H)

Uncertain
Affinities uncertain gen. nov. 1 sp. nov. 1 (Fig. 16B, F)
Affinities uncertain gen. nov. 2 sp. nov. 2 (Figs 16C, G, 17D)
Pseudoclelandia sp. nov. 4 (Fig. 17C)
Pseudoclelandia sp. 3 (Fig. 17B)

Remarks. Even fewer species are shared between the Fillmore Formation and the Garden City Formation in the *Pseudohystricurus obesus* Zone than in the underlying *Pseudoclelandia cornupsittaca* Zone (see above), with only the zonal name bearer and *Hyperbolochilus marginauctum* confirmed at present. Ross (1951) lumped the *Pseudoclelandia cornupsittaca* Zone and the overlying *Pseudohystricurus obesus* Zone as his "Zone F" and at HC6 they together only occupy a few meters of section. However, the faunas of the zones in the Garden City Formation are almost entirely different from one another, with only *H. marginauctum* apparently shared between them.

COMPARISON WITH OTHER REGIONS

The only other significant northern Laurentian Stairsian faunas to have been described in the literature are those from British Columbia dealt with by Kobayashi (1955), and from Alberta by Dean (1989), who revised some of Kobayashi's taxa. In either case the amount of data and scope of illustration is limited, but some species (e.g., *Gonioteloides monoceros* Kobayashi 1955; *Hystricurus eos* [Kobayashi 1955]) are clearly shared and there is good reason to expect that were more information available the biostratigraphic scheme established herein would be applicable to these localities lying to the east along the northern Laurentian margin. Pratt (1988) described a low diversity fauna from the Rabbitkettle Formation of the southern Mackenzie Mountains, Northwest Territories, which contains *Leiostegium* and *Kainella* and is likely of early Stairsian age. It may be possible to correlate this fauna directly with the scheme established herein once detailed taxonomic work on the relevant groups is undertaken. Similarly, material from Colorado described by Berg & Ross (1959) could well be directly correlated if better known, as it contains representatives of leiostegiids, *Kainella*, *Paraplethopeltis* and *Gonioteloides*.

Stairsian-equivalent faunas from southern Laurentia (in terms of Ordovician geography) have been described from, for example, Texas (Bridge & Cloud 1947), Missouri (Heller 1956), New York (Flower 1968; Landing *et al*. 2012), Oklahoma (Stitt 1983), western Newfoundland (Boyce 1989), and from the Laurentian-derived Norwegian Caledonides by Gobbett (1960). However, no benthic trilobite species have been confirmed to occur in both northern and southern Laurentia, as it appears that the Transcontinental Arch formed a strong distributional barrier through most of the Early Ordovician. This was the basis of Loch's (1995, 2007) advocacy of separate stage nomenclature and zonations for northern versus southern Laurentia. Boyce's (1989) assignment of material from the Boat Harbour Formation of Newfoundland to *Hystricurus oculilunatus* Ross 1951, for example, was rejected by Westrop (in Landing *et al*. 2003, p. 93). While the extinction marking the base of the Stairsian can be recognised in southern Laurentia, there are few if any southern Laurentia data from the interval of the extinction marking the base of the Tulean. Nevertheless, all known data are consistent with the notion that the higher extinction also took place across the entire continent (at minimum), and recognition of stadial equivalence does not seem problematic (Landing *et al*. [2012], for example, apply the Skullrockian and Stairsian stages to southern Laurentian successions in New York State). (Note that the same is not true of the Tulean and Blackhillsian stages; as pointed out by Adrain *et al*. [2009, pp. 551–552], a distinction between these stages even in northern Laurentia is of limited utility.) Stairsian correlation between southern and northern Laurentia at species/zonal level thus far does not seem possible. The appearance of pelagic telephinids in the upper Stairsian (*Goniophrys* Ross 1951) offers limited hope, but the taxon has not been discovered in southern Laurentia.

Stairsian-equivalent faunas with otherwise "typical" Laurentian elements can be recognised from tropical regions of other palaeocontinents, but thus far the record is very limited. The best described occurrence with the most species belonging to groups known in Laurentia only from the Stairsian is a fauna from Tasmania described by Jell & Stait (1985). This assemblage contains hillyardinines, hystricurines, leiostegiids and cheirurids directly comparable with those occurring in northern Laurentia. *Hystricurus penchiensis* (Lu *in* Lu *et al*. 1976), from South China appears to represent *Flectihystricurus*. Jell & Stait (1985, p. 4) assigned material from Tasmania to this species, but on their plate caption (Jell & Stait 1985, p. 28) the species was identified as "*Hystricurus timsheaensis* sp. nov.". The Tasmanian species seems clearly distinct from *F. penchiensis*, and it, too, should be assigned to *Flectihystricurus*. The material assigned by Jell & Stait (1985, p. 5, pl. 2, figs 1–15, pl. 3, figs 9, 10, 13) to *Hystricurus lewisi* (Kobayashi 1940) represents at least three species. Four cranidia (Jell & Stait 1985, pl. 2, figs 1–4), including the holotypes of both *Tasmanaspis lewisi* Kobayashi 1940, and *T. longa* Kobayashi 1940, represent *T. lewisi*, of which *T. longa* is a junior subjective synonym. These cranidia have unambiguously different morphology from the remainder assigned by Jell & Stait: there is only a fine granulate sculpture, the glabella is shorter relative to its width, the anterior border is much longer and the anterior border furrow more shallow, the anterior sections of the facial suture are strongly anteriorly divergent, and the palpebral lobe is large and the palpebral furrow very shallow. Jell & Stait (1985, p. 7) ascribed the differences in the anterior region to flattening of Kobayashi's specimens, but the specimens have multiple obvious differences which cannot be explained by differential preservation. *Tasmanaspis* Kobayashi 1940, should be recognised as a monotypic, inadequately known, hystricurid genus. For the other material assigned by Jell & Stait, some (pl. 2, figs 5–9, 12) seem to represent a species of *Flectihystricurus*. One librigena (Jell & Stait 1985, pl. 2, fig. 10A, B) represents *Hystricurus* s.s. of Adrain *et al*. (2003), and likely should be associated with a *Hystricurus* pygidium assigned by Jell & Stait to "*Hystricurus* cf. *H. robustus*" (Jell & Stait 1985, pl. 3, fig. 14). The remaining specimens (Jell & Stait, pl. 2, figs 11, 13–15, pl. 3, figs 9, 10, 13) certainly represent a hillyardinine. Of the other material assigned

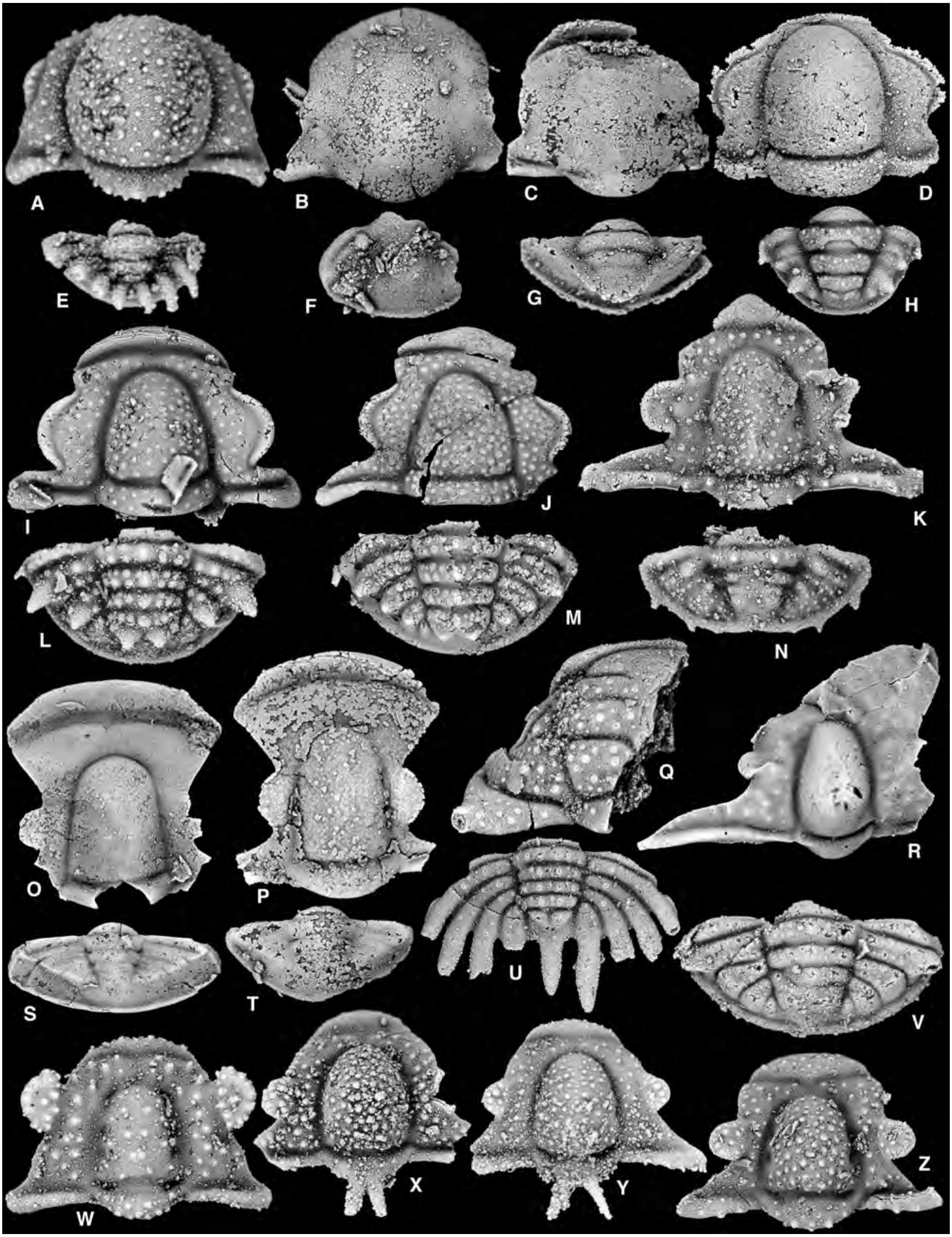


Figure 16. Trilobites of the *Pseudohystricurus obesa* Zone from the Ibex area, western Utah. All views are dorsal, and all specimens are from G 48.5 m. **A**, **E**, ***Pseudohystricurus obesus*** Ross 1951. A, cranidium, SUI 134236, x19. E, pygidium, SUI 134237, x20. **B**, **F**, **Affinities uncertain gen. nov. 1 sp. nov. 1**. B, cranidium, SUI 134238, x9. F, pygidium, SUI 134239, x12. **C**, **G**, **affinities uncertain gen. nov. 2 sp. nov. 2**. C, cranidium, SUI 134240, x12. G, pygidium, SUI 134241, x10. **D**, **H**, ***Goniophrys*** **sp. nov. 1**. D, cranidium, SUI 134242, x10. H, pygidium, SUI 134243, x10. **I**, **L**, ***Hystricurus*** **sp. nov. 3**. I, cranidium, SUI 134244, x10. (*continued opposite*)

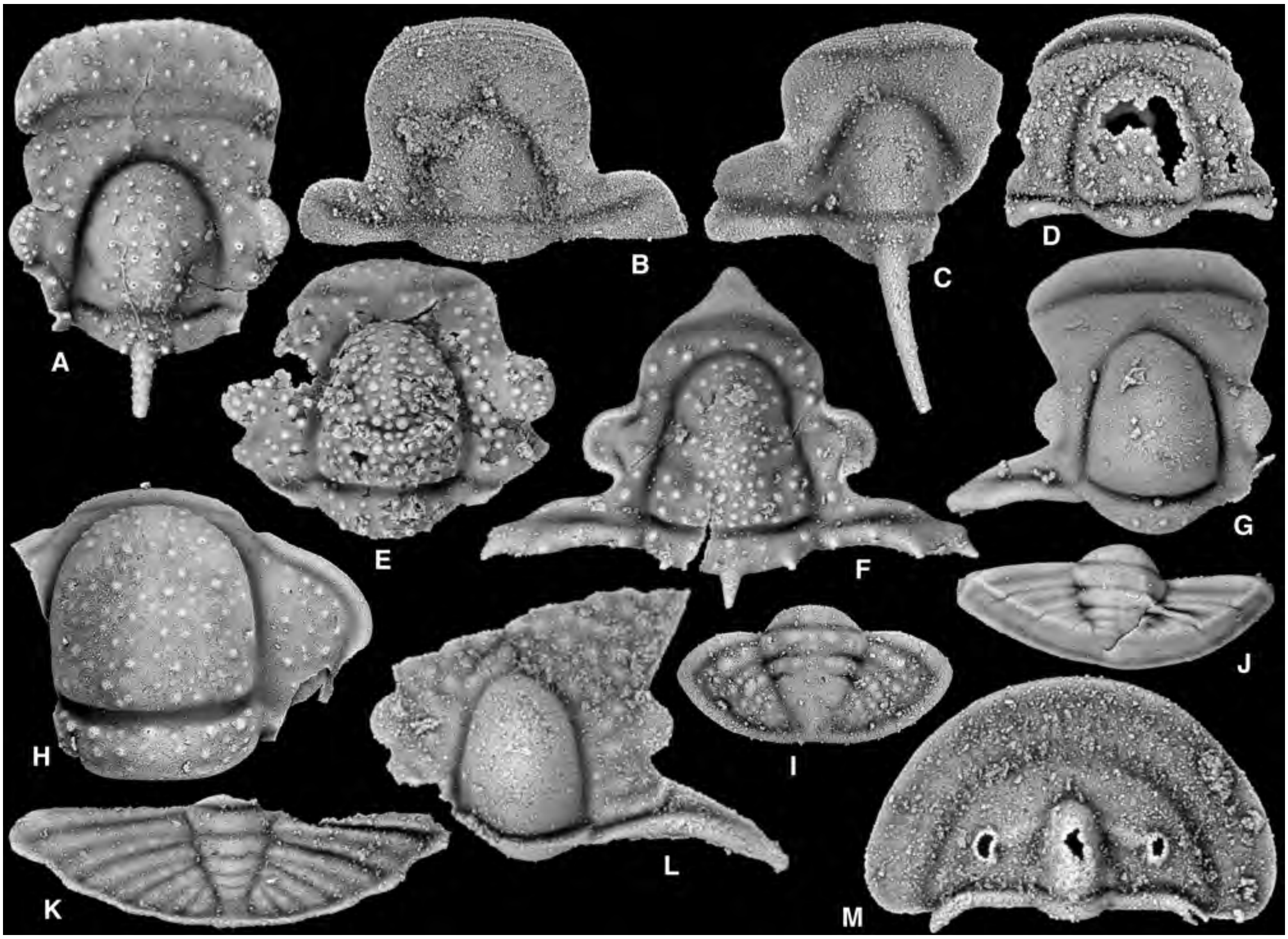


Figure 17. Trilobites of the *Pseudohystricurus obesa* Zone from the Bear River Range, southeastern Idaho. All views are dorsal, and all specimens are from HC6 134.0T m. **A**, ***Hillyardina* sp. nov. 3**, cranidium, SUI 134260, x10. **B**, ***Pseudoclelandia* sp. 3**, cranidium, SUI 134261, x20. **C**, ***Pseudoclelandia* sp. nov. 4**, cranidium, SUI 134262, x22. **D**, **affinities uncertain gen. nov. 2 sp. nov. 2**, cranidium, SUI 134263, x20. **E**, ***Parahystricurus* sp. nov. 6**, cranidium, SUI 134264, x8. **F**, **I**, ***Flectihystricurus acumennasus*** (Ross 1951). F, cranidium, SUI 134265, x9. I, pygidium, SUI 134266, x12. **G**, **J**, ***Hyperbolochilius marginauctum*** Ross 1951. G, cranidium, SUI 134267, x10. J, pygidium, SUI 134268, x6. **H**, ***Goniophrys prima*** Ross 1951, cranidium, SUI 134269, x9. **K**, **L**, ***Metabowmania* sp. nov. B**. K, pygidium, SUI 134270, x10. L, cranidium, SUI 134271, x12. **M**, ***Hypothetica* sp. nov. 1**, cranidium, SUI 134272, x15.

to "*Hystricurus* cf. *H. robustus*", an articulated thorax and partial cranidium (Jell & Stait, pl. 3, fig. 12) is difficult to identify, but the pygidia (Jell & Stait, pl. 3, figs 8, 11) and at least some of the cranidia (Jell & Stait 1985, pl. 4, figs 3, 4, 6) are definitely hillyardinine. *Hystricurus robustus* Ross 1951, is a hillyardinine and will be assigned to a new genus in a forthcoming work on that subfamily. Finally, *Tanybregma tasmaniensis* Jell & Stait 1985, is a hillyardinine.

Goniophrys laifengensis Zhou in Zhou *et al*. 1977, and *G. subcylindricus* Xiang & Zhou 1987, both from South China, appear to be correctly assigned. In all of these cases the species are associated with numerous taxa not shared with Laurentia. The Tasmanian fauna, for example, contains common asaphids, whereas asaphids are entirely unknown from the Laurentian Stairsian.

SYSTEMATIC PALAEONTOLOGY

Note. Where possible, new and revised zones treated herein have used a previously named species as name bearer. In four cases (five counting Unnamed Zone 1) this has proven impossible as no adequate potential name bearing species has been described. Hence we name and describe four zonal name bearers below. In each case, extended taxonomic works on the respective group are in progress and each species will be treated in more detail in those works. In particular, we confine ourselves here to a level of illustration adequate to demonstrate the novelty and general morphology of each species. This represents a fraction of that which we

L, pygidium, SUI 134245, x7.5. **J**, **M**, ***Hystricurus oculilunatus*** Ross 1951. J, cranidium, SUI 134246, x5. M, pygidium, SUI 99737, x4. **K**, **N**, ***Flectihystricurus* sp. nov. 4**. K, cranidium, SUI 134247, x10. N, pygidium, SUI 134248, x10. **O**, **S**, ***Hyperbolochilus marginauctum*** Ross 1951. O, cranidium, SUI 134249, x5. S, pygidium, SUI 134250, x3. **P**, **T**, ***Hyperbolochilus* sp. nov. 9**. P, cranidium, SUI 134251, x7. T, pygidium, SUI 134252, x6. **Q**, **U**, **Pilekiinae gen. nov. 1 sp. nov. 1**. Q, cranidium, SUI 134253, x8. U, pygidium, SUI 134254, x7. **R**, ***Metabowmania morgani*** Adrain & Westrop 2007b, cranidium, SUI 102931, x7.5. **V**, **Hystricuridae gen. nov. 2 sp. nov. A**, pygidium, SUI 134255, x7.5. **W**, ***Parahystricurus* sp. nov. 5**, cranidium, SUI 134256, x12. **X**, ***Parahystricurus bispicatus*** Hintze 1953, cranidium, SUI 134257, x8. **Y**, ***Parahystricurus* sp. nov. 3**, cranidium, SUI 134258, x8. **Z**, ***Parahystricurus* sp. nov. 4**, cranidium, SUI 134259, x9.

have used to summarise the full range of intraspecific and ontogenetic variation as well as geographic and stratigraphic distribution in other recent work (e.g., Adrain *et al*. 2011b; Adrain *et al*. 2012).

Repository. Figured material is housed in the Paleontology Repository, Department of Geoscience, University of Iowa, Iowa City, with specimen number prefix SUI.

Family HYSTRICURIDAE Hupé 1953

Paraplethopeltis Bridge & Cloud 1947

Type species. Paraplethopeltis obesa Bridge & Cloud 1947, from the Tanyard Formation, Texas, USA.

Other species. Paraplethopeltis carinifera Flower 1968, Tribes Hill Formation, New York; *P. depressa* Bridge & Cloud 1947, Tanyard Formation, Texas; *P. genacurva* Hintze 1953, House Formation, Utah; *P. generecta* Hintze 1953, House Formation, Utah; *P. helli* sp. nov., Fillmore Formation, Utah; *Hystricurus* (*Hystricurus*) *scrofulosus* Fortey & Peel 1989, Christian Elv Formation, Daugaard-Jensen Land, Greenland; *Hystricurus* (*Paraplethopeltis*) sp. nov. A of Fortey & Peel (1989), Christian Elv Formation, Daugaard-Jensen Land, Greenland; *Hystricurus*? sp. aff. *H.*? *genacurvus* (Hintze) of Berg & Ross (1959), Manitou Formation, Colorado; "Undetermined hystricurid(?) species" of Ross (1970, p. 73, pl. 10, figs 32-34), Goodwin Formation, Nevada (assignment tentative, as Ross's photographs are tiny); "*P. genacurva* Hintze" of Stitt (1983, p. 22), Mackenzie Hill Formation, Oklahoma (*P. obesa* of Stitt [1983, p. 22], also from the Mackenzie Hill Formation, appears to be correctly assigned); *P*. sp. of Strauss *et al*. (2013, fig. 3E, F), Nanook Formation, Alaska; *P*. sp. 1 and *P*. sp. 2 of Taylor *et al*. (2004, fig. 10E and 10W respectively), both from the Hitt Canyon Formation, New Mexico; *P*. sp. nov. 1 (herein), House Formation, Utah.

Remarks. Paraplethopeltis and related genera will be the subject of a forthcoming work. As far as is known, the genus is restricted in stratigraphic occurrence to the lower part of the Stairsian, and in western Laurentia occurs only in the lowest two zones. Misassociation of sclerites illustrated by Hintze (1953) was discussed above under the *P. genacurva* Zone.

***Paraplethopeltis helli* sp. nov.** (Figs 6A, D, 18)

Material. Holotype, cranidium, SUI 134273 (Fig. 18A, D, J, K, M), assigned specimens SUI 134274–134278 from Section C 2.6T m, and assigned specimen SUI 134279 from Section B-TOP 14.0–14.5 m, both Fillmore Formation (upper Tremadocian; Stairsian; *Paraplethopeltis helli* Zone), southern House Range, Ibex area, Millard County, western Utah.

Etymology. After Richard Hell.

Diagnosis. Most dorsal surfaces with distinct tubercles, ranging in expression from subdued to prominent and densely scattered; cranidial anterior border furrow, axial furrows, preglabellar furrow, SO, and librigenal lateral border furrow all deeply impressed; librigenal field with faint scattered tubercles, mainly on adaxial two thirds; genal spine about as long as field (exsag.); pygidium with prominent median nodes on axial rings and prominent larger tubercle set near the fulcrum on each posterior pleural band.

Description. Cranidial measurements were made on the two cranidia of Figure 18 and an additional specimen from C 2.6T m that will be figured in an expanded work of the genus. Cranidium with maximum cranidial width across posterior projections 144.2% (140.0–148.8) sagittal length; cranidial width across ∂ 110.7% (106.3–114.0) cranidial sagittal length; cranidial width across β 82.0% (80.0–84.5) cranidial sagittal length; distance across γ 81.1% (80.4–82.4) cranidial sagittal length; distance across ε 94.7% (93.5–96.3) cranidial sagittal length; pronounced cranidial convexity produced by strongly dorsally inflated glabella and posterior fixigena, anterior fixigena, preglabellar field, and anterior border strongly downturned from horizontal plane; anterior border longest sagittally, progressively shorter abaxially so that border tapers to a point at intersection with anterior border furrow, sagittal length longer than preglabellar field (sag.) in plan view, anterior margin describing gentle smooth arc, posterior margin also gently arched, but disrupted medially by a prominent posteriorly directed depression; anterior border nearly subtriangular in transverse profile, with dorsal margin strongly arched forming a rounded peak medially, ventral margin very gently arched to nearly transverse medially with lateral portions more strongly concave; sculpture of fine raised anastomosing lines covers anterior portion of anterior border in plan view and majority of anterior border in anterior view, lines are arranged subparallel to external margin of border, secondary sculpture of very fine granules present on posterior portion of border adjacent to anterior border furrow; anterior border gently sloping downward away from preglabellar field in lateral profile, with thin strip of doublure curving under border visible on some specimens (Fig. 18K); anterior border furrow moderately long, dorsally concave, slightly shallower medially at break in course where furrow is directed posteriorly; anterior sections of facial sutures laterally convex opposite anterior border, laterally concave opposite anterior border furrow and adjacent portions of anterior border and frontal areas, strongly laterally bowed around anterolateral corner of frontal area, and then becoming nearly straight to slightly sinuous and directed just slightly posteromedially to γ; anterior fixigena sloped strongly downward from interocular fixigena; preglabellar field similarly strongly downturned, in plan view field is shortest sagittally and lengthened exsagittally, sagittal length 7.6% (6.3–9.8) cranidial sagittal length; ventral surface of preglabellar field with small swollen sector medially between anterior border furrow and preglabellar furrow; anterior fixigena and lateral portions of preglabellar field are covered with medium and small sized widely spaced tubercles, tubercles become smaller and more faint anteriorly, medial portion of preglabellar field mostly lacking tubercles, faint caecal pitting present; palpebral lobes long and moderately narrow, occupying about half of cranidial sagittal length, lobe moderately strongly laterally bowed, lobe not particularly well preserved on largest specimens, but appears to have background sculpture of fine granules (Fig. 18B), the presence of a few larger tubercles arranged along the external margin of the lobe is suggested (Fig. 18A, B), but they are not well preserved; lobe set off from interocular fixigena by distinct palpebral furrow, which is largely effaced anteriorly, furrow strongly bowed similar to lobe; eye ridge very faint, directed strongly anterolaterally

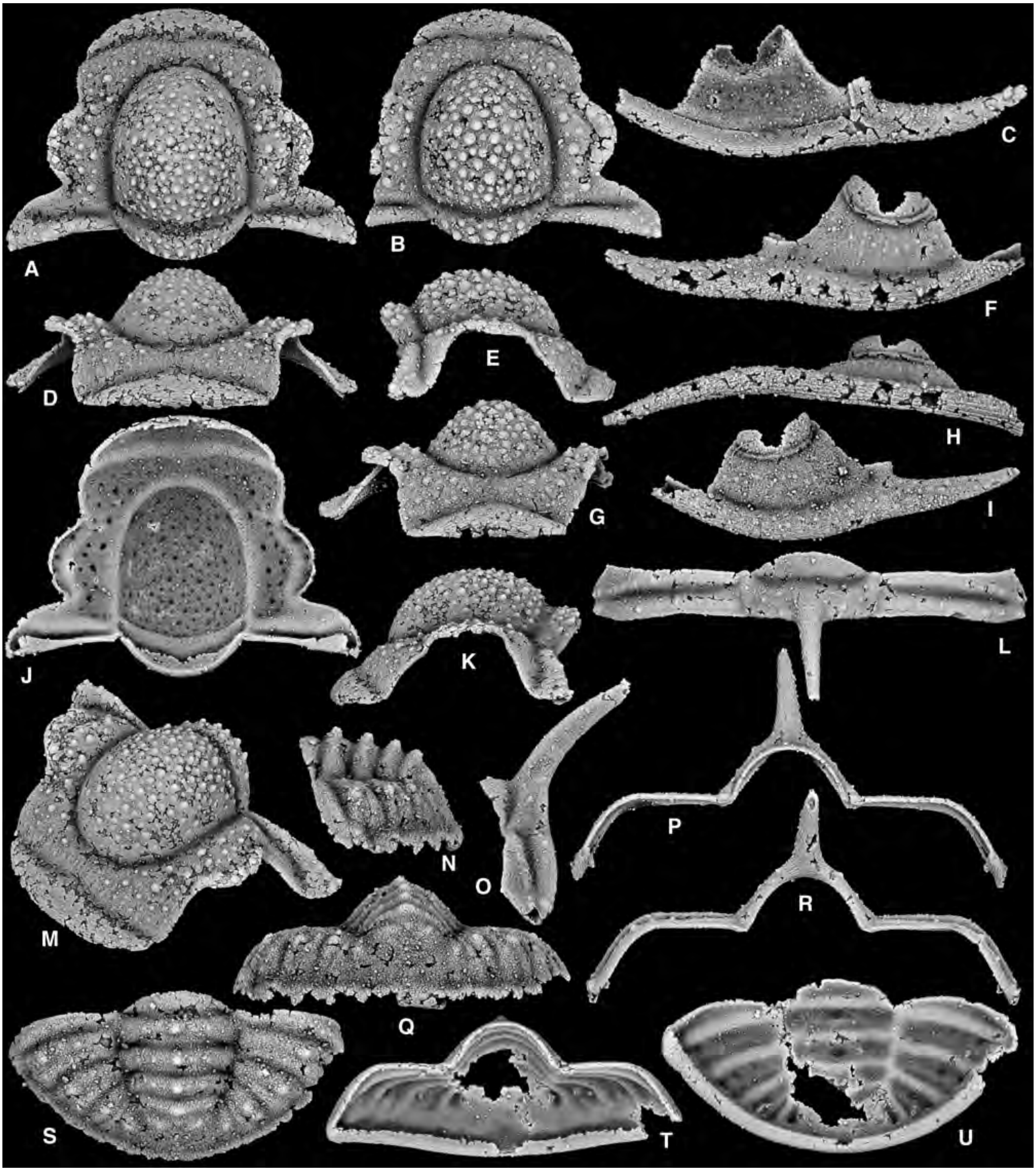


Figure 18. ***Paraplethopeltis helli*** sp. nov., from Section C 2.6T m and B-TOP 14.0–14.5 m, Fillmore Formation (upper Tremadocian; Stairsian; *Paraplethopeltis helli* Zone), southern House Range, Ibex area, Millard County, western Utah. **A**, **D**, **J**, **K**, **M**, cranidium, holotype, SUI 134273, dorsal, anterior, ventral, left lateral, and oblique views, x7.5 (C 2.6T m). **B**, **E**, **G**, cranidium, SUI 134274, dorsal, right lateral, and anterior views, x10 (C 2.6T m). **C**, **F**, **H**, right librigena, SUI 134275, internal, external, and ventrolateral views, 12 (C 2.6T m). **I**, left librigena, SUI 134276, external view, x12 (C 2.6T m). **L**, **O**, **P**, **R**, thoracic segment, SUI 134277, dorsal, left lateral, anterior, and posterior views, x10 (C 2.6T m). **N**, **Q**, **S**, pygidium, SUI 134278, left lateral, posterior, and dorsal views, x12 (C 2.6T m). **T**, **U**, pygidium, SUI 134279, anterior and ventral views, x10 (B-TOP 14.0–14.5 m).

toward anterolateral margin of glabella, more clearly expressed ventrally; interocular fixigena nearly horizontal with palpebral lobe in transverse profile; posterior fixigena strongly sloped down toward posterior border furrow, slope is steeper than that of anterior fixigena, forming small subtriangular posterolateral projection that is extended beyond lateral extent of palpebral lobe; sculpture of widely spaced, but prominent medium to small sized tubercles present on majority of fixigenae except for lateral projection of posterior fixigena, tubercles are roughly aligned linearly along the length of the fixigena following the curve of the lateral margin of the glabella, background sculpture of fine granules present on all portions of fixigena; posterior section of facial suture directed posterolaterally, forming a broad convex arc across anterior margin of posterior projection; posterior border furrow distinct, deeply impressed, but shallower abaxially from fulcrum, shortest adaxially and longer abaxially (Fig. 18B); posterior border shortest (exsag.) proximally, significantly lengthened distally, forming distinct broad and rounded distal tip; sculpture of sparse smaller sized distinct tubercles present on distal tip, with larger sized tubercles arranged closer to posterolateral margin, one or two very small faint tubercles present on main portion of border; posterior margin of posterior border between axial furrow and fulcrum directed slightly posterolaterally and nearly transverse, portion of margin from fulcrum distally similarly transverse and directed more strongly posterolaterally; thin strip of doublure present beneath posterior border, shortest proximally, lengthening distally so that strip forms a triangle distally; glabella large, roughly elliptical outline in plan view, maximum width 88.7% (86.4–92.9) sagittal length excluding LO, sagittal length 62.8% (60.4–65.5) cranidial sagittal length, strongly dorsally inflated, with apex sitting high above fixigena and strongly vaulted in both transverse and sagittal profiles; sculpture of densely spaced, prominent, small and medium sized tubercles covers majority of glabella, tubercles are largest and most densely spaced posteromedially, with the lateral and anterior margins possessing fewer and smaller tubercles, background sculpture of fine granules also present; axial furrows deep opposite glabella, slightly deeper at fossulae (Fig. 18A), slightly shallower opposite LO, where axial furrows intersect posterior border furrow, width across posterior contact of furrows with posterior margin 49.3% (49.2–49.5) cranidial sagittal length; axial furrows narrowest opposite LO, wider opposite palpebral lobes, slightly narrower anteriorly, running without obvious distinction or change in course into preglabellar furrow; preglabellar furrow deep and moderately narrow, slightly shallower medially (Fig. 18B, G), describing strongly curved arc; glabellar furrows not clearly expressed; LO moderately short (sag.), with sagittal length 9.6% (9.0–10.5) that of cranidium, and sagittal length 74.8% (68.8–84.5) that of anterior border, progressively shorter (exsag.) abaxially tapering almost to a point, anterior and posterior margins very strongly posteriorly bowed, with sculpture similar to that on main glabella of densely spaced, medium and small sized tubercles; distal tips of LO lacking tubercles; entire LO with background sculpture of fine granules; doublure beneath LO short (sag.; exsag.), extending only about halfway across length of LO, longest sagittally and strongly tapering abaxially, anterior margin strongly posteriorly bowed as anterior margin of LO; SO deep, long (sag.; exsag.), strongly bowed posteriorly, but slightly less so than posterior margin of LO, confluent with axial furrow and forming obtuse angle at intersection; tuberculate sculpture present on dorsal surface of cranidium expressed ventrally as small, prominent pits.

Librigenal measurements were made on Figure 18F, I. Main body of librigena (excluding anterior projection and genal spine) with width opposite median point of visual surface 33.6% (33.6–33.6) exsagittal length; main body with exsagittal length about 64% total librigenal length; anterior section almost transversely straight opposite field, with very slight outward bow just before eye socle, strong bend across lateral border furrow, and very gently curved to almost transverse across lateral border and anterior projection; anterior projection with length about 20% exsagittal librigenal length; posterior section very gently bowed opposite main portion of field, very strongly bent opposite posteriormost portion of field and posterior border furrow, almost straight across posterior border; visual surface incomplete, but long, occupying 35.3% (34.6–36.0) of exsagittal librigenal length, bounded by deep, narrow furrow; socle narrow, with sculpture of fine raised lines running subparallel to base of visual surface; socle separated from field by deep, narrow furrow; field with very faint caecal sculpture, overlain by fine granules, and a band of more prominent tubercles running across proximal portion of field and oriented subparallel to base of visual surface; lateral border furrow moderately broad, deepest anteriorly, significantly shallower posteriorly toward genal angle; posterior border furrow deepest at base of genal spine; lateral border broad, widens slightly toward base of genal spine, with lateral margin moderately curved, curve strongest at midlength, strongly inflated, with ventrolateral margin forming broad surface; primary sculpture of prominent raised lines running subparallel with margin, lines run from anterior projection along lateral border and onto genal spine, lines cover all of lateral border and anterior projection in external and ventrolatral views, lines cover outer portion of doublure beneath anterior projection and lateral border, inner portion smooth; secondary sculpture of fine granules present on lateral border, and genal spine, a few small scattered tubercles arranged linearly subparallel to margin also present along lateral border adjacent to lateral border furrow, row of tubercles continues onto genal spine (Fig. 18I); posterior border very small, subtriangular, does not extend far beyond base of genal spine; doublure beneath lateral and posterior borders moderately wide, extending to ventral expression of lateral and posterior border furrows; inner margin of doublure under posterior border slightly thickened; genal spine moderately long, with length about 36% total librigenal length, blade like, subelliptical in section, tapered to a blunt point distally, with sculpture of fine raised lines continuing from lateral and posterior borders running down length of spine on all aspects (Fig. 18C, F, H); base of genal spine and margin of posterior border intersect at slightly obtuse angle.

Hypostome and rostral plate not identified.

Thoracic segments with axial ring wider anteriorly than posteriorly, sculpture of scattered small sized tubercles; segment possess a prominent axial spine that appears derived from the posteromedial portion of the axial segment in plan view (Fig. 18B), but from the entire segment in sagittal profile (Fig. 18O), spine is subcircular in cross section, directed strongly posterodorsally, and moderately arched; ring furrow long, deep, broadly posteriorly bowed, transverse medially with distal tips directed anterolaterally on segment bearing axial spine; articulating half ring large, lenticular to subcrescentic in outline; axial furrows very shallow and narrow; pleural furrow moderately long (exsag.) and impressed; anterior pleural band distinct, and forming inflated ridge adjacent to pleural furrow, sculpture of very small faint tubercles present on ridge-like portion from fulcrum distally; anterolateral corner of anterior pleural band developed into a prominent triangular facet; posterior pleural band also distinct, but less ridge like and lacking inflation of anterior band, sculpture of small faint tubercles arranged linearly along middle portion of band; anterior margin of pleural region forms a narrow transverse rim which articulates with a narrow groove along the posterior edge of the pleurae of the next segment anteriorly; articulatory protrusion developed at anterior end of the axial furrow, very small, articulates with a very small depression in the posterior end of axial furrow of the next segment anteriorly; small section of doublure present beneath distal tips of pleurae, with sculpture of fine raised lines (Fig. 18P); fulcrum is set far distally from axis, with the portion of the pleura distal to the fulcrum turned down about 55° from horizontal depending on position in the thorax; entire dorsal surface with sculpture of fine granules that sometimes merge into a series of short raised anastomosing lines (e.g., sculpture on axis below base of axial spine as seen in posterior view; Fig. 18R).

Pygidial measurements were made on Figure 18S and one additional specimen from B-TOP 14.0–14.5 m that will be figured in a forthcoming work. Pygidium with maximum width across second ring furrow 202.5% (198.3–206.8) sagittal length; articulating half ring moderately short, sagittal length 12.5% (11.6–13.4) total pygidial length, anterior margin describing gentle anteriorly convex arc, ring held nearly parallel to horizontal axis and below apex of first axial ring segment, weakly inflated in sagittal profile, with sculpture of fine granules; axis of five segments with maximum axial width across first segment 34.7% (33.7–35.7) maximum pygidial width; axis tapered (tr.) posteriorly, with width across fifth segment 58.9% width across first segment; length of axis excluding articulating half ring 70.9% (67.1–74.8) total sagittal length of pygidium; first ring furrow moderately long and deep, nearly transverse; second ring furrow similar to first, but more uniformly transverse, with distal tips forming deep slits; third ring furrow slightly shorter (sag.; exsag.) than second, and slightly posteriorly bowed medially, with distal tips forming similarly deep, but more posterolaterally directed slits; fourth ring furrow still distinct, but overall shorter and shallower, with more pronounced posterior bow medially so that furrow is more V-shaped; fifth ring furrow faint; first axial ring of similar length sagittally than exsagittally (including pseudo-articulating half ring), with sculpture of fine granules covering entire ring, large distinct median tubercle present along posterior margin, with two much smaller and less prominent tubercles present on either side of median tubercle; pseudo-articulating half ring of second segment clearly differentiated, small, with sculpture of small fine granules; posterior rings progressively smaller, median tubercles remain large and prominent, but smaller flanking tubercles become greatly reduced posteriorly; pseudo-articulating half ring of third segment less clearly differentiated, but overall similar to that of second, those of subsequent segments not clearly differentiated; axis terminated by small terminal piece with bilobed posterior margin; first segment with maximum exsagittal pleural length 25.6% (25.2–26.0) sagittal axial length, anterior margin describing broad convex arc that is only slightly disrupted at fulcrum; anterior pleural band strongly inflated forming a prominent and distinct rib in lateral profile, sculpture of fine granules; posterior pleural band slightly shorter (exsag.) than anterior band, with similar sculpture of fine granules, with a rounded tubercle-like protuberance developed at fulcrum, band continues past fulcrum and terminates at border furrow (Fig. 18N); in lateral profile distal tips of anterior and posterior pleural bands converge toward each other from fulcrum toward border; pleural furrow moderately long (exsag.), deep, terminated past fulcrum at border furrow; subsequent pleural furrows with similar morphology; interpleural furrows much shallower and very faintly impressed, terminated at border furrow; subsequent interpleural furrows with overall similar morphology; morphology of pleural region of segments two and three generally similar to segment one, but progressively narrower, and directed more posterolaterally; fourth segment also expressed, but greatly reduced in size; pleural bands and furrows terminated by broad, shallow, but concave border furrow; border furrow is slightly deeper and broader opposite pleural furrows; border is distinct, moderately inflated, runs around lateral and posterior margins of pygidium in smooth arc; doublure beneath lateral and posterior borders narrow, deflected upward toward ventral surface of pygidium, with sculpture of fine raised anastomosing lines running parallel to margin; distal tips of pleurae, border furrow, and border strongly downturned from horizontal plane at fulcrum forming a short and steep wall around pygidium (Fig. 18Q).

Remarks. Of described species, *Paraplethopeltis helli* is most similar to *P. scrofulosa* (Fortey & Peel 1989), as the species share well expressed tuberculate sculpture on large specimens. They differ in that cranidia of *P. helli* have narrower interocular fixigenae, narrower (tr.) anterior borders, shorter LO (sag.; exsag.), shorter posterior projections (exsag.; especially directly behind the palpebral lobe), and generally less dense sculpture. Librigenae of *P. helli* have smaller, much less densely tuberculate fields and much longer genal spines. Pygidia of *P. helli* have less dense tuberculate sculpture, a smaller and less inflated fourth axial ring, and prominent versus subdued or absent axial tubercles on each ring.

Paraplethopeltis helli is also similar to the older *P. genacurva*. Cranidia share very similar dimensions, except that the anterior regions, frontal areas, and preglabellar field of those of *P. genacurva* are longer. The main differences in the cranidia are due to effacement: large cranidia of *P. genacurva* are almost entirely smooth and have relatively shallow furrows. The posterior projections in *P. helli* have sharp distal tips whereas those in *P. genacurva* are lobate and rounded. Smaller cranidia of *P. genacurva* (unpublished data) are faintly tuberculate and have deeper furrows and more strongly resemble those of *P. helli*. Similarly, smaller librigenae of *P. genacurva* have subdued tubercles on the field (lost entirely in larger specimens) and a genal spine about as long as the field, very similar to librigenae of *P. helli*. Larger librigenae of *P. genacurva*, however, develop a broader, entirely effaced, field, a much shallower lateral border furrow, and a much longer genal spine with a strongly adaxially curved tip. Pygidia of the species are very similar in general proportions and both have well impressed pleural, interpleural, axial and ring furrows. They also share median axial nodes, though these are prominent in *P. helli* but subdued and in larger specimens nearly effaced in *P. genacurva*. The main difference between the pygidia otherwise is that those of *P. helli* have distinct tuberculate sculpture on the rings and anterior and posterior pleural bands, whereas those of *P. genacurva* lack dorsal sculpture aside from the axial nodes. Comparisons to and between other species, along with a hypothesis of phylogenetic relationship, will be made in a forthcoming work on the genus.

Hystricurus Raymond 1913

Type species. Bathyurus conicus Billings 1859, from the Fort Cassin Formation, Quebec, Canada.

Other species. See Adrain *et al.* (2003, p. 562), with the following additions: *Bathyurus cordai* Billings 1860, Lévis Formation, Quebec; *Bathyurus*? *crotalifrons* Dwight 1884, Rochdale Formation, New York (see Landing *et al*. 2012); *Bathyurus seelyi* Whitfield 1889, Rochdale Formation, New York; *Hystricurus* sp. nov. 1 (herein), Fillmore Formation, Utah; *Hystricurus* sp. nov. 2 (herein), Fillmore Formation, Utah (*Hystricurus* sp. nov. B of Adrain *et al*. [2003]); *Hystricurus* sp. nov. 3 (herein), Fillmore Formation, Utah; *Hystricurus* sp. nov. A (herein), Fillmore Formation, Utah; *Hystricurus* sp. nov. B (herein), Fillmore Formation, Utah; *Hystricurus* sp. nov. C (herein), Fillmore Formation, Utah. The status of the species *Vermilionites bisulcatus* Kobayashi 1955, and *Hystricurus platypleurus* Kobayashi 1955, both from the McKay Group, British Columbia, is uncertain.

Diagnosis. See Adrain *et al*. (2003, p. 562).

Remarks. Hystricurus had been used as a nearly meaningless form taxon for Lower Ordovician trilobites now assigned to numerous different subfamilies and genera. Adrain *et al*. (2003) restricted the concept of the genus to a putative clade of usually strongly tuberculate species with “fiddle-shaped” glabellae and distinctive pygidia with large fulcral nodes/spines overlying a steep, nearly vertical region bounded by a strong, rim-like border. A forthcoming work will describe all of the new species illustrated briefly herein and consider the phylogenetic structure of the genus and its potential sister group.

Hystricurus zanderi sp. nov. (Figs 7J, N, 19)

2003 *Hystricurus* cf. *deflectus* Heller; Adrain *et al*., p. 563, fig. 4D, H, L.

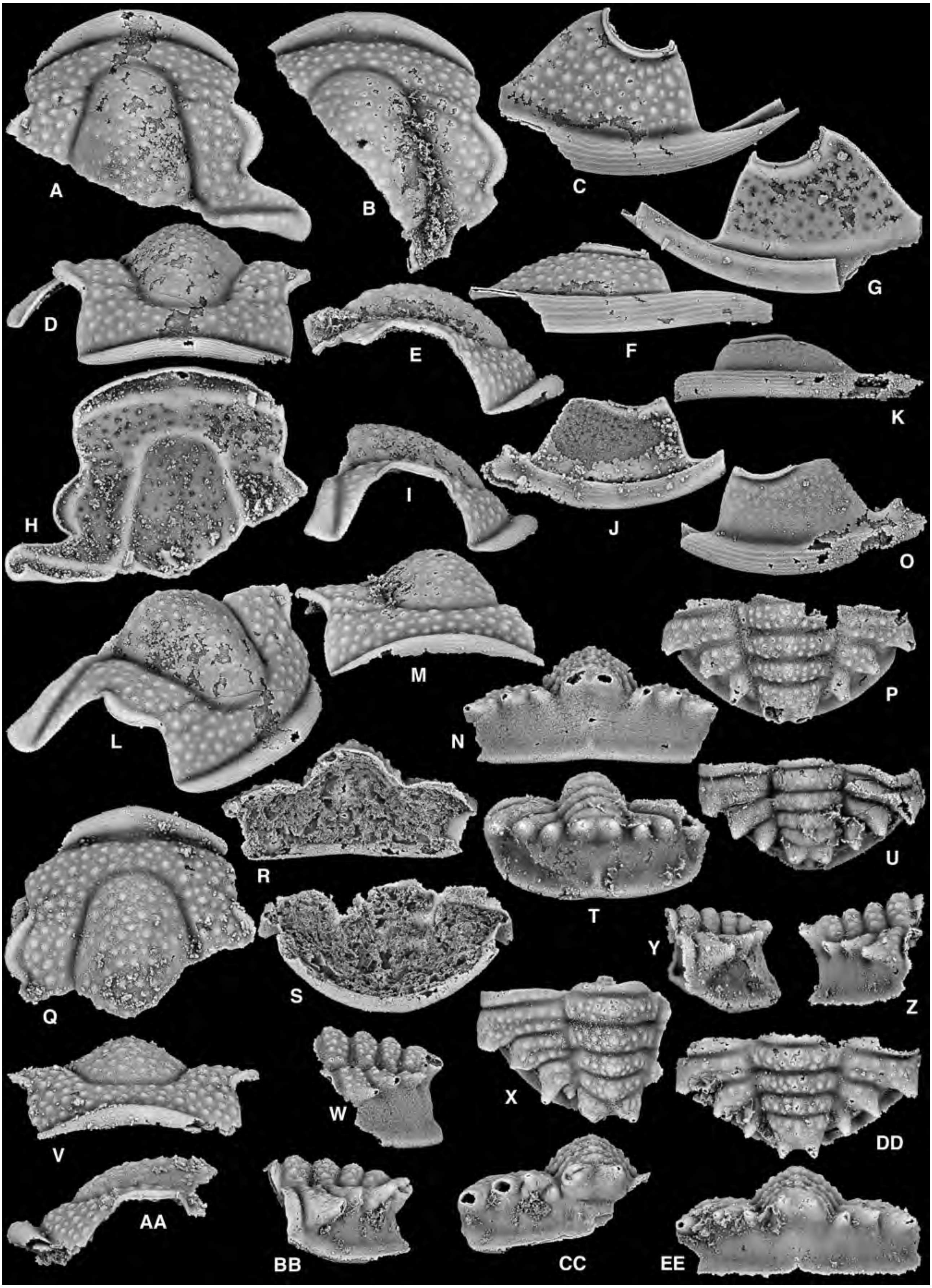
Material. Holotype, pygidium, SUI 134283 (Fig. 19N, P, R, S, W) and assigned specimens SUI 99742, 134280–134282, 134284–134286, from Section MME 22.3 m, Fillmore Formation (upper Tremadocian; Stairsian; *Hystricurus zanderi* Zone), Middle Mountain, Ibex area, Millard County, western Utah.

Etymology. After Robin Zander.

Diagnosis. Glabella relatively narrow, especially anteriorly, and weakly dorsally inflated; palpebral lobes short (exsag.); pygidium with fulcral spines and pair of spines on rear of axis large and overhanging rear margin; vertical area above border tall.

Description. Recovered cranidia incomplete, but with sagittal length less than maximum width across posterior projection; anterior border with distinct dorsal inflation, longest sagittally, with sagittal length nearly equal to that of preglabellar field in plan view, progressively shorter abaxially, anterior margin describing moderately to strongly bowed arc in plan view, gently dorsally bowed in transverse profile just barely obscuring anterior border furrow, with sculpture of about five or six fine raised lines on anterior portions, lines run subparallel to margin, posterior portion of border covered by fine granules; anterior border furrow is longest sagittally, with slight lenticular bulge medially, progressively shorter exsagittally, deep along entire course, but slightly shallower medially, anterior contact with anterior border and posterior contact with preglabellar field both appear sharp in plan view; anterior sections of facial sutures laterally convex opposite anterior border, laterally concave opposite anterior border furrow and adjacent portion of frontal area, strongly, but unevenly convex opposite frontal area; preglabellar furrow deep, confluent with axial furrows; preglabellar field shorter sagittally than exsagittally, very faint median furrow present, furrow more deeply impressed anteriorly than posteriorly, also expressed ventrally (Fig. 19H); frontal area and preglabellar field very strongly (Fig. 19E, I) to moderately (Fig. 19AA) sloped downward toward anterior border furrow; anterior border is directed upward from horizontal plane in contrast to preglabellar field and frontal areas; anterolateral corners of frontal area mostly facing anteriorly with anterolateral corners turned slightly obliquely; palpebral lobes long (exsag.), lobe strongly laterally bowed, curve slightly stronger posteriorly so that lobe appears slung posteriorly, lobe with very narrow, rim-like border around margin (Fig. 19L); palpebral furrow distinct, sinuous, deepest opposite posterior margin of lobe, shallowest medially, and deep again opposite anterior portion of lobe, but anterior portion of furrow shallower than posterior portion; interocular fixigena wide, with width about 49% maximum glabellar width (measured on Fig. 19A), held nearly horizontal, adaxial portion sloping slightly toward axial furrow in transverse profile; eye ridge weakly expressed, running obliquely from anterior margin of palpebral lobe to anterolateral corner of glabella, furrow bounding anterior and posterior margins clearly discernible dorsally, more deeply impressed on some specimens (Fig. 19B) than others (Fig. 19Q), clearly expressed ventrally; posterior fixigena known from only one larger specimen (Fig. 19A), strongly sloped downward from horizontal plane, portion distal to fulcrum facing more obliquely, abaxial portion developed into small triangular posterolateral projection extending a short distance beyond lateral extent of palpebral lobe; posterior section of facial suture directed posterolaterally at about 115° across posterior fixigena, describing convex arc across posterior fixigena and posterior border, with a small disruption in course at posterior border furrow; posterior border furrow distinct, long (exsag.), proximal portion shallower than distal portion, of similar length along entire course, almost exactly transverse and directed just slightly anterolaterally; posterior border strongly dorsally inflated, proximally very short (exsag.), lengthened distally, terminating in semi-lobate distal tip, sculpture of very faint tubercles are present on proximal portion of border; distinct ridge running along transverse length of border proximally and turned posterolaterally

Figure 19. ***Hystricurus zanderi*** sp. nov., from Section MME 22.3 m, Fillmore Formation (upper Tremadocian; Stairsian; *Hystricurus zanderi* Zone), Middle Mountain, Ibex area, Millard County, western Utah. **A**, **D**, **H**, **I**, **L**, cranidium, SUI 99742, dorsal, anterior, ventral, right lateral, and oblique views, x7.5. **B**, **E**, **M**, cranidium, SUI 134280, dorsal, right lateral, and anterior views, x5. **C**, **F**, **G**, right librigena, SUI 134281, external, ventrolateral, and internal views, x4. **J**, **K**, **O**, left librigena, SUI 134282, internal, ventrolateral, and external views, x7.5. **N**, **P**, **R**, **S**, **W**, pygidium, holotype, SUI 134283, posterior, dorsal, anterior, ventral, and left lateral views, x4. **Q**, **V**, **AA**, cranidium, SUI 134284, dorsal, anterior, and left lateral views, x7.5. **T**, **U**, **Y**, pygidium, SUI 134285, posterior, dorsal, and left lateral views, x12. **X**, **BB**, **CC**, pygidium, SUI 99743, dorsal, left lateral, and posterior views, x4. **Z**, **DD**, **EE**, pygidium, SUI 134286, right lateral, dorsal, and posterior views, x7.5.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distally, ridge divides border into two sectors, a smaller subtriangular anterior portion that faces anteroobliquely, and a larger posterior portion that faces posterodorsally; posterior margin of posterior border directed posterolaterally at about 100° angle; small triangular portion of glabella present at posterolateral tip of posterior border (Fig. 19H); glabella broadly subtriangular, but slightly waisted anteriorly, with broadly rounded anterior margin in plan view, sagittal length greater than maximum width, strong independent inflation, with apex reached at posterior margin and sagittal profile strongly sloping downward toward preglabellar furrow; axial furrows moderately narrow and deep; short portion of axial furrow between posterolateral corner of glabella and intersection with posterior border furrow straight (Fig. 19A), directed posterolaterally around anterolateral corner of LO, axial furrow continues around posterolatral corner of LO to margin; glabellar furrows not clearly expressed; glabella, fixigenae, frontal areas, and preglabellar field with sculpture of small and medium sized tubercles; sculpture of densely spaced fine granules covers palpebral lobe and furrow, granules merged on anterior portion of lobe to form a short series of anastomosing lines (Fig. 19L).

Librigena with socle strongly inflated, with sculpture of fine, closely spaced raised lines running subparallel to margin of visual surface, set off from visual surface by narrow and shallow furrow (Fig. 19C), separated from field by slightly longer and deeper furrow; field longer than wide, broadly subrectangular, with portion opposite anterior facial suture shorter than portion opposite posterior facial suture, with background sculpture of fine granules, overlain by medium and small sized tubercles roughly arranged into rows oriented sub parallel to socle margin; anterior section of facial suture with slight anterior bow opposite proximal portion of field just below base of visual surface, distinct almost 90° change in course at lateral border furrow and proximal portion of lateral border, gently curved across border and anterior projection; posterior section describing gentle convex curve opposite field, strongly curved at border furrow across posterior border; anterior projection long; lateral border furrow broad, deepest medially with anterior and posterior portions slightly shallower; lateral border widest medially opposite field, slightly tapered anteriorly and posteriorly, fine granules present on border along margin adjacent to lateral border furrow; lateral margin gently curved; anterior projection and lateral border strongly convex, forming moderately tall face in ventrolateral view (Fig. 19F); sculpture of prominent raised lines running subparallel with margin present on external and ventrolatral aspects of anterior projection and lateral border, lines more closely spaced anteriorly toward tip of anterior projection, orientation of lines slightly disrupted at base of genal spine; posterior border on smaller specimens greatly reduced to small protuberance adjacent to base of genal spine (Fig. 19O), set off from genal spine by shallow, but distinct furrow; doublure beneath anterior projection and lateral border broad, reaching external margin of lateral border furrow beneath lateral border and beyond proximal extent of anterior projection so that the anterior portion of the doublure is visible in external view; doublure appears to continue beneath posterior border (Fig. 19J), forming a small shallow depressed area at genal angle; sculpture of very fine raised lines present along length of doublure.

Hypostome, rostral plate and thorax not identified.

Pygidial measurements were made on Figure 19U, X and one additional specimen from MME 22.3 m that will be figured in a separate expanded treatment of the genus. Pygidium wider (tr.) than long (sag.), with maximum width achieved across posterior portion of second axial segment on two largest specimens; fulcrum is set very far distally from axis, with portion of pygidium distal to fulcrum strongly downturned from horizonal plane forming a nearly vertical face, posteromedian portion of face is angled slightly anteriorly in transverse profile; face is bounded dorsally by pygidial spines and ventrally by a moderately narrow, but well inflated border that bounds lateral and posterior margins of pygidium; pygidial border set off from vertical face by shallow, but concave border furrow, in plan view furrow forms broad concave region below pygidial spines; main surface of vertical face with sculpture of densely spaced, fine granules; pygidial border with sculpture of fine raised lines arranged parallel to margin; doublure present ventrally beneath posterior and at least part of lateral borders; axis composed of four segments and distinct terminal axial piece, maximum axial width across first segment 34.6% maximum pygidial width (measured on Fig. 19X), width across anterior margin of terminal axial piece 62.6% (62.1–63.1) width across first segment; length of axis excluding articulating half ring 43.5% maximum pygidial width (measured on Fig. 19X); axis with strong to moderate dorsal convexity, with apex reached at first axial segment and gently sloping posteroventrally in transverse profile; articulating half ring broken on all recovered specimens, but apparently very short (sag., exsag.), posterior margin almost exactly transverse, strong dorsal convexity in sagittal profile and sitting below apex of first axial segment, with sculpture of fine granules; first ring furrow deep, short, and almost exactly transverse or slightly anteriorly bowed; second ring furrow similar to first, forming a deeper pit adjacent to intersection with axial furrow; third ring furrow similar in all aspects to second, except that distal tips are directed strongly posterolaterally; fourth ring furrow slightly shallower, but also deep, distal tips directed strongly posterolaterally as third ring furrow, and median portion posteriorly bowed; fifth ring furrow shallow, more strongly posteriorly bowed medially than fourth ring furrow; first axial ring of similar length sagittally and exsagittally, with pseudo-articulating half ring of second segment largely merged and only faintly set off by narrow and faint furrow; second ring with morphology similar to first, but distal tips along posterior margin directed posterolaterally and pseudo-articulating half ring not developed; third ring overall shorter (sag.; exsag.), distal tips more directed posterolaterally, median portion with slight posterior bow; fourth ring slightly shorter exsagittally than sagittally, median portion more strongly posteriorly bowed than third segment; first to fourth axial segments with sculpture of mostly medium and a few smaller sized, densely spaced tubercles, large and distinct median tubercle present on each segment; axis terminated by distinct terminal piece developed into two, short, subconical posterodorsally directed spines, spines are set off from each other by very shallow median furrow, tuberculate sculpture of previous rings more subdued on terminal piece; shallow pit developed medially below base of terminal axial piece (best seen in posterior view); short median ridge is developed behind axis (Fig. 19T) from border, ridge does not reach posterior margin of axis in posterior view, but is visible behind axis in plan view (Fig. 19U); first segment with anterior margin describing gently convex arc to fulcrum, directed slightly posterolaterally, portion from fulcrum distally directed slightly anterorlaterally; anterior pleural band longest (exsag.) distally, tapering to a point adaxially at intersection with axial furrow, anterior margin bounded by very narrow rim-like ridge, moderately inflated, distal tip square in plan view, with sculpture of very fine granules, some specimens (e.g., Fig. 19U) with very faint row of tubercles present along posterior margin of band; posterior pleural band longer (sag.; exsag.) than anterior band, longer (exsag.) distally than main portion of band, with sculpture of fine granules overlain by more prominent medium and small sized tubercles; posterior pleural band is merged distally with subsequent anterior pleural band and developed into a prominent spine, which is directed posterolaterally and also slightly dorsally, spine is conical in cross section; pleural furrow deep, shallower adjacent to axial furrow, moderately long along entire course, terminated just past start of subvertical face of pygidium, directed posterolaterally in plan view; interpleural furrow significantly shallower than pleural furrow, deepest medially abaxial to fulcrum, shallower but discernible adjacent to axis, progressively effaced toward base of spine becoming completely effaced on spine so that posterior pleural band of segment one and anterior pleural band of segment two appear merged, directed just slightly posterolaterally; interpleural furrow between segments two and three slightly impressed, with that between segments three and four very faintly visible on largest pygidium; morphology of second pleural segment similar to first, but overall shorter and with shorter pygidial spine; third pleural segment even shorter and more strongly posterolaterally directed, with third posterior pleural band and fourth anterior pleural band expressed solely as prominent subconical spine, strongly posterolaterally directed; very short and minute fourth pygidial spine developed on one specimen (Fig. 19X, CC) between third spine and spine of terminal axial piece.

Remarks. At present, no other member of the genus is really adequately known, though many of the species illustrated herein are represented by extensive collections. The morphologically closest species to *Hystricurus zanderi* is *Hystricurus* sp. nov. 1 (Fig. 8S, W) from the *Rossaspis leboni* Zone. *Hystricurus zanderi* differs from *H.* sp. nov. 1 in having a cranidium with a more anteriorly bowed anterior margin, a longer preglabellar field, more subdued tuberculate sculpture, and a narrower, less dorsally inflated glabella. The pygidia of *H. zanderi* differ from those of *H.* sp. nov. 1 in the possession of more robust fulcral spines with more posteriorly extended tips, and taller vertical regions above the border with less expression of pleural and interpleural furrows.

Family CHEIRURIDAE Hawle & Corda 1847

Rossaspis Harrington 1957

Type species. Protopliomerops superciliosa Ross 1951, from the Garden City Formation (upper Tremadocian; Stairsian; *Pseudoclelandia cornupsittaca* Zone), Idaho, USA.

Other species. Rossaspis leboni sp. nov., Fillmore Formation (upper Tremadocian; Stairsian; *Rossaspis leboni* Zone), Utah, USA; *Rossaspis* sp. 1 (herein), Fillmore Formation, Utah; *Rossaspis* sp. nov. 2 (herein), Fillmore Formation, Utah; *Rossaspis* sp. nov. 3 (herein), Fillmore Formation, Utah; *Rossaspis* sp. (herein), Fillmore Formation, Utah.

Remarks. Rossaspis appears to represent a clade, but full diagnosis and discussion is deferred until the type species is revised and three additional new species (illustrated in open nomenclature herein) are described.

***Rossaspis leboni* sp. nov.** (Figs 8B, F, 20)

Material. Holotype, cranidium, SUI 134287 (Fig. 20A, D, E, G, K) and assigned specimens SUI 134077, 134288, 134290, 134291, from Section MME 49.8 m, Fillmore Formation (upper Tremadocian; Stairsian; *Rossaspis leboni* Zone), Middle Mountain, Ibex area, Millard County, western Utah. Assigned specimen SUI 134289 from Section HC6 58.4 m, Garden City Formation (upper Tremadocian; Stairsian; *Rossaspis leboni* Zone), west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho.

Etymology. After Simon Le Bon.

Diagnosis. Cranidium with S1 and S2 nearly transverse; glabella with even scattering of very dense, small tubercles; axial and glabellar furrows narrow; anterior border short (sag.; exsag.); pygidial pleural spines laterally extended, turned posteriorly near tips, tips blunt; pygidial terminal piece prominent and inflated.

Description. Cranidial measurements were made on Fig. 20A, C, and four addititional specimens from MME 49.8 m that will be figured in a forthcoming work. Cranidium with maximum cranidial sagittal length 40.9% (37.0–44.3) maximum width across posterior projections; width across across γ 106.9% (100.6–111.5) maximum width sagittal length, and 43.7% (40.0–46.8) maximum width across posterior projections; anterior margin of anterior border describing broad, anteriorly convex arc in plan view, with anterior sections of facial sutures following this curve opposite anterior border; facial suture making sudden change in course at intersection with anterior border furrow, strongly anterolaterally bowed opposite anterior portion of small palpebral lobe, with sudden change in course opposite posterior portion of palpebral lobe so that suture abruptly cuts laterally across fixigena and lateral border; main portion of palpebral lobe situated opposite L3, posterior margin defined by deep and narrow palpebral furrow that runs from point opposite middle of L3 laterally to point just before facial suture, in anterior view posterior margin of lobe is strongly deflected upward from horizontal plane (Fig. 20G); eye ridge prominent and confluent with palpebral lobe, together they possess slight independent inflation from adjacent areas of cranidium, anterior margin running obliquely from palpebral lobe to fossulae with anterior margin bounded by anterior border furrow, posteriorly bounded palpebral furrow; anterior border very short in front of main portion of glabella, lengthened exsagittally forming small subtriangular area adjacent to anterolateral corner of glabella and eye ridge, border sits below glabella in lateral profile and is angled downward from horizontal plane; in anterior profile anterior border describing broad concave arc medially opposite rostral suture, with general bow of this arc continued abaxially to palpebral lobes with only slight disruptions along course; sculpture of fine, densely spaced granules overlain by small sized, scattered tubercles covers border; anterior border furrow short (sag.), deep, and confluent with preglabellar furrow in front of glabella, defining anterior margin of eye ridge abaxially, significantly narrower and shallower along this portion; anterior border furrow, axial furrow, and abaxial tip of S3 intersect at fossulae, which

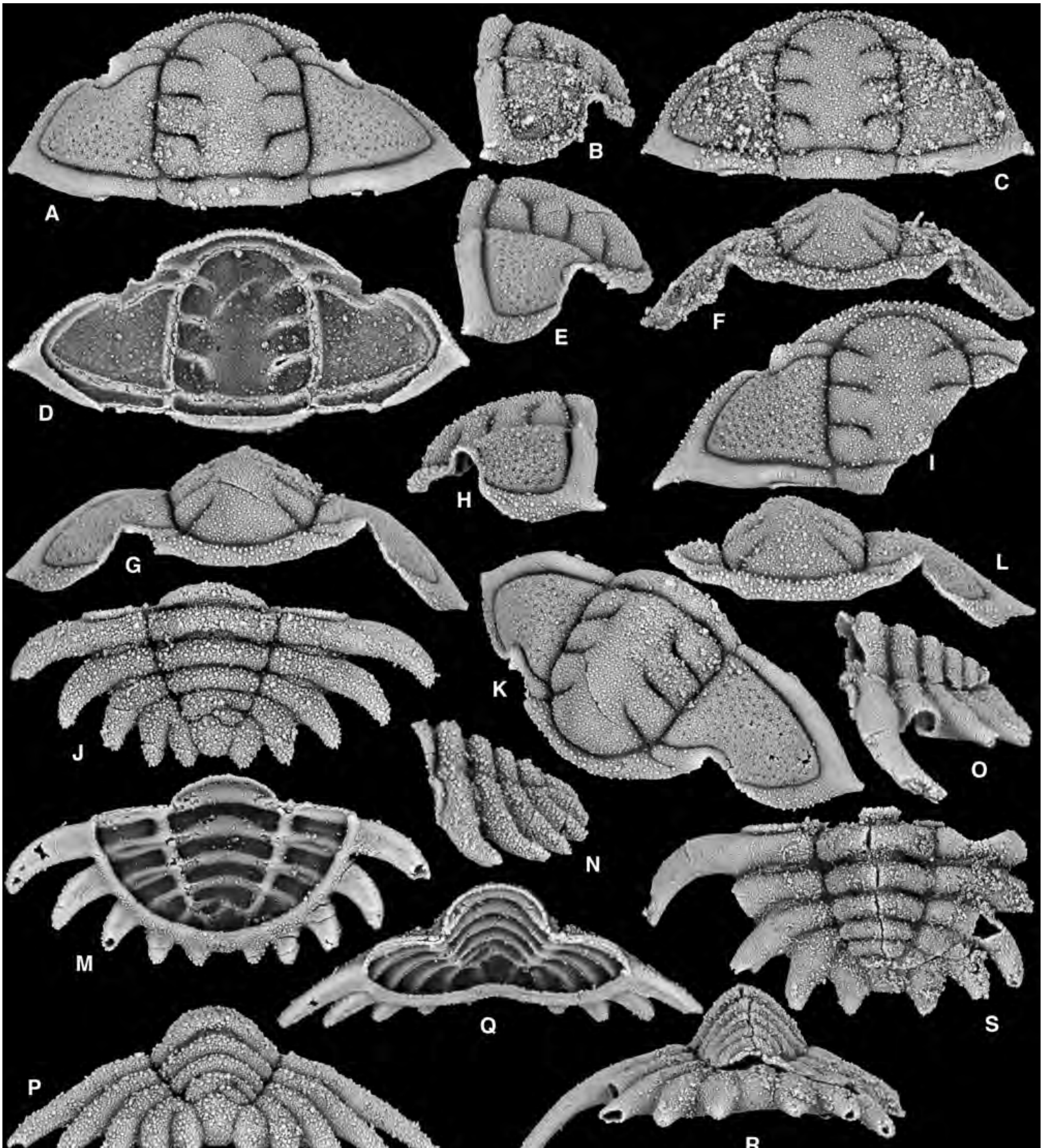


Figure 20. ***Rossaspis leboni*** sp. nov., from Section MME 22.3 m, Fillmore Formation, Middle Mountain, Ibex area, Millard County, western Utah, and Section HC6 58.4 m, Garden City Formation, west side of Hillyard Canyon, Bear River Range, Franklin County, southeastern Idaho, both upper Tremadocian, Stairsian, *Rossaspis leboni* Zone. **A**, **D**, **E**, **G**, **K**, cranidium, holotype, SUI 134287, dorsal, ventral, right lateral, anterior, and oblique views, x12 (MME 49.8 m). **B**, **C**, **F**, cranidium, SUI 134288, right lateral, dorsal, and anterior views, x12 (MME 49.8 m). **H**, **I**, **L**, cranidium, SUI 134289, left lateral, dorsal, and anterior views, x12 (HC6 58.4 m). **J**, **M**, **N**, **P**, **Q**, pygidium, SUI 134290, dorsal, ventral, left lateral, posterior, and anterior views, x15 (MME 49.8 m). **O**, **R**, **S**, pygidium, SUI 134291, left lateral, posterior, and dorsal views, x12 (MME 49.8 m).

are deep and large; fixigena large, with exsagittal length adjacent to axial furrow 55.9% (53.3–60.2) cranidial sagittal length, maximum width 83.4% (78.5–87.2) glabellar width, portion adaxial to fulcrum held nearly parallel to horizontal plane, portion abaxial to fulcrum strongly downturned from horizontal plane, covered with sculpture of fine granules and prominent small pits, some cranidia with a scattering of small tubercles on fixigena (e.g., Fig. 20I); lateral border broad, confluent with posterior border around genal angle, which is developed into a short posterolaterally directed spine, with sculpture of fine granules and on some specimens a few small tubercles, short row of small tubercles situated along middle of border present on some specimens (Fig. 20I); posterior border shorter (exsag.) proximally between axial furrow and fulcrum, lengthened distally from fulcrum, border with sculpture of fine densely spaced granules; posterior border with posterior margin straight and directed slightly anterolaterally from axial furrow to fulcrum, from fulcrum distally describing very gentle concave curve, curve strongest at fulcrum forming slight posteriorly directed bulge; lateral border furrow deep and very narrow, directed strongly posterolaterally, confluent with posterior border furrow at intersection at genal angle, posterior border furrow similar to lateral border furrow, slightly longer medially, overall directed just slightly anterolaterally abaxially from axis; axial furrows deep and narrow opposite main portion of glabella, shallower and narrower opposite LO, width across posterior contact of furrows with posterior margin 70.5% (64.8–76.4) cranidial sagittal length, short posterolaterally directed section situated at anterior corner of LO connects axial furrow with SO and posterior border furrow; glabella with maximum width across L1 97.2% (90.2–102.6) sagittal length excluding LO; sagittal glabellar length (excluding LO) 75.6% (71.7–77.7) that of cranidium; glabella subquadrate in plan view with strongly rounded anterior margin, more dorsally convex than adjacent areas of cranidium; S1 deep, partially isolating L1, main portion directed slightly posteromedially from axial furrow adaxially, with proximal tips directed more posteriorly; S2 similar to S1, but almost exactly transverse, with smaller portion of proximal tips directed posteromedially; S3 similarly deep, but describing gentle anteriorly concave arc; L1 partially isolated, subrectangular, with moderate dorsal inflation; L2 and L3 with inflation similar to L1, with adaxial margins not defined; sculpture of large, densely spaced granules covers glabella, with row of very small tubercles or larger granules arranged along margins of L1 and L2 in some specimens (e.g., Fig. 20I); SO similar in depth and width to S1–S3, deeper opposite posterior margin of L1, medial portion opposite area between proximal tips of S1 nearly transverse and set anteriorly so that it encroaches on posterior portion of glabella, distal portions of SO opposite rear margins of L1 slightly deeper and set back from medial portion, gently anteriorly concave around L1; LO with sagittal length 16.6% (14.2–19.1) that of cranidium, anterior margin follows course of SO so that medial portion of LO is longer than distal portions opposite L1, sculpture of large densely spaced granules covers LO, median node prominent, set at midline; all furrows expressed dorsally are expressed as prominent ridges ventrally (Fig. 20D); thin strip of doublure present beneath LO, extends only about half the distance across LO and does not reach ventral expression of SO, longest sagittally and tapering abaxially; doublure also present beneath posterior border from about fulcrum abaxially, doublure lengthens toward genal angle.

Librigena, rostral plate, hypostome and thorax unknown.

Pygidial measurement were made on Figure 20J and one additional specimen from MME 49.8 m that will be figured in a separate publication. Pygidium spinose with five pairs of pygidial spines, maximum with across distal tips of first pygidial spine pair 244.3% (236.5–252.1) sagittal pygidial length; first pleural segment with maximum exsagittal pleural length 21.5% (20.4–22.6) sagittal axial length; anterior pleural band greatly reduced to extremely short (exsag.) strip, occupying space between axis and fulcrum; posterior pleural band making up majority of exsagittal length of pleural band, with length similar to that of first axial segment, long adjacent to axis, tapers slightly medially, lengthens abaxially from fulcrum, terminating in long, free pygidial spine, with sculpture of coarse granules present between axis and fulcrum, sculpture becomes much finer distal to fulcrum; first pygidial spine pair longest, slightly dorsoventrally flattened, directed posterolaterally, with distal portion directed more strongly posterolaterally, directed downward from horizontal plane; pleural furrow deep and short, directed slightly posterolaterally; interpleural furrow similar to pleural furrow, but anteriorly bowed, extending to pygidial margin; second and third anterior pleural bands similarly short as first, but more lenticular in outline with pleural and interpleural furrows confluent adjacent to axis, furrows also intersect distally; subsequent anterior pleural bands not clearly expressed, with pleural and interpleural furrows confluent along entire course; subsequent posterior pleural bands with morphology similar to first, but overall smaller and progressively more posteriorly directed; second and third pygidial spine pairs very similar to first, but smaller; fourth pair are small and directed posteriorly almost parallel to sagittal axis; fifth spine pair shortest and directed slightly posteromedially; pleural region covered by sculpture of densely spaced coarse granules on proximal portion, sculpture becomes finer distal to fulcrum along length of spines, spines mostly lacking sculpture of granules ventrally, with slightly depressed smooth region along middle of spine (Fig. 20M); axis of six segments, axial width across first segment 29.4% (28.2–30.5) maximum pygidial width, length of axis excluding articulating half ring 35.9 (34.6–37.1) total sagittal length of pygidium; axis funnel shaped in outline, with width across sixth segment 40.5% (37.3–43.6) width across first segment; articulating half ring short (sag.; exsag.), sagittal length 8.9% (8.7–9.2) total pygidial length, much shorter (sag.; exsag.) than first axial segment, semilunate, with sculpture of very fine granules; first ring furrow deep, progressively deeper abaxially, gently anteriorly bowed; second ring furrow similar to first, but median section slightly longer; third and fourth ring furrows short and deep along entire course; fifth ring furrow slightly shorter than fourth; sixth ring furrow narrower and shallower, with median portion strongly anteriorly bowed; first axial ring longer exsagittally than sagittally; posterior rings progressively smaller, more similar in length sagittally and exsagittally; axis terminated by small terminal piece, subtrapezoidal in outline, posterior portion strongly downturned from horizontal (Fig. 20N, P); entire axis covered with sculpture of coarse granules; axial furrow narrow and deep, deeper at intersection with ring furrows and interpleural/pleural furrows, very shallow opposite terminal axial piece; distinct border visible ventrally marking lateral and posterior margin of pygidium with intersection of pygidial spines, strongly inflated, with sculpture of granules (Fig. 20M), inner margin deflected upward toward ventral surface of pygidium.

Remarks. Rossaspis leboni differs from *R. superciliosa* in the possession of a shorter anterior border, particularly exsagittally, markedly narrower cranidial furrows, glabellar furrows that are more transversely aligned versus posteromedially directed, a fine, dense tuberculate sculpture everywhere, versus prominently larger tubercles aligned along glabellar and axial furrows, and a narrower (tr.) palpebro-ocular ridge. Pygidia differ in that those of *R. leboni* have much more transversely directed pleural spines which are only turned posteriorly near the tips. Those of *R. superciliosa* are even curved and much more posteriorly directed. The tips of the spines in *R. leboni* and quite blunt whereas those in *R. superciliosa* are sharply pointed. The terminal piece in *R. superciliosa* is weakly inflated whereas in *R. leboni* it is strongly inflated and separated from the fifth pair of pleural spines by a well impressed continuation of the axial furrows.

Family Uncertain

Pseudoclelandia Ross 1951

Type species. Pseudoclelandia cornupsittaca Ross 1951, from the Garden City Formation, Idaho, USA.

Other species. Pseudoclelandia fluxafissura Ross 1951, Garden City Formation, Idaho; *P. lenisora* Ross 1951, Garden City Formation, Idaho; *P. weymouthae* sp. nov., Fillmore Formation, Utah; *Pseudoclelandia* sp. nov. 1 (herein), Fillmore Formation, Utah; *Pseudoclelandia* sp. nov. 2 (herein), Fillmore Formation, Utah; *Pseudoclelandia* sp. nov. 3 (herein), Fillmore Formation, Utah; *Pseudoclelandia* sp. nov. 4 (herein), Garden City Formation, Idaho; *Pseudoclelandia* sp. 1, Fillmore Formation, Utah; *Pseudoclelandia* sp. 2, Fillmore Formation, Utah; *Pseudoclelandia* sp. 3, Garden City Formation, Idaho.

Remarks. Apart from *Pseudoclelandia weymouthae*, described herein, no members of the genus are adequately known. Nevertheless the taxon is common throughout most of the Stairsian. The known species will be revised based on new collections and several new species described in a forthcoming work. In the present state of knowledge, detailed comparisons are difficult.

Pseudoclelandia weymouthae sp. nov. (Figs 13E, I, 21)

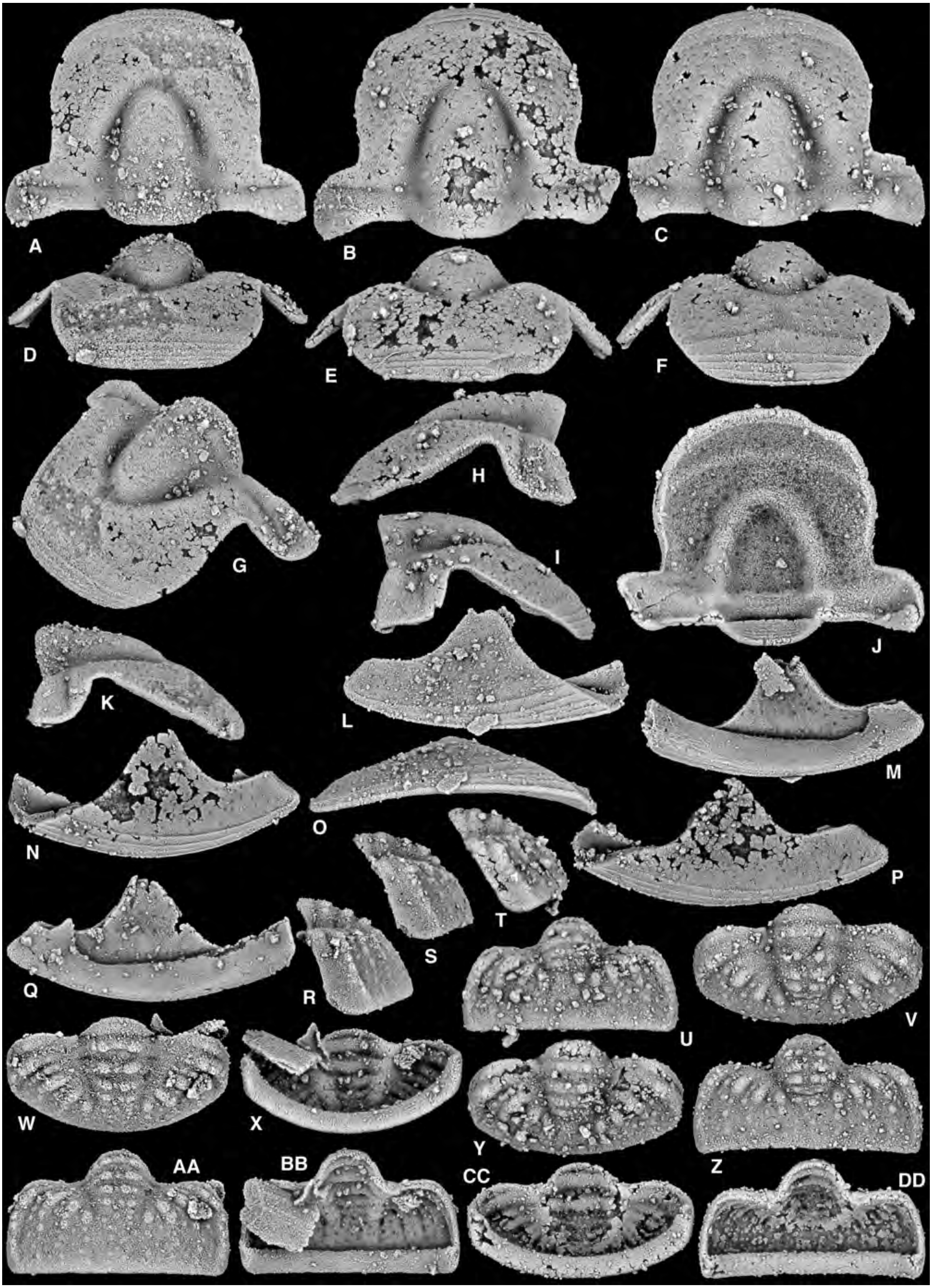
Material. Holotype, cranidium, SUI 134292 (Fig. 21A, D, G, K) and assigned specimens SUI 134294, 134297, 134300, from Section C 115.8 m, southern House Range, and assigned specimens SUI 134188, 134293, 134295, 134296, 134298, 134299, from Section AAA 114.5T m, northern House Range, both Fillmore Formation (upper Tremadocian; Stairsian; *Pseudoclelandia weymouthae* Zone), Ibex area, Millard County, western Utah.

Etymology. After Tina Weymouth.

Diagnosis. Cephalon lacking tuberculate sculpture, with prominent raised lines on cranidial anterior and librigenal lateral borders, fine punctate sculpture on most external surfaces; glabella elongate, lobation weakly defined; pygidium with paired tubercles on axial rings and rows of tubercles on posterior pleural bands.

Description. Cranidial measurements were made on Figure 21A, B, C and four additional specimens from AAA 114.5T m. Cranidium strongly vaulted with portion of fixigena anterior to posterolateral projection, preglabellar field, and anterior border forming broad field, sloped strongly downward from horizontal plane, facing mostly anteriorly, but slightly anterolaterally; maximum cranidial width across posterior projections 145.0% (142.0–152.2) sagittal length; anterior border moderately long (sag.; exsag.), slightly shorter abaxially, with sagittal length 11.9% (10.7–13.3) sagittal length of cranidium, much shorter than LO with sagittal length 64.4% (54.8–72.3) length of LO, prominent sculpture of five to six raised lines running almost parallel to margin in plan view, posteriormost line slightly peaked medially in anterior view (Fig. 21F) and marking posterior extent of anterior border, there is a short gap between this line and the next line anteriorly on most specimens (e.g., Fig. 21F), remaining lines are all more closely spaced, border sloping strongly downward; anterior margin of anterior border describing gentle arc in plan view, medial portion almost exactly transverse in anterior view; anterior border furrow very short (sag.; exsag.) and shallow, in sagittal profile expressed as very slight disruption in slope between preglabellar field and anterior border, with curve similar to that of anterior border in plan view, very slightly medially bowed in anterior view; anterior sections of facial sutures straight and strongly posterolaterally directed opposite anterior border, more laterally convex opposite frontal area, with only a very slight hint of disruption across anterior border furrow; sutures continue posteriorly with slight lateral concavity before distinct change in course at start of posterolateral projection of posterior fixigena; posterior section of facial suture laterally convex across posterolateral projection of fixigena; preglabellar field long (sag.; exsag.), with sagittal length 18.5% (16.5–20.7) that of cranidium, slope similar to that of anterior fixigena, very faint median furrow present on some specimens (e.g., Fig. 13E); sculpture of small pits present on preglabellar field and anterior fixigena (Fig. 21F), sculpture expressed ventrally (Fig. 21J); posterior fixigena inflated opposite proximal portion of posterior border furrow, extended laterally forming short (exsag.), subtriangular, posterolateral projection; posterior border furrow moderately long (exsag.) and shallow, deepest at fulcrum, contact anteriorly with posterior fixigena opposite fulcrum sharp, more gradational contact laterally along anterior margin and posteriorly with posterior border; posterior border long (exsag.) proximally, progressively longer distally, flattened in lateral profile, posterior margin of border almost exactly transverse to fulcrum, portion distal to fulcrum strongly directed posterolaterally so that distal tip forms a posterolaterally directed projection, lateral margin of distal tip gently laterally convex; glabella subtriangular, strongly dorsally inflated, with maximum width posteriorly 90.3% (84.6–99.5) sagittal length excluding LO, sagittal length (excluding LO) 49.5% (46.0–56.0) that of cranidium; in lateral profile highest point of glabella reached posteriorly

Figure 21. ***Pseudoclelandia weymouthae*** sp. nov., from Section AAA 114.5T m, northern House Range, and Section C 115.8 m, southern House Range, both Fillmore Formation (upper Tremadocian; Stairsian; *Pseudoclelandia weymouthae* Zone), Ibex area, Millard County, western Utah. **A**, **D**, **G**, **K**, cranidium, holotype, SUI 134292, dorsal, anterior, oblique, and right lateral views, x12 (C 115.8 m). **B**, **E**, **H**, **J**, cranidium, SUI 134293, dorsal, anterior,left lateral, and ventral views, x15 (AAA 114.5T m). **C**, **F**, **I**, cranidium, SUI 134294, dorsal, anterior, and right lateral views, x14 (C 115.8 m). **L**, **M**, **O**, right librigena, SUI 134295, external, internal, and ventrolateral views, x15 (AAA 114.5T m). **N**, **Q**, left librigena, SUI 134296, external and internal views, x15 (AAA 114.5T m). **P**, left librigena, SUI 134297, external view, x15 (C 115.8 m). **R**, **W**, **X**, **AA**, **BB**, pygidium, SUI 134298, left lateral, dorsal, ventral, posterior, and anterior views, x14 (AAA 114.5T m). **S**, **V**, **Z**, **CC**, **DD**, pygidium, SUI 134299, x14 (AAA 114.5T m). **T**, **U**, **Y**, pygidium, SUI 134300, left lateral, posterior, and dorsal views, x17 (C 115.8 m).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opposite SO, with posterior margin of LO sitting even slightly higher, glabellar profile strongly sloped downward from horizontal plane anteriorly so that anterior margin is nearly inline with slope of preglabellar field and anterior border; axial furrows very broad and deep opposite main anterior portion of glabella, narrower anteriorly joining preglabellar furrow in a smooth continuous arc, much shallower posteriorly opposite posterolateral corners of glabella, shallower still opposite LO, with width across posterior contact of furrows with posterior margin 50.6% (48.2–53.7) cranidial sagittal length; intersection of axial and posterior border furrows with SO forming broad shallow depression that encroaches onto posterolateral margins of glabella; preglabellar furrow shallower and short, strongly anteriorly bowed medially; glabella smooth with furrows not expressed; LO long (sag.), with sagittal length 18.6% (16.4–20.8) that of cranidium, much longer sagittally than exsagittally, posterior margin strongly posteriorly bowed, anterior margin almost transverse; SO very faint, distal tips deeper, nearly transverse; doublure broad and semicircular under LO, anterior margin just reaching posterior margin of SO as expressed ventrally, with sculpture of fine raised lines running subparallel to margin; additional small triangular section of doublure present ventrally at posterolateral tip of posterior border (Fig. 21J).

Librigenal measurements were made on Figure 21L and one additional specimen from AAA 114.5T m to be figured in a forthcoming work. Librigena with maximum width behind eye 48.1% (45.3–51.0) total librigenal length (including anterior projection and genal spine); anterior section of facial suture with length 62.8% (60.0–65.6) total length librigenal length, gently curved across field and border, with curve slightly stronger opposite distal portion of field just before border furrow; posterior section of facial suture with length 45.5% (41.0–50.0) total librigenal length, strongly curved; field subtriangular in outline, with maximum width 38.8% (37.4–40.2) total librigenal length; lateral border furrow shallow, expressed mainly as slightly concave region between field and border; posterior border furrow similar to lateral border furrow, very faint; lateral border with lateral margin gently laterally bowed, widest anteriorly, tapering to a point distally and termination of genal spine, with sculpture of about five prominent raised lines running roughly parallel to margin, proximal line prominent, clearly setting border off from field, all lines more widely spaced anteriorly and becoming progressively closer toward distal tip of genal spine so that only two lines continue onto tip of genal spine, line along lateral margin more prominent that others (Fig. 21O); lateral border in ventrolateral view gently arched (Fig. 21O), sloping upward toward genal field; cuticle thickened at lateral margin of librigena (Fig. 21L, N); posterior border very short, sculpture of raised lines fainter than on lateral border, proximal line from lateral border continues around tip of genal spine onto lateral border setting it off from field; genal spine short, tapered to a blunt point; area in front of base of genal spine (confluence of lateral and posterior borders) forming broad flattened area, sculpture of scattered pits present in this region (Fig. 21N) and continuing onto field, clearly visible on ventral surface of field (Fig. 21M); anterior projection short, sculpture on lateral border continues onto projection; doublure broad, portion beneath anterior projection visible in external view (Fig. 21N, P), broadest anteriorly and tapering toward genal angle, external third of doublure with sculpture of fine raised lines, lines finer than those on dorsal surface of lateral border, inner two thirds of doublure more smooth, inner margin gently curved, with strong bend at genal angle and across posterior border; portion of doublure beneath posterior border developed into a short triangular process (Fig. 21Q).

Hypostome and thorax not identified.

Pygidial measurements were made on Figures 13I, 21W, V, Y. Pygidium with maximum with across second segment 187.0% (176.7–193.3) sagittal length; axis triangular in plan view, strongly convex (Fig. 21DD), composed of five segments, first four segments clearly expressed and very small terminal piece best seen in lateral profile, maximum axial width across first segment 31.9% (29.9–33.7) maximum pygidial width, length of axis excluding articulating half ring 60.0% (64.5–71.6) total sagittal length of pygidium; articulating half ring large and long with sagittal length 15.5% (13.5–18.5) total pygidial length, anterior margin strongly convex, posterior margin very gently anteriorly convex, ring sloped posteroventrally in line with general sagittal profile of axis; first ring furrow moderately short (sag.; exsag.) and shallow; second ring furrow nearly as deep as first, but slightly posteriorly bowed medially; third and fourth ring furrows shallow, but longer than first two; fifth ring furrow mostly effaced; first axial ring slightly longer sagittally than exsagittally (including partially merged second pseudo-articulating half ring), with sculpture of two prominent nodes present on either side of sagittal line; pseudo-articulating half ring of second segment clearly visible, but poorly developed, set off by narrow short furrow; posterior rings progressively smaller, but with essentially the same morphology and sculpture, width across fourth segment 67.3% (64.6–71.4) width across first segment; pseudo-articulating half rings of subsequent segments not clearly expressed; axis terminated by very small terminal piece, just barely visible in plan view as two very small nodes, more clearly identified in lateral profile by change in slope between fourth axial segment and post-axial region; anterior margin of first pleural band anteriorly concave opposite axial furrow, strongly anteriorly convex across fulcrum, with small subtriangular facet developed at anterolateral corner; first pleural segment with maximum exsagittal length 30.6% (27.3–33.2) sagittal axial length; anterior pleural band of first segment longest adaxially from fulcrum, much shorter distal to fulcrum and adjacent to axial furrow; posterior pleural band longer than anterior band, more prominent with stronger inflation than anterior band, very faint sculpture of small tubercles visible in lateral profile, tubercles continue past fulcrum almost to pygidial margin; posterolateral faces of pygidium from fulcrum distally form just slightly less than vertical "wall" (Fig. 21R–T); pleural furrow short (exsag.), nearly effaced between fulcrum and axial furrow, deeper from fulcrum distally, but terminated just past fulcrum before pygidial margin, directed posterolaterally; interpleural furrows similar to pleural furrows but more clearly define almost to pygidial margin; morphology of pleural region of segments two and three generally similar to segment one, but progressively narrower, more weakly expressed, turned slightly more posterolaterally, and with sculpture of small tubercles, sculpture stops just past fulcrum; pleura of fourth segment barely expressed as small node adjacent to terminal axial piece, in posterior view expressed as prominent round nodes with sculpture of faint smaller tubercles continuing onto "wall;" pleural bands terminate at pygidial border; border most clearly expressed in posterior view as short section with very slight independent inflation and distinct sculpture of closely spaced fine granules; ventral pygidial margin describing very slightly medially bowed margin, distal portion of "wall" with sculpture of fine raised granules and dashes arranged in an anastomosing pattern; doublure broad around lateral and posterior pygidial margins, inner margin describing smooth arc similar to that of pygidial margin, oriented subvertical (Fig. 21R) against ventral surface of pygidium, sculpture of fine raised lines covering entire doublure (Fig. 21S).

Remarks. Of the three species previously described by Ross (1951), two were based on a single cranidium and one on a single cranidium and a single librigena. Of these, *Pseudoclelandia cornupsittaca* is not closely similar to *P. weymouthae*, as it has a deep anterior border furrow which connects medially to the preglabellar furrow and has strong tuberculate sculpture, among other prominent differences. *Pseudoclelandia lenisora* (from the *Bearriverops logani* Zone) is similar to *P. weymouthae* in general dimensions, but is also densely tuberculate. *Pseudoclelanida fluxafissura* is the closest presently named species. It differs from *P. weymouthae* in the possession of a shorter cranidium, more laterally extended anterior facial sutures, and a more subtriangular, versus anteriorly extended, glabella. Much more satisfactory comparisons will be facilitated when the species are revised on the basis of extensive new material in a forthcoming work, and further comments are deferred until then.

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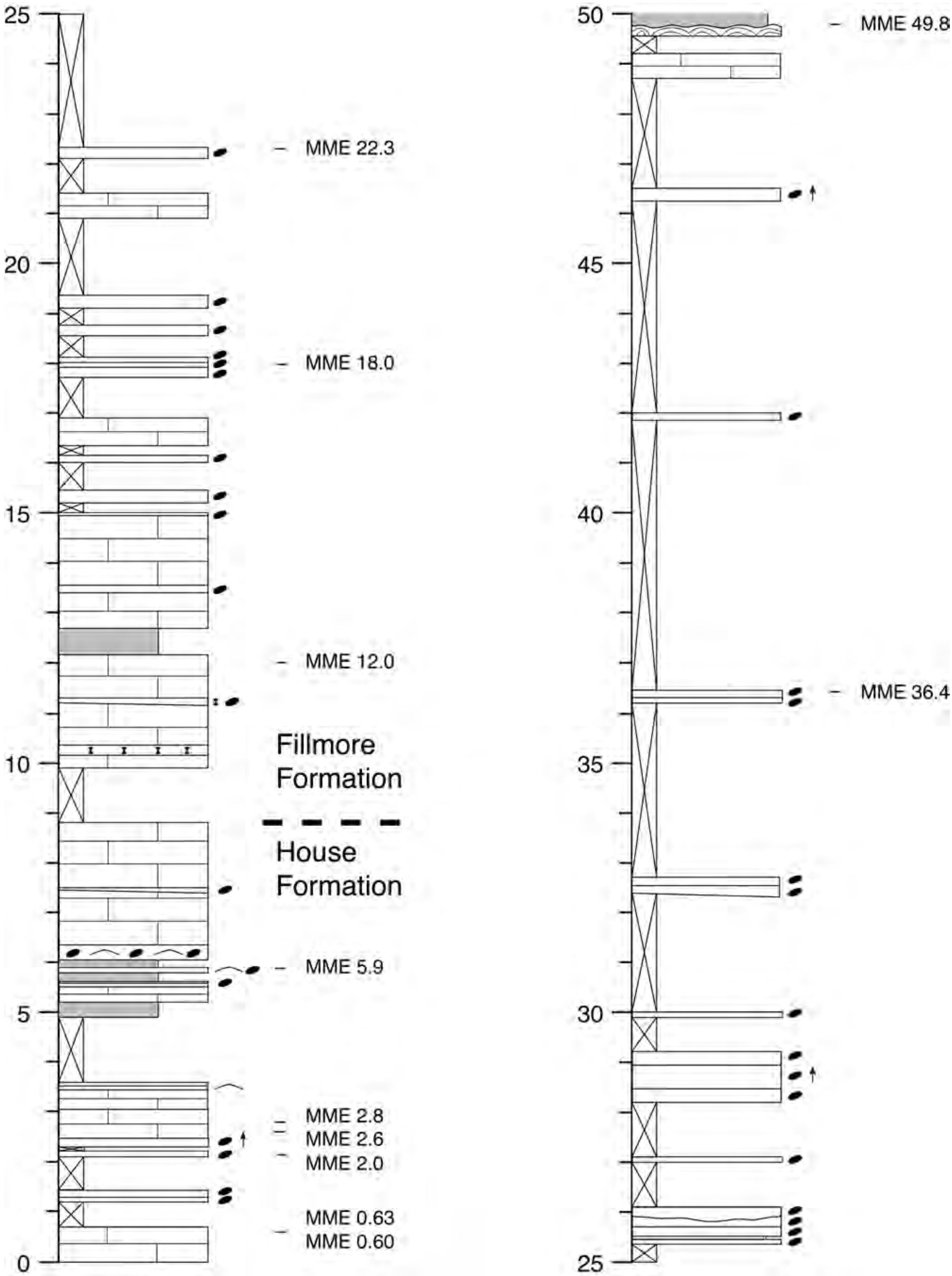
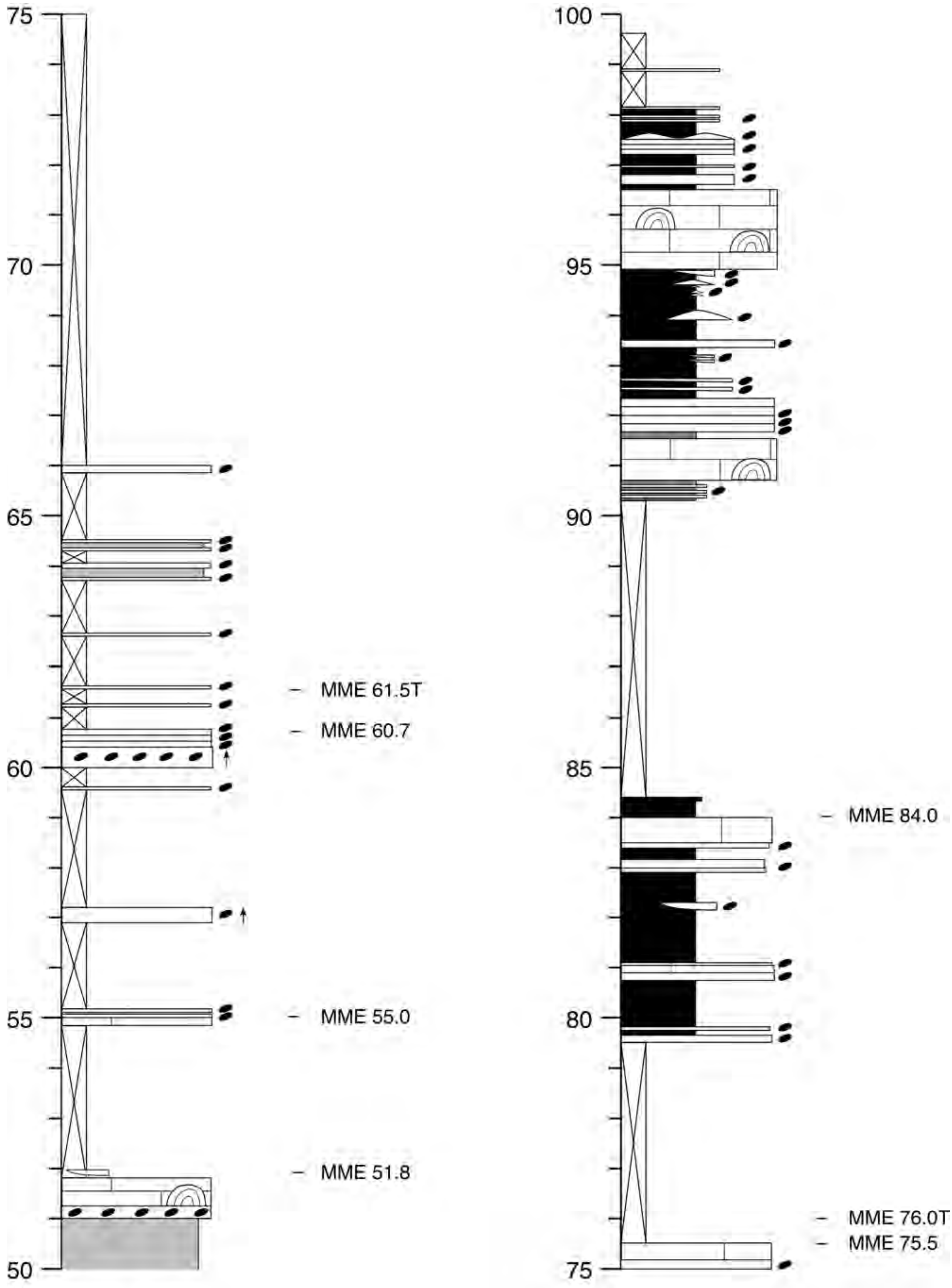
APPENDIX 1. Stratigraphic log of Ibex Section MME through the upper House Formation and lower part of the Fillmore Formation (measured and logged by Westrop and Adrain). See Figure 1 for position and line of section. Our new sampling horizons are indicated in metres to the right of the columns. Legend is on page 205.



APPENDIX 1 (continued)



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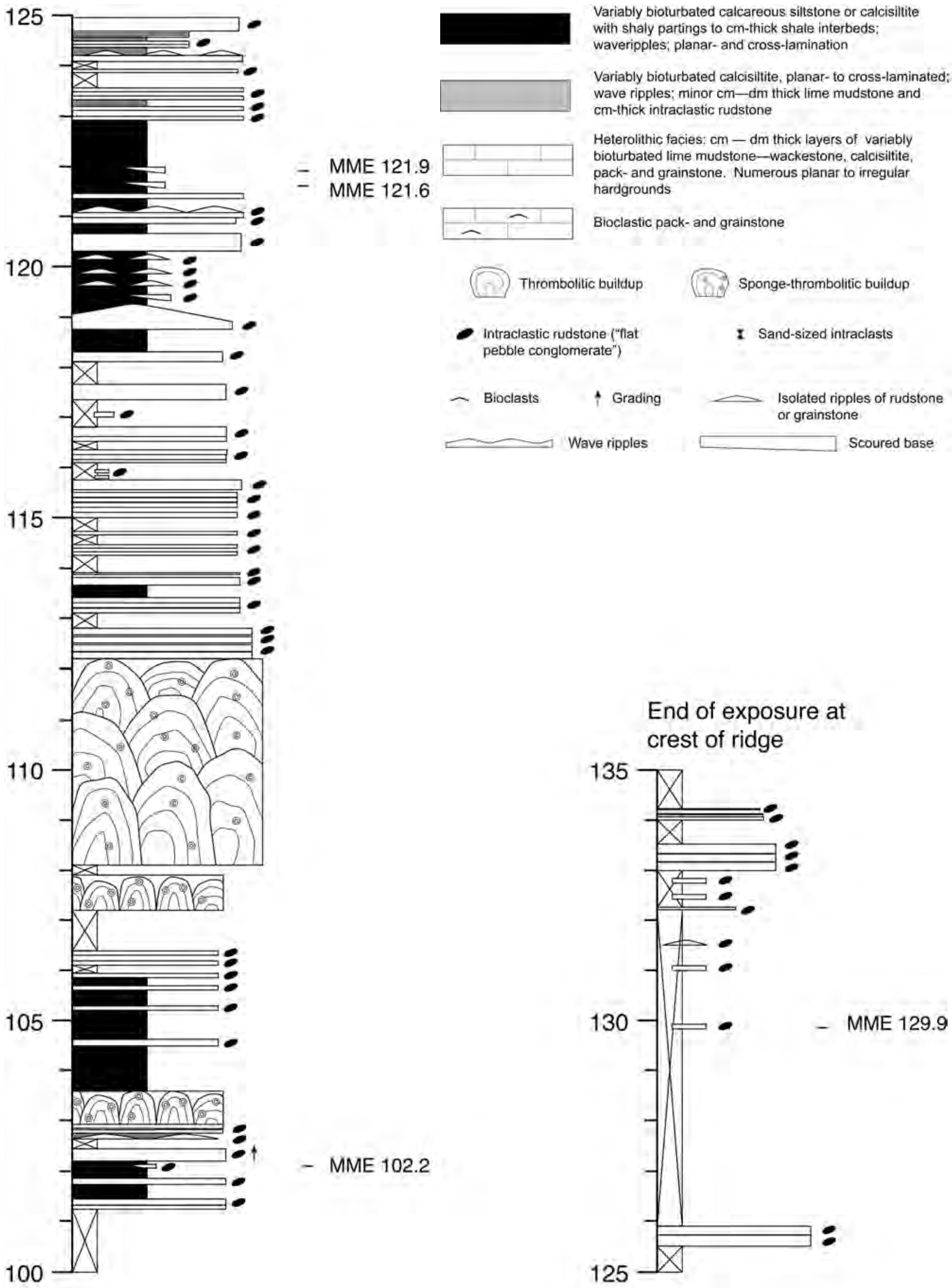
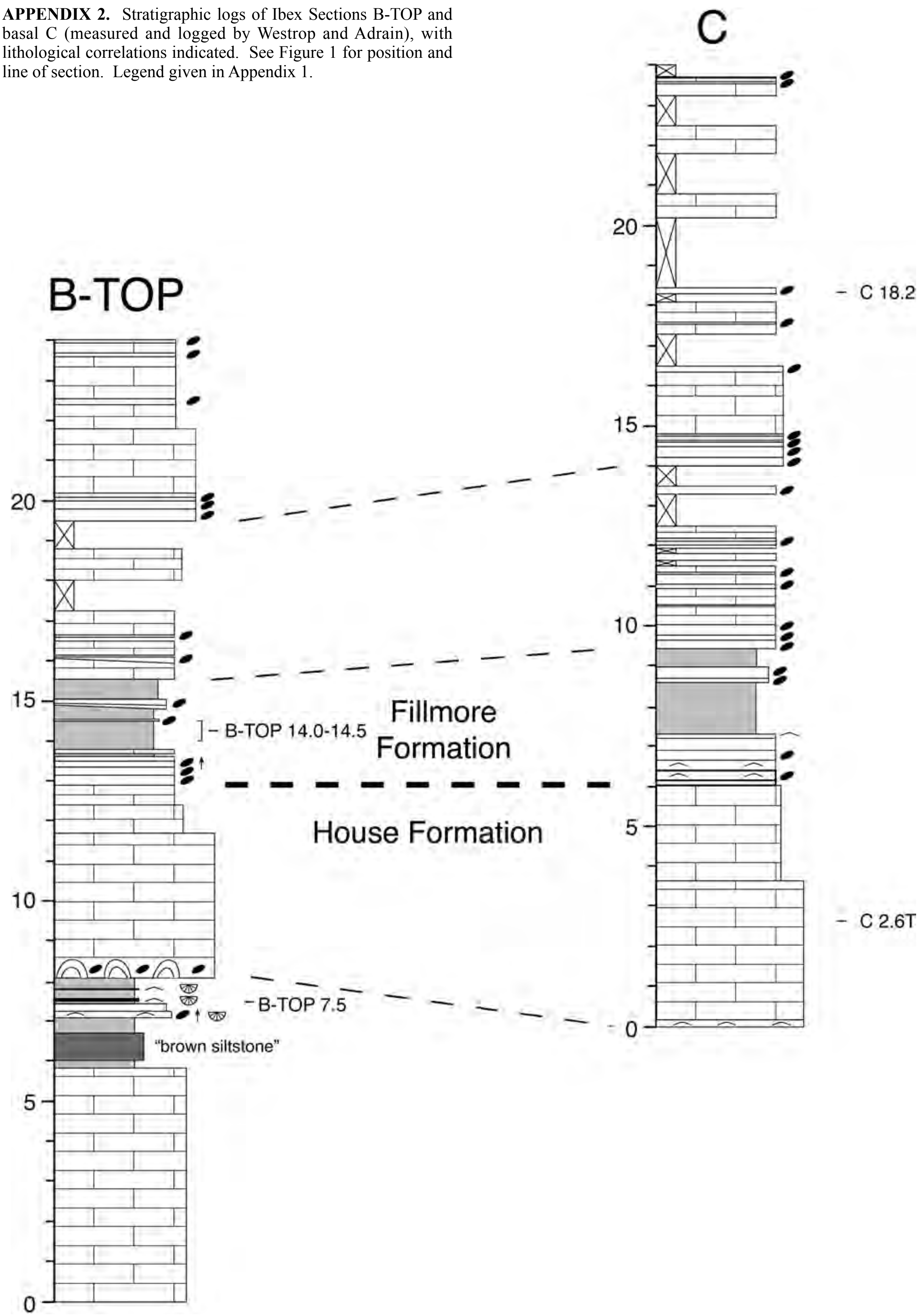
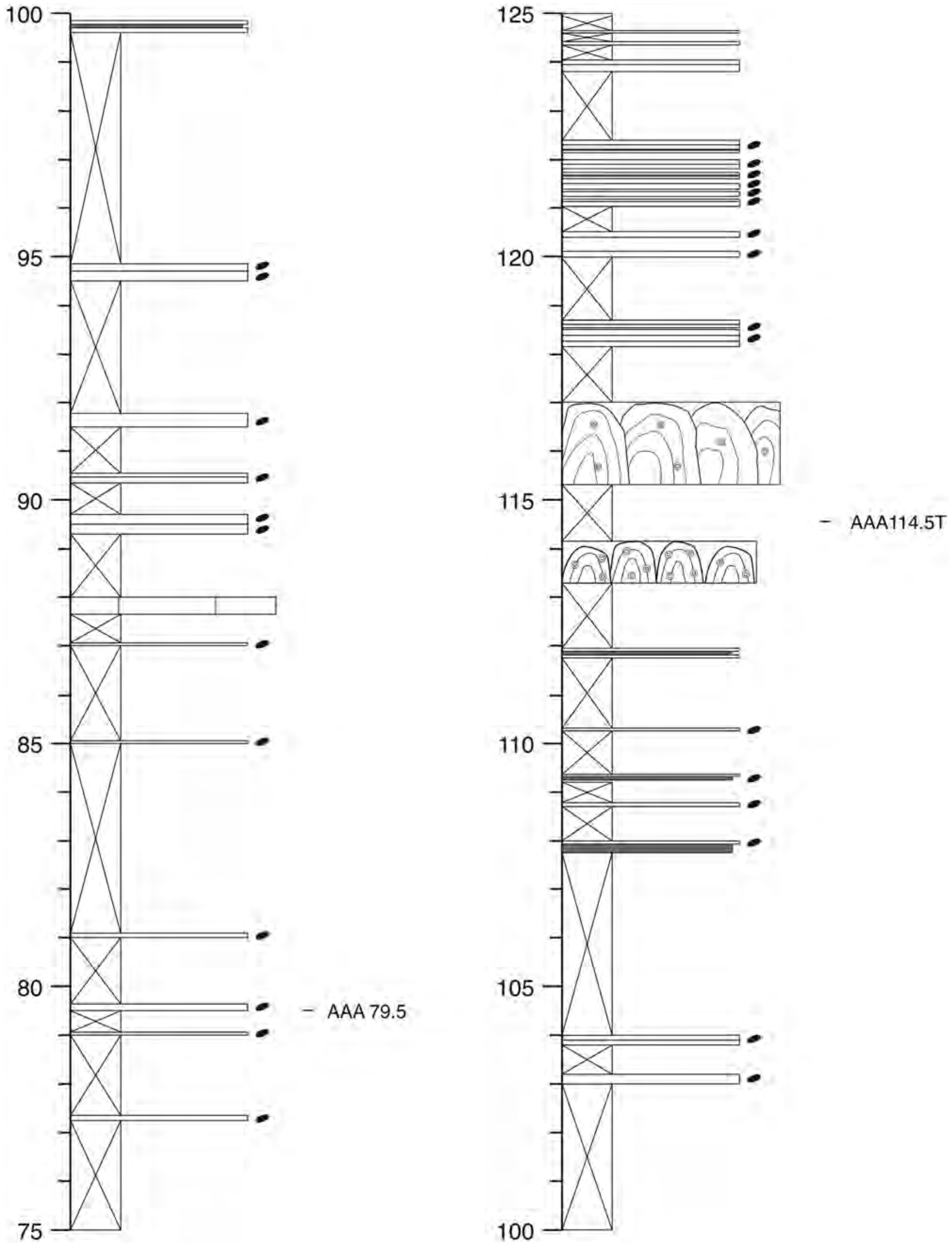


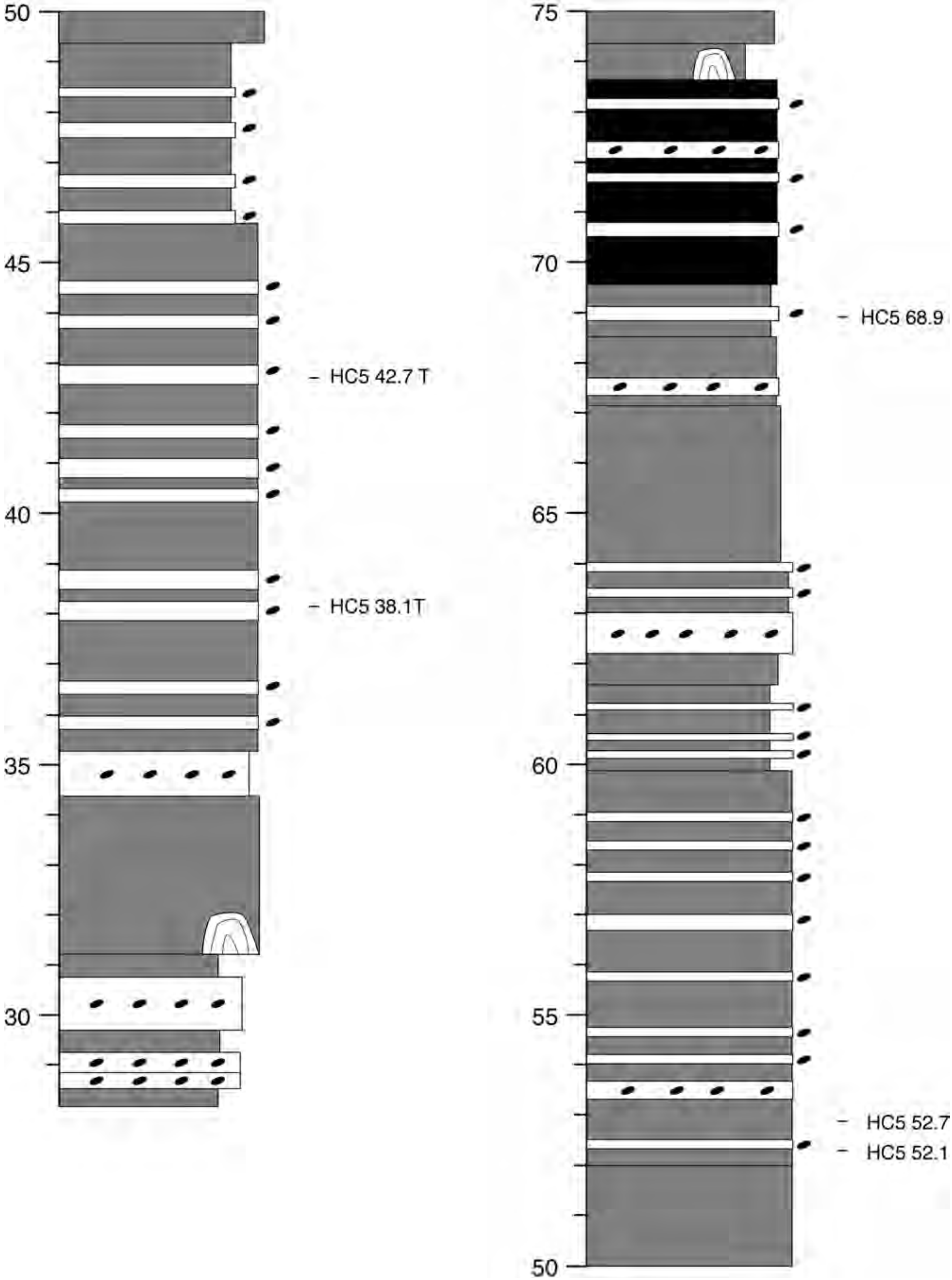
APPENDIX 2. Stratigraphic logs of Ibex Sections B-TOP and basal C (measured and logged by Westrop and Adrain), with lithological correlations indicated. See Figure 1 for position and line of section. Legend given in Appendix 1.



APPENDIX 3. Stratigraphic log of the upper part of Ibex Section AAA (measured and logged by Westrop and Adrain). See Figure 1 for position and line of section. Legend given in Appendix 1.



APPENDIX 4. Stratigraphic log of a portion of Bear River Range Section HC5 (measured and logged by Landing). See Figure 2 for position and line of section. Legend given in Appendix 1.



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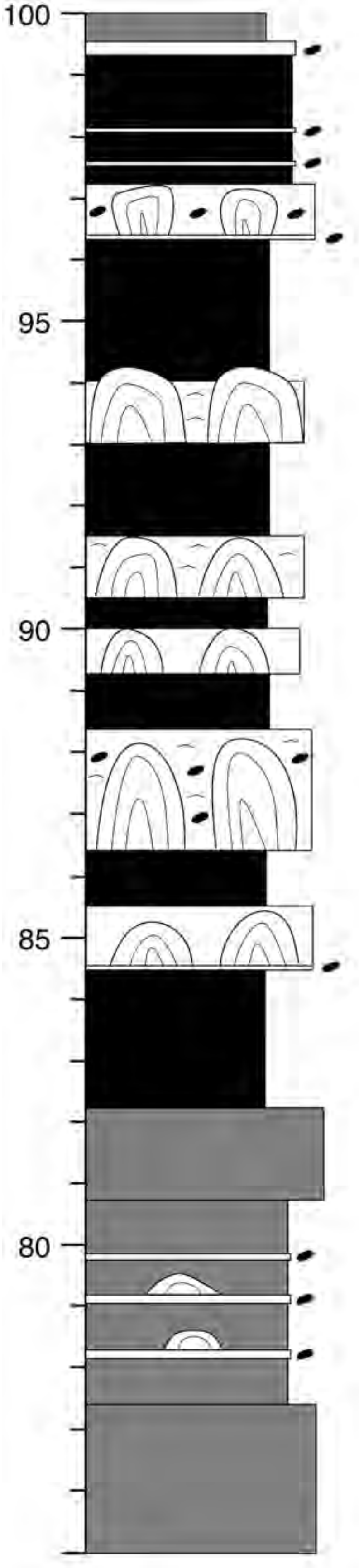

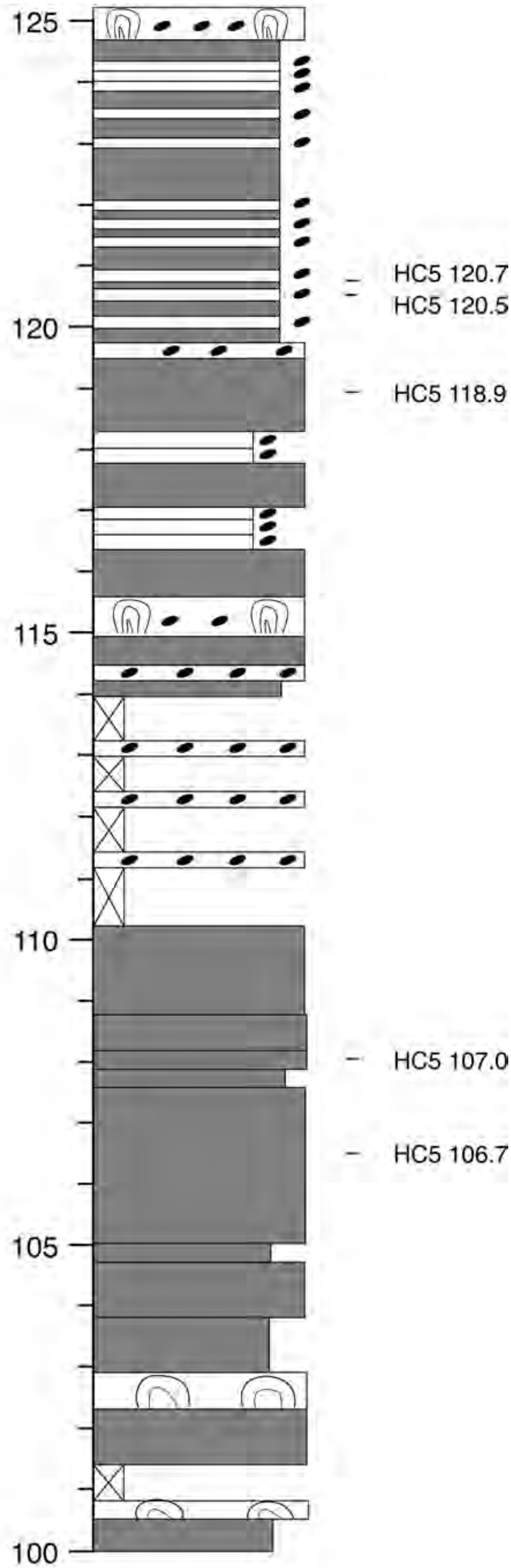

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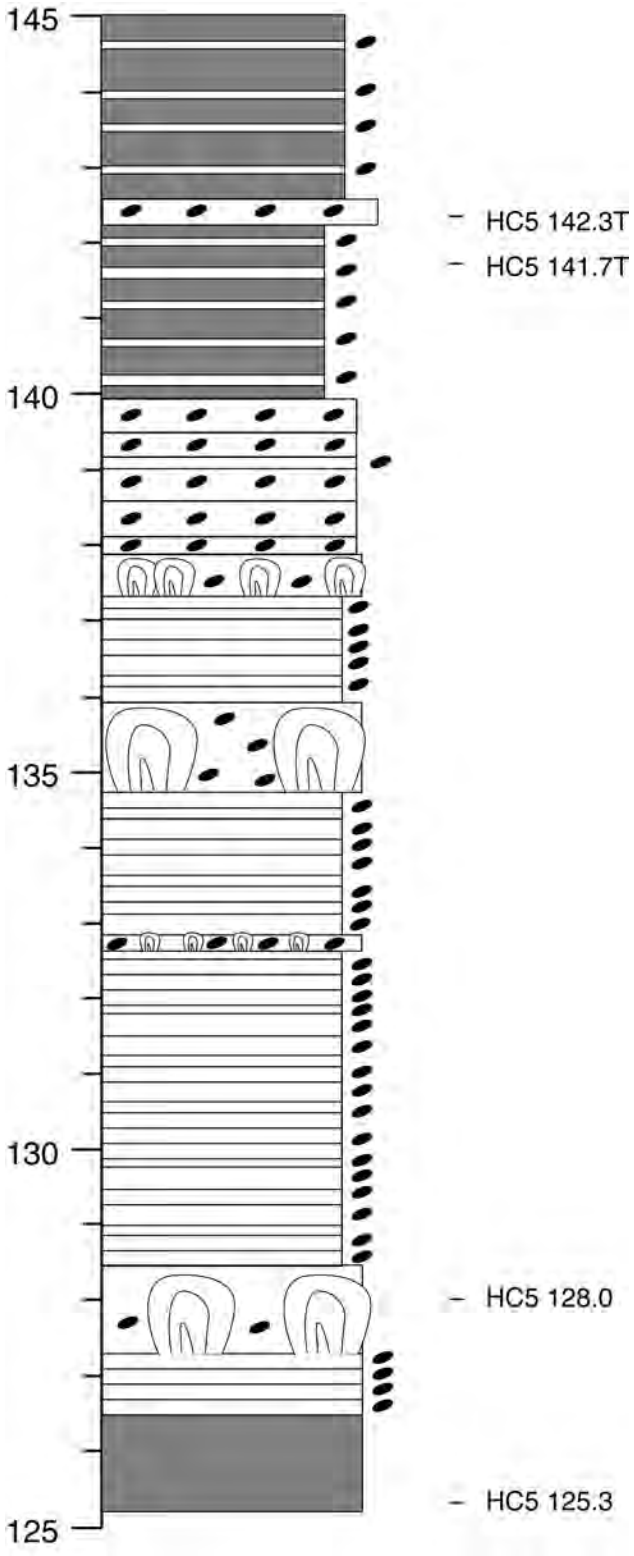
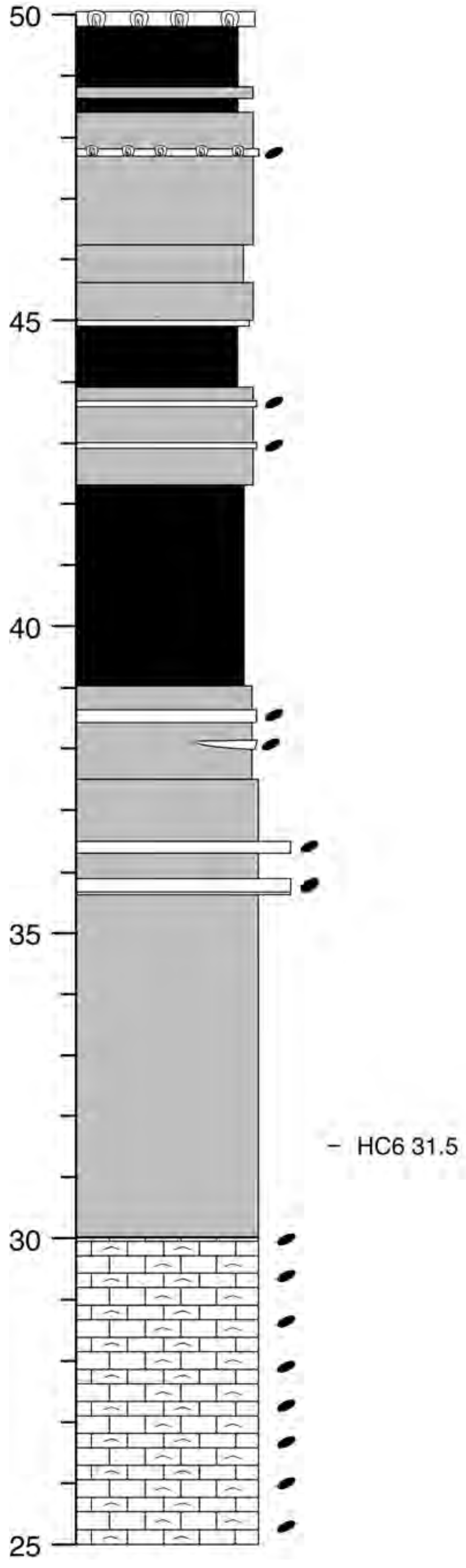


APPENDIX 5 Stratigraphic log of a portion of Bear River Range Section HC6 (measured by Adrain, logged by Landing). See Figure 2 for position and line of section. Legend given in Appendix 1.



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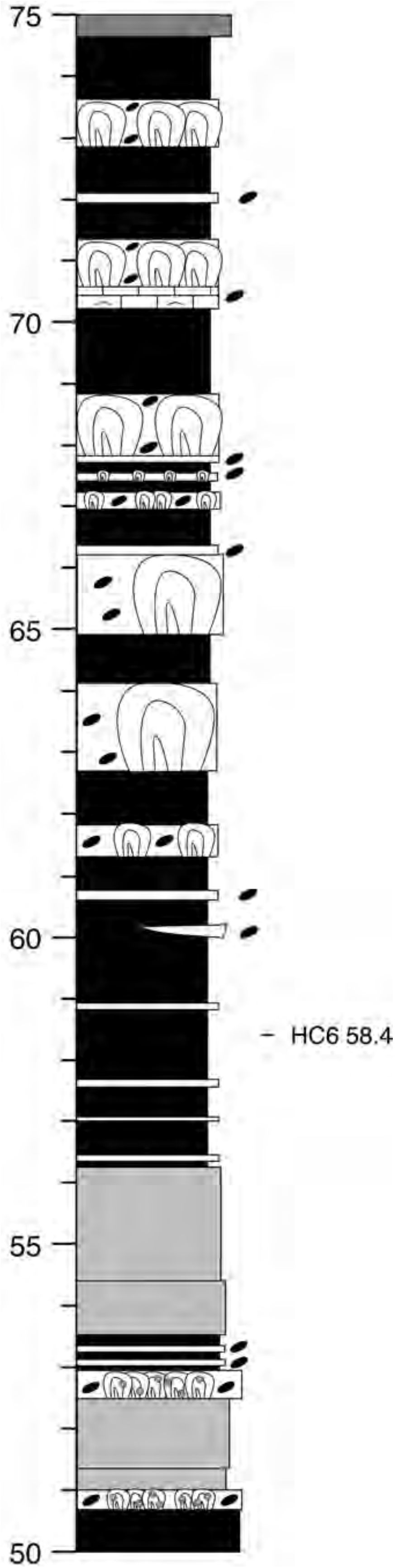

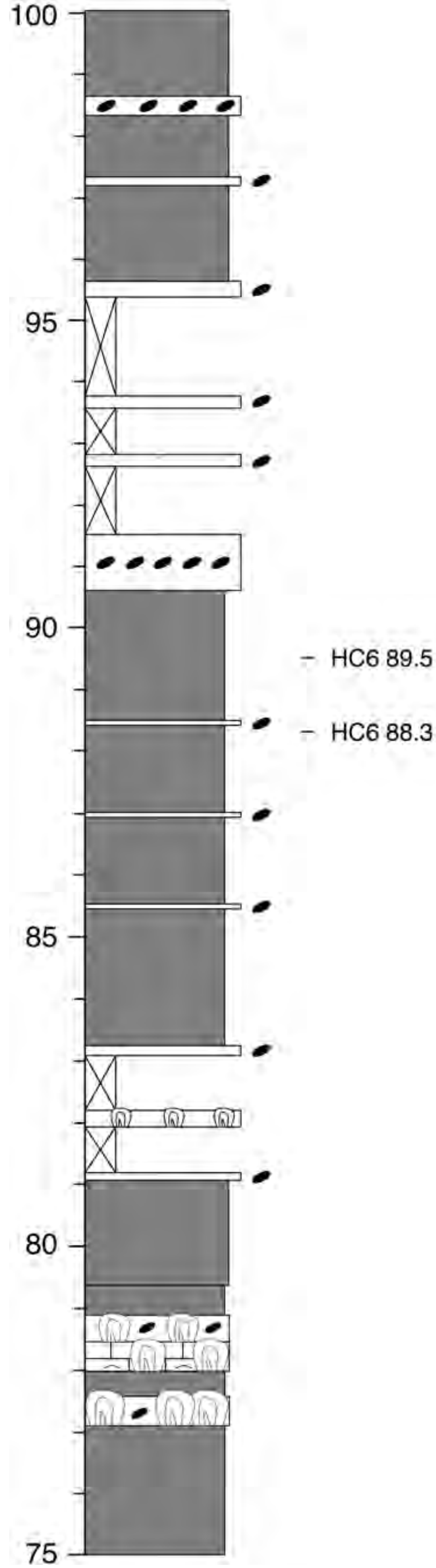

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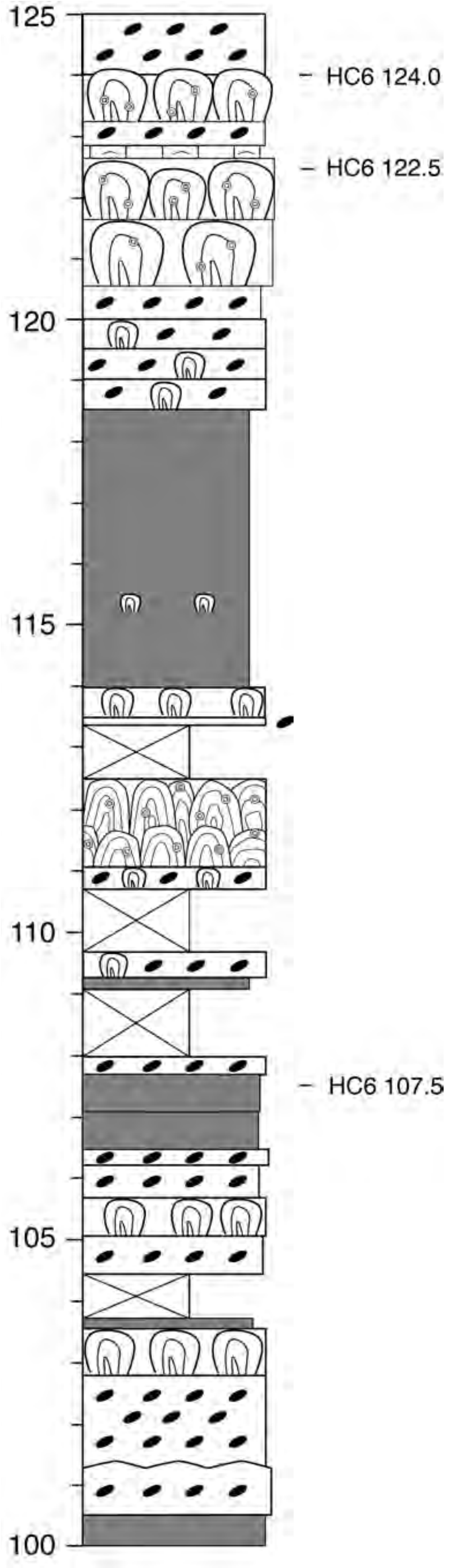
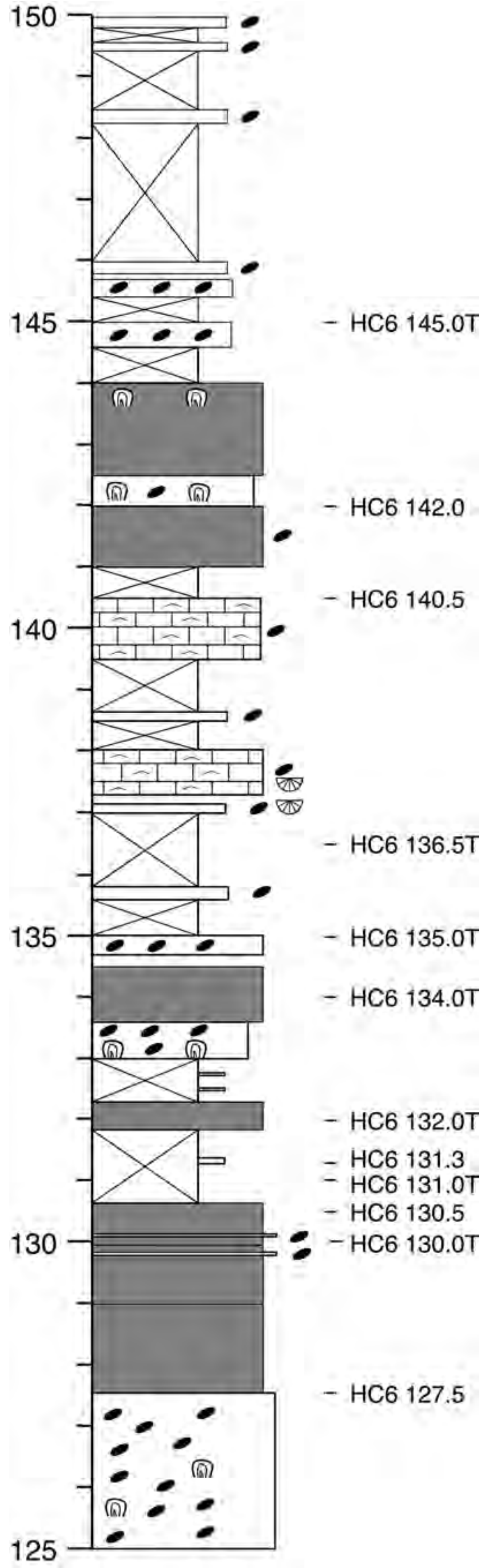
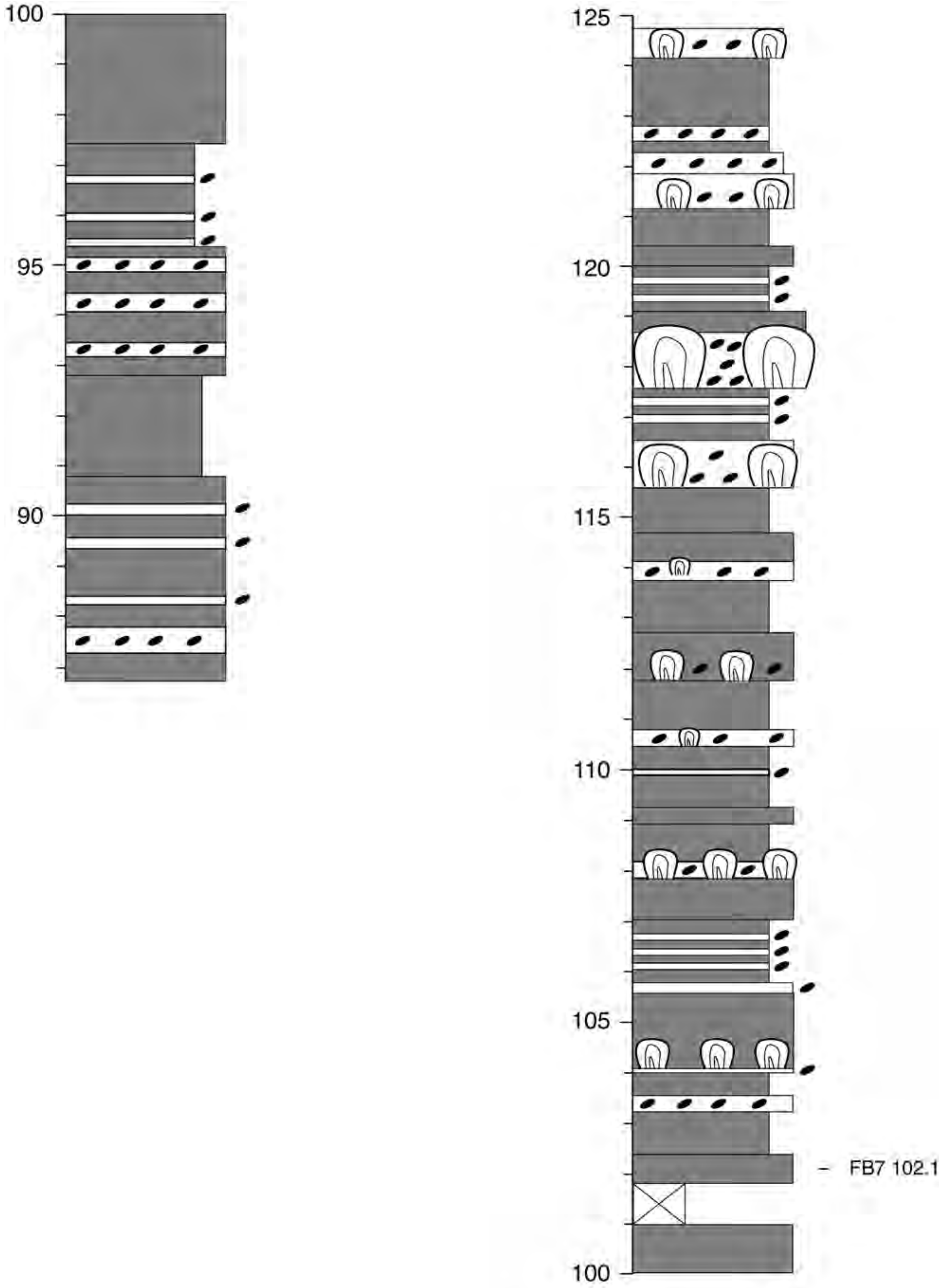




APPENDIX 6 Stratigraphic log of a portion of Bear River Range Section FB7 (measured and logged by Landing). See Figure 2 for position and line of section. Legend given in Appendix 1.



APPENDIX 6 (continued)