Systematic revision of the latest middle Cambrian trilobites from Cerro El Solitario, Mendoza, Argentina

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Latest middle Cambrian trilobites from the Ángel Borrello collections in the Museum of Natural Sciences of La Plata, Argentina, are described. The specimens were collected from open-shelf lithofacies of Cerro El Solitario (Solitario Olistolith), Precordillera of Mendoza, western Argentina. Taxa include *Agnostus microcephalus* Rusconi, *Ammagnostus beltensis* (Lochman in Lochman & Duncan), *Kormagnostus* sp., *Clavagnostus calensis* Rusconi, *Oedorhachis typicalis* Resser, *Lejopyge* sp., *Tomagnostella nepos* (Brøgger), *Diplagnostus planicauda* (Angelin), *Ptychagnostus aculeatus* (Angelin), *Cedaria calensis* (Rusconi), *C. cortesi* (Poulsen), *C. harringtoni* (Poulsen), *Talbotinella communis* Poulsen, *Elrathia hornensis* (Rusconi), *Bolaspidella lucieae* Poulsen, *Marjumia*? sp., *Modocia*? sp., *Asaphiscus* cf. *villavicencis* (Rusconi), *Goycoia tellecheai* Rusconi and *Parabolina*? sp. In addition, selected type specimens of the Rusconi collections in the Museum J.C. Moyano, Mendoza, are reillustrated. *Cedaria* Walcott, *Marjumia* Walcott, *Modocia* Walcott, *Elrathia* Walcott, and *Asaphiscus* Meek are reported from this locality for the first time. Widely distributed agnostoids characterise the upper *Lejopyge laevigata* Zone, whereas some ptychopariids are compatible with the partially coeval *Cedaria minor* Zone. Athough most of the polymeroid species of Cerro El Solitario are endemic, generic occurrences strongly support affinities with North America and Greenland.

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THE CAMBRIAN-ORDOVICIAN invertebrates collected by Dr. Ángel V. Borrello and his associates during the 1960s constitute records of great scientific value for the Museum of Natural Sciences of La Plata, Argentina. This material is represented by several thousands of specimens from classic localities of northwestern (Cordillera Oriental) and western (Precordillera) Argentina. Trilobites clearly dominate these collections, followed by brachiopods, graptolites, molluscs, hyoliths, ostracodes, sponges and ichnofossils.

Borrello (1963, 1964, 1965, 1967) and Borrello & Pernas (1965) partially described this material, focusing their studies on the trilobites from La Laja Formation (Borrello 1962) in the Villicum and Zonda Ranges, eastern Precordillera of San Juan (Fig. 1). They provided the basis for the Cambrian biostratigraphy of that formation by recognising the *Olenellus*, *Bathyuriscus-Elrathina* and *Glossopleura-Kootenia* Zones, and establishing close faunal affinities with North America (cf. Harrington & Leanza 1943; V. Poulsen 1958; see also Bordonaro & Pratt 2008).

In addition, Borrello summarised the stratigraphic implications of specimens reported from the western Precordillera of Mendoza. Based on material collected by himself, as well as on additional information published by Rusconi (e.g., 1945, 1954, 1955, 1956a, b, 1962), Leanza (1947), V. Poulsen (1958) and C. Poulsen (1960), Borrello (1965, 1971) provided preliminary lists of faunas from the Cerro Pelado, Cerro Solitario, El Totoral and San Isidro areas (Fig. 1), which were assigned to classic middle Cambrian and Furongian biozones of Laurentia. Many of these samples were examined in collaboration with P. Hupé (Sorbonne, Paris) in the 1960s but, since then detailed systematic study has not been undertaken.

Beginning with the comprehensive taxonomic revision of the Borrello collections, the trilobites

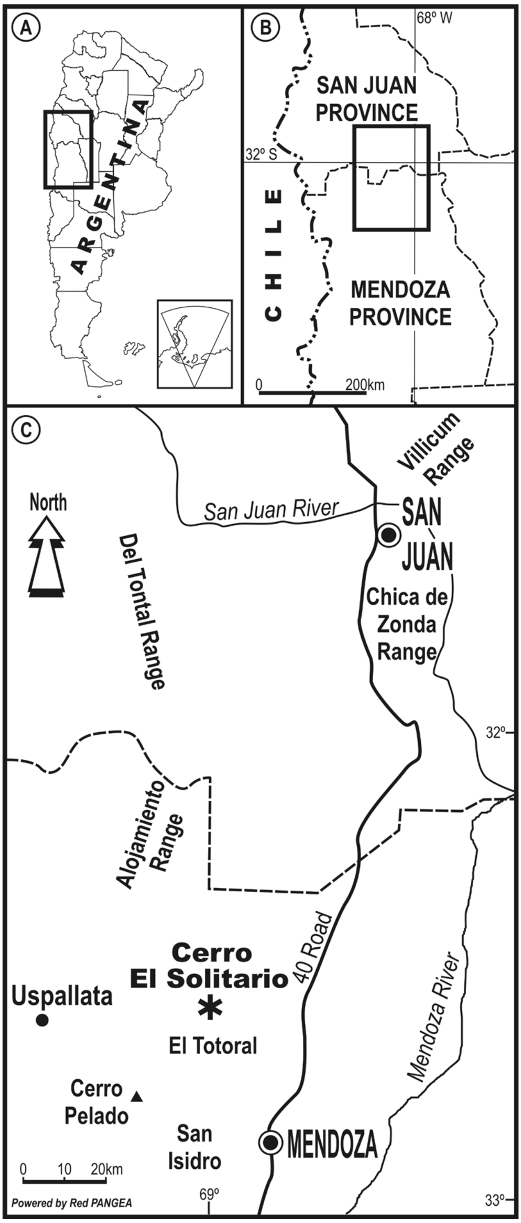


Fig. 1. Location of collecting site in northern Mendoza, western Argentina.

from the Cerro El Solitario locality, northern Mendoza, are described herein. The material studied consists of more than 500 specimens from the dark limestones of the Solitario Olistolith (late middle Cambrian). Several agnostoids from this locality are index fossils with great potential for intercontinental correlation. In addition, information on the systematic affinities of the polymeroids and their biostratigraphic and palaeobiogeographic implications is updated.

PREVIOUS WORK AND STRATIGRAPHIC SETTING

The Cambrian rocks of the Precordillera of Mendoza consist mainly of limestones, marls, marly shales and shales representing outer shallow platform to upper slope environments (Bordonaro 1985; Bordonaro & Banchig 1996; Bordonaro 2003). Although some units are regarded as autochthonous (e.g., Cerro Pelado and El Relincho Formations at Cerro Pelado locality, Furongian; Heredia 1996), these rocks generally constitute allochthonous blocks (olistoliths) of different sizes (from a few centimetres to several dozens of metres) (=La Cruz Limestones *sensu* Keller 1999) within the Ordovician shales of the Estancia San Isidro Formation (Heredia & Beresi 2004). The most classic localities are Cerro El Solitario ("Solitario Olistolith", upper middle Cambrian), El Totoral ("Totoral Olistoliths", middle Cambrian), and San Isidro ("San Isidro Olistoliths", middle Cambrian; "San Martín Olistolith", upper middle Cambrian; "La Cruz Olistoliths", Furongian) (e.g., Gallardo *et al*. 1988; Bordonaro *et al*. 1993; Bordonaro & Banchig 1996 and references therein; Bordonaro 2000, 2003; Heredia & Beresi 2004) (Fig. 1). Their trilobites are mainly characteristic of fairly deep, open-marine environments, and have great importance in biostratigraphy (Bordonaro & Liñán 1994; Bordonaro & Banchig 1995; Shergold *et al*. 1995).

The Cerro El Solitario fossil locality was discovered by C. Rusconi and M. Tellechea (Museo de Historia Natural de Mendoza) in the late 1940s. This outcrop is located about 40 km NNW of Mendoza city, near Canota, and consists of a medium size olistolith (Solitario Olistolith), which is partially covered by alluvial material. The succession is composed of 20 m of thinly bedded dark limestones and black shales representing open shelf lithofacies. The trilobites were originally studied by Rusconi (1950a, 1950b, 1951, 1952; see also Cerdeño 2005), who provided brief descriptions of 40 new species of agnostoids and polymeroids, and pointed out their differences with respect to faunas of other localities of the Precordillera of Mendoza.

C. Poulsen (1960) collected additional trilobites from Cerro El Solitario and described 18 new species. Essentially on the basis of the occurrences of some agnostoids (e.g., *Diplagnostus*, *Clavagnostus*) and *Bolaspidella*, C. Poulsen (1960) postulated a late middle Cambrian age for the outcrop. Unfortunately, he was not able to check the Rusconi collections (see C. Poulsen 1960, p. 4), a fact that made taxonomic comparison of the faunas difficult. In addition, Castellaro (1963) reillustrated some polymeroids described by C. Poulsen (1960).

Subsequently, Borrello (1965) started a project which aimed to collect new material from the classic Cambrian localities of the Precordillera, and to summarise their biostratigraphic and palaeobiogeographic implications. Borrello (1971) listed C. Poulsen's species from Cerro El Solitario and pointed out their Laurentian affinities, though a systematic revision of new collections was left pending.

The trilobites from Cerro El Solitario were more recently revised, with special emphasis on the agnostoid faunas. Robison (1988) examined the C. Poulsen collections and reassigned to *Diplagnostus planicauda* (Angelin), *Kormagnostus seclusus* (Walcott), *Ammagnostus beltensis* (Lochman in Lochman & Duncan) and *Oedorhachis typicalis* Resser some of the species described by Rusconi (1952) and C. Poulsen (1960), indicating a close correlation with material from the Holm Dal Formation in Greenland (*Lejopyge laevigata* Zone, late middle Cambrian). Bordonaro & Liñán (1994) collected new agnostoid material from the Solitario Olistolith, recognised some of C. Poulsen's species, as well as *Ptychagnostus aculeatus* (Angelin) and *Tomagnostella exsculpta* (Angelin) (see also Bordonaro & Banchig 1995). Finally, Tortello & Bordonaro (1997) fully revised the agnostoids of the Rusconi collections and restricted the valid species from Cerro El Solitario to *Agnostus microcephalus* (Rusconi), *Kormagnostus seclusus*, *K.*? *beltensis*, *Ptychagnostus aculeatus*, *Lejopyge laevigata* (Dalman), *Tomagnostella exsculpta*, *Diplagnostus planicauda*, *Oedorhachis typicalis*, *Clavagnostus calensis* Rusconi and *Clavagnostus repandus* (Westergård in Holm & Westergård).

IMPLICATIONS OF THE FAUNAS

Most of the agnostoids from Cerro El Solitario constitute open-ocean faunas which enable rather precise intercontinental correlations (Bordonaro & Liñán 1994; Tortello & Bordonaro 1997). *Agnostus microcephalus* and *Ammagnostus beltensis*, previously described from North America and Greenland (Robison 1988; Pratt 1992), characterise the *Lejopyge laevigata* Zone and the partially coeval *Cedaria minor* Zone. Similarly, *Oedorhachis typicalis* is a common element of the *C. minor* Zone of Canada and the *L. laevigata* Zone of North America, Greenland and Australia (Robison 1988; Pratt 1992 and references therein), whereas *Clavagnostus calensis* is known from contemporaneous levels of China, Tasmania and Antarctica (see Peng & Robison 2000; Jago *et al*. 2004). The occurrences of the widely distributed taxa *Lejopyge*, *Tomagnostella*, *Ptychagnostus aculeatus* and *Diplagnostus planicauda* (e.g., Daily & Jago 1975; Robison 1984; Laurie 1989; Pratt 1992; Westrop *et al*. 1996; Peng & Robison 2000 and references therein; Geyer & Shergold 2000; Axheimer *et al*. 2006; Babcock *et al*. 2005; Høyberget & Bruton 2008) strongly confirm a latest middle Cambrian age for the Solitario Olistolith. *Ptychagnostus aculeatus* typically occurs in the upper part of the *L. laevigata* Zone (Robison 1984).

Valdemar Poulsen (1958) and Borrello (1971) originally determined the close affinities between the Cambrian trilobites of the Argentine Precordillera and those of North America. Similarly, Robison (1988, p. 30) pointed out the strong Laurentian aspect of the polymeroids from Cerro El Solitario described by C. Poulsen (1960), a fact that is further corroborated here. Although most of the species of Ptychopariida revised below are endemic, the record of certain genera (*Cedaria* Walcott, *Marjumia* Walcott, *Modocia* Walcott, *Elrathia* Walcott, *Bolaspidella* Resser, *Asaphiscus* Meek) provides new biostratigraphic information on the Solitario Olistolith, which is compatible with the scheme of open-shelf polymeroid biozones of the middle Cambrian of North America (e.g., Robison 1964a, b, 1976; Pratt 1992; Shergold 1997). The genus *Cedaria*, which clearly dominates the assemblages of El Solitario, is widely represented in the uppermost middle Cambrian (*Lejopyge laevigata* Zone; *Cedaria* Zone) of the United States, Canada and Greenland (Palmer 1962 and references therein; Robison 1988; Pratt 1992). Although rare elsewhere (e.g., Rushton 1978), *Marjumia* and *Modocia* are mostly confined to the Marjumian stage in North America and Greenland (Robison 1988, p. 71; Pratt 1992, p. 60). *Marjumia*? sp. and *Asaphiscus* cf. *villavicencis* from El Solitario mostly resemble material from the *Cedaria minor* Zone of Canada and the *Lejopyge laevigata* Zone of the Great Basin, respectively. Similarly, *Bolaspidella*, as revised by Robison (1964a, 1988), is common and widespread in open-shelf lithofacies of Laurentia, with an observed stratigraphic range from the *Ptychagnostus gibbus* to *Lejopyge laevigata* zones. *Bolaspidella* commonly occurs in association with *Elrathia* Walcott (Robison 1976).

Laurentian affinities of the faunas from Cerro El Solitario are also supported by the morphological similarities between *Talbotinella* and *Elrathia* sp. indet., from the Marjumian of Newfoundland (Westrop 1992), as well as by the resemblance of *Parabolina*? sp. to *Parabolina*? *naomi* Pratt, 1992, from the lower Furongian of northwestern Canada.

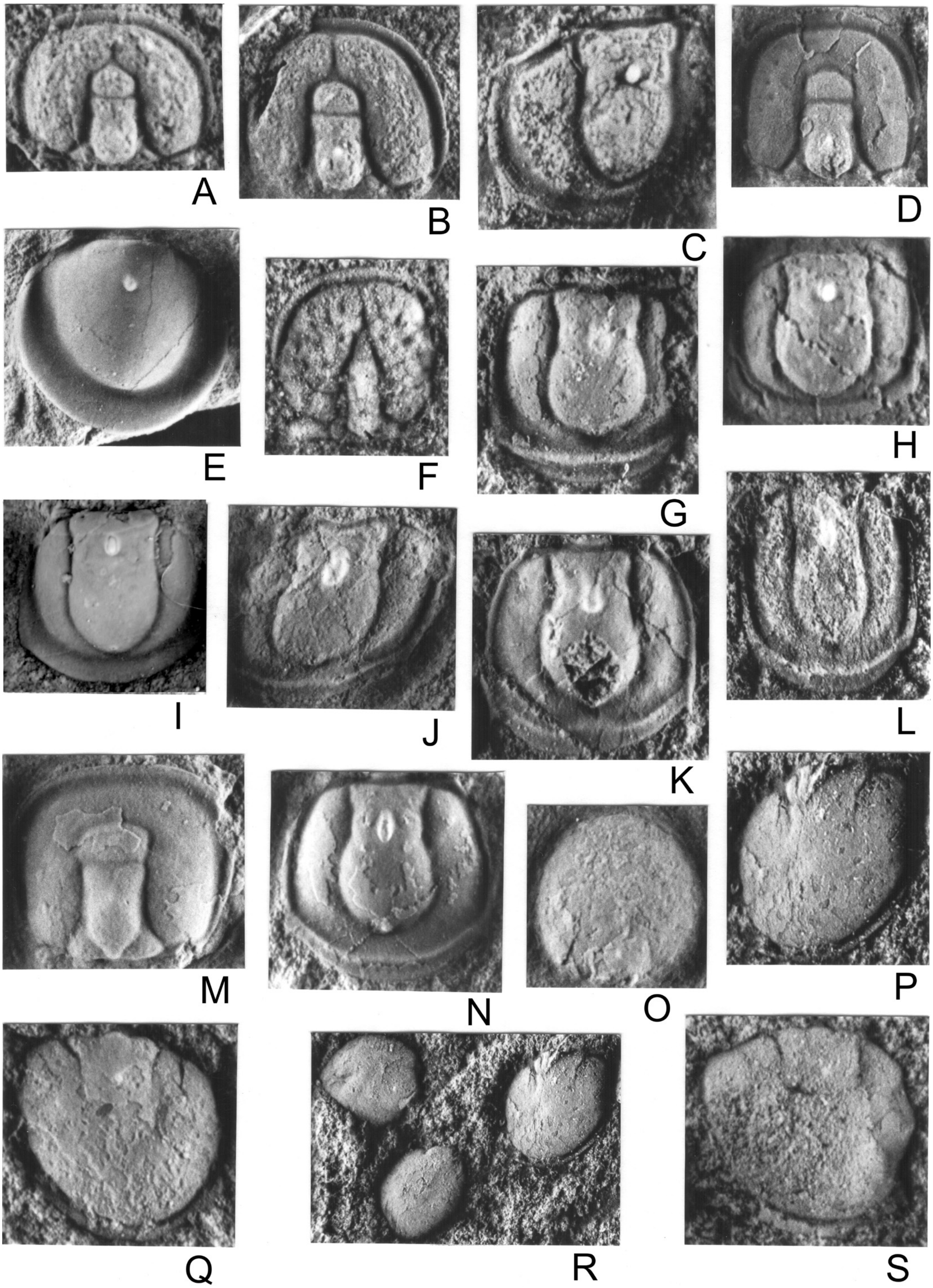


Fig. 2. **A–C**, *Agnostus microcephalus* (Rusconi, 1950b); **A**, cephalon, MLP 32320, x12; **B**, cephalon, MLP 32299, x9; **C**, pygidium, latex mould, MLP 32470, x10.3. **D, H-I**, *Ammagnostus beltensis* (Lochman in Lochman & Duncan, 1944); **D**, cephalon, MLP 32535, x8.3; **H**, pygidium, MLP 32457, x9; **I**, pygidium, MLP 32476, x9.6. **E**, *Kormagnostus* sp., pygidium, MLP 32395, x7.5. **F**, *Clavagnostus calensis* Rusconi, 1950a, cephalon, MLP 32357, x9.6. **G, J-N**, *Oedorhachis typicalis* Resser, 1938; **G**, pygidium, latex mould, MLP 32378, x9.1; **J**, distorted pygidium, MLP 32286, x7.7; **K**, pygidium, MLP 32304, x8.2; (continued opposite)

SYSTEMATIC PALAEONTOLOGY

Most of the agnostoids of the Borrello collections are widespread species which have been fully described by previous authors, so they are only briefly treated here. The material studied is housed in the Museo de Ciencias Naturales de La Plata (MLP), Argentina. In addition, selected type specimens of the Rusconi collections at the Museo de Ciencias Naturales y Antropológicas "Juan Cornelio Moyano" (MCNAM), Mendoza, Argentina, are reillustrated in Figure 9.

Order AGNOSTIDA Salter, 1864
Superfamily AGNOSTOIDEA M'Coy, 1849
Family AGNOSTIDAE M'Coy, 1849
Subfamily AGNOSTINAE M'Coy, 1849

Agnostus Brongniart, 1822

Type species. *Entomostracites pisiformis* Wahlenberg, 1818.

Agnostus microcephalus (Rusconi, 1950b) (Fig. 2A-C)

Synonymy. See Tortello & Bordonaro (1997).

Material. Three complete specimens, 33 cephala and 29 pygidia (MLP 32281, 32283, 32284, 32287, 32295, 32298, 32299, 32303, 32304, 32317, 32319, 32320, 32332, 32333, 32355, 32383, 32403, 32409, 32411, 32423, 32434, 32444, 32448, 32454, 32456, 32470–32473, 32478, 32489, 32493, 32497, 32508, 32512, 32540, 32541), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. Tortello & Bordonaro (1997, p. 75) revised *Agnostus microcephalus* (Rusconi) (=*A. exsulatus* Poulsen) and reillustrated the holotype cephalon (Rusconi 1950b, fig. 7; Tortello & Bordonaro 1997, fig. 3.1), which is laterally distorted. Additional material from El Solitario has been reported by C. Poulsen (1960, pl. 1, figs 3, 4) and Bordonaro & Liñán (1994, pl. 1, figs 1–3 only, see below), whereas Robison (1988, figs 7.4–7.11) and Pratt (1992, pl. 1, figs 1–13) described well preserved specimens from the *Lejopyge laevigata* Zone of North Greenland and the *Cedaria minor* Zone of northwestern Canada, respectively. Pratt (1992) provided a complete diagnosis of the species. The pygidial border furrow of the material from Canada seems to be slightly narrower than that of specimens illustrated herein.

Bordonaro & Liñán (1994, pl. 1, figs 4, 5) assigned two imperfectly preserved pygidia from El Solitario to *Agnostus exsulatus*. However, because these specimens exhibit a postaxial furrow and a sagittally widen, nonspinose border, they are reassigned here to *Tomagnostella* sp.

Family AMMAGNOSTIDAE Öpik, 1967

Ammagnostus Öpik, 1967

Type species. *Ammagnostus psammius* Öpik, 1967.

Ammagnostus beltensis (Lochman in Lochman & Duncan, 1944) (Fig. 2D, H-I)

1960 *Stigmagnostus canotensis* (Rusconi); C. Poulsen, pl. 1, fig. 11 (only).
1994 *Baltagnostus*? sp.; Bordonaro & Liñán, pl. 1, fig. 15.

Complete synonymy. See Robison (1988), Pratt (1992) and Tortello & Bordonaro (1997).

Material. Seven cephala and 18 pygidia (MLP 32282, 32285, 32296, 32310, 32317, 32318, 32322, 32340, 32352, 32398, 32451, 32457, 32458, 32473, 32476, 32496, 32500, 32535), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. Although this species was previously referred to *Kormagnostus* Resser with question by Pratt (1992) (see also Tortello & Bordonaro 1997), Peng & Robison (2000, p. 25) provided arguments in favour of an assignment to *Ammagnostus*. Robison (1988) first confirmed the occurrence of *A. beltensis* in El Solitario by synonymising some C. Poulsen species, and Tortello & Bordonaro (1997) described additional specimens from the Rusconi collections.

Some specimens of *Ammagnostus beltensis* from the upper middle Cambrian of Greenland (Robison 1988, fig. 10.2) and Canada (Pratt 1992, pl. 3, fig. 5) show slight indications of scrobicules, structures that are also preserved in the cephalon illustrated herein (Fig. 2D). Thus, a weakly scrobiculate cephalon from El Solitario referred to *Stigmagnostus canotensis* (Rusconi) by C. Poulsen (1960, pl. 1, fig. 11) is reassigned

L, distorted pygidium, latex mould, MLP 32293, x8; **M**, cephalon, MLP 32541, x9.3; **N**, pygidium, MLP 32341, x7.8. **O-S**, *Lejopyge* sp.; **O**, cephalon, MLP 32505, x8.1; **P**, pygidium (see also Fig. 2R), MLP 32337, x10; **Q**, pygidium, MLP 32331, x9.1; **R**, cephalon and pygidium, MLP 32337, x5.6; **S**, pygidium, MLP 32358, x10.6.

to *Ammagnostus beltensis*.

Baltagnostus? sp., from the upper middle Cambrian of the Precordillera of San Juan (Bordonaro & Liñán 1994, pl. 1, fig. 15), consists of a pygidium with a long, weakly pyriform axis, effaced ring furrows, a terminal secondary node, a moderately wide border furrow, and small posterolateral spines. Therefore, it is also added to the synonymy list of *Ammagnostus beltensis*.

Kormagnostus Resser, 1938

Type species. *Agnostus seclusus* Walcott, 1884, by synonymy with *Kormagnostus simplex* Resser, 1938 (see Robison 1988).

Kormagnostus sp. (Fig. 2E)

1997 *Kormagnostus seclusus* Walcott; Tortello & Bordonaro, figs 3.15–3.17.
1994 *Tomagnostella exsculpta* (Angelin); Bordonaro & Liñán, pl. 2, figs 10, 11 (only).

Material. Three pygidia (MLP 32395, 32398, 32510), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. Robison (1988) first reported the occurrence of *Kormagnostus seclusus* Walcott in Cerro El Solitario. In addition, Tortello & Bordonaro (1997) illustrated several cephala and pygidia from the Rusconi collections. The pygidium of *K. seclusus* commonly shows a wide intraspecific variation, especially with respect to definition of the axial furrows, shape of the posterior axis, and degree of development of the pygidial posterolateral spines (e.g., Rasetti 1948; Palmer 1954a; Lochman & Hu 1960; Hu 1971; Robison 1988; Pratt 1992).

The scarce pygidia described herein (Fig. 2E; see also Tortello & Bordonaro 1997, figs 3.15–3.17) are strongly effaced and seem to have an entire margin. Although these specimens resemble those of *K. seclusus* characterised by having vestigial spines (e.g., Lochman & Hu 1960, pl. 99, figs 5, 6, 8, 11, 12, 18–21, 23, 24, 26, 27, 30, 31; Pratt 1992, pl. 3, figs 2, 3, 17–20, 25, 27), they are most similar to the smooth, nonspinose pygidia of *Kormagnostus minutus* (Schrank, 1975), from the late middle Cambrian-early late Cambrian (*Proagnostus bulbus* Zone to *Glyptagnostus reticulatus* Zone) of China (Peng & Robison 2000, figs 24.1–24.20 and references therein) and possibly Antarctica (Shergold & Webers 1992, pl. 1, fig. 15). Until more material from Cerro El Solitario becomes available for further analyses, the specimens studied are referred to under open nomenclature.

Two cephala assigned by Bordonaro & Liñán (1994, pl. 2, figs 10, 11) to *Tomagnostella exsculpta* (Angelin) are characterised by having a wide border furrow and a straight F3. Therefore, they are reassigned here to *Kormagnostus* sp.

Family CLAVAGNOSTIDAE Howell, 1937

Clavagnostus Howell, 1937

Type species. *Agnostus repandus* Westergård in Holm & Westergård, 1930.

Clavagnostus calensis Rusconi, 1950a (Fig. 2F)

Synonymy. See Bordonaro & Liñán (1994), Tortello & Bordonaro (1997) and Peng & Robison (2000).

Material. 16 cephala and 12 pygidia (MLP 32298, 32301, 32310, 32315, 32318, 32320, 32357, 32358, 32399, 32401, 32402, 32406, 32425, 32447, 32453, 32470, 32497), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. Bordonaro & Liñán (1994, pl. 1, figs 8–14) described several specimens of *C. calensis* from Cerro El Solitario, and Tortello & Bordonaro (1997, fig. 4.23) reillustrated the holotype pygidium and reviewed its synonymy. In addition, Peng & Robison (2000, figs 27.1–27.10) documented holaspid ontogenetic variation in material from China, revised the diagnosis of the species and listed additional synonyms (Lu & Lin 1989; Jago & Webers 1992). *Clavagnostus calensis* is also documented in the late middle Cambrian of Tasmania (Jago & Daily 1974) and Antarctica (Jago & Webers 1992) (Peng & Robison 2000).

Family DIPLAGNOSTIDAE Whitehouse, 1939

Oedorhachis Resser, 1938

Type species. *Oedorhachis typicalis* Resser, 1938.

Oedorhachis typicalis Resser, 1938 (Fig. 2G, J–N)

Synonymy. See Robison (1988), Pratt (1992) and Tortello & Bordonaro (1997).

Material. Three cephala and 9 pygidia (MLP 32286, 32293, 32304, 32313, 32323, 32341, 32354, 32377, 32378, 32387, 32541), from the

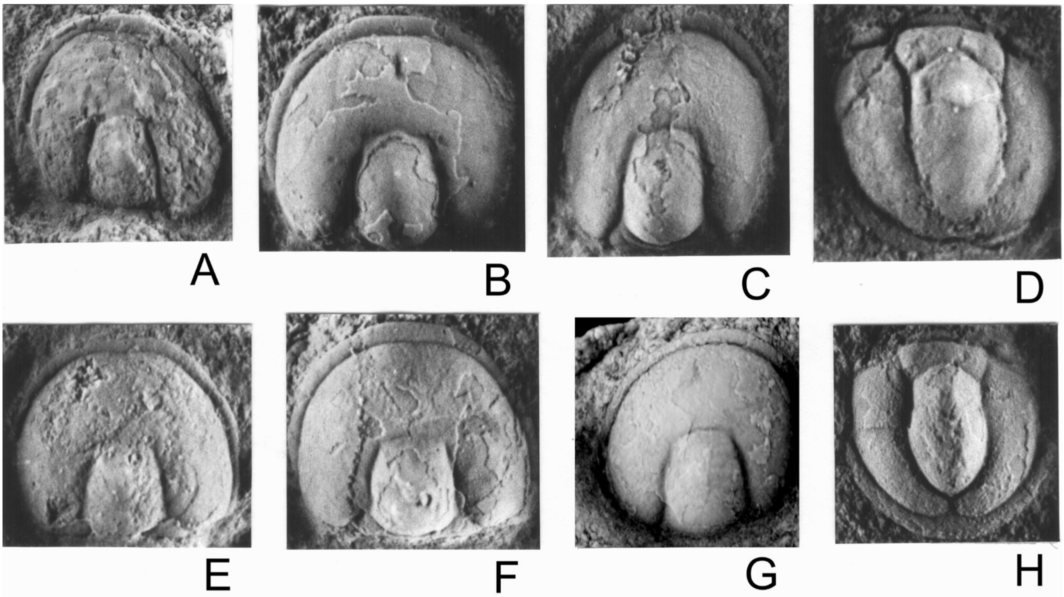


Fig. 3. *Tomagnostella nepos* (Brøgger, 1878); **A**, cephalon, MLP 32305, x7.5; **B**, cephalon, MLP 32392, x8.1; **C**, cephalon, MLP 32309, x9; **D**, pygidium, MLP 32301, x9.6; **E**, cephalon, MLP 32308, x8.3; **F**, cephalon, MLP 32473, x10; **G**, cephalon, MLP 32397, x8.1; **H**, pygidium, MLP 32498, x8.3.

Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. A slightly anteriorly expanded glabella, a short anteroglabella, large basal lobes, the presence of a pyriform pygidial axis, a zonate posterior border, and short marginal spines are characters of *Oedorhachis typicalis* (see emended diagnosis by Robison 1988). Robison (1988) illustrated different morphotypes, which were partially attributed to ontogenetic variation.

The occurrence of *Oedorhachis typicalis* in Cerro El Solitario was pointed out first by Robison (1988) (C. Poulsen 1960, pl. 1, fig. 8; Bordonaro & Liñán 1994, pl. 1, figs 16–18). Later, Tortello & Bordonaro (1997, figs 4.19, 4.20) revised additional specimens from the Rusconi collections. New pygidia show a conspicuous terminal node (Fig. 2N), and a sagittally enlarged auxiliary furrow (Fig. 2K).

This species has been reported from the late middle Cambrian (*Lejopyge laevigata* Zone) of Greenland, Canada, USA (Appalachians), Australia and Argentina (e.g., Resser 1938; Robison 1988; Pratt 1992 and references therein). However, it must be noted that the collections studied from these localities are not large enough to establish patterns of phenotypic variation. Future analyses may change the concept and distribution of this taxon.

Family PTYCHAGNOSTIDAE Kobayashi, 1939

Lejopyge Hawle & Corda, 1847

Type species. Battus laevigatus Dalman, 1828.

Lejopyge sp. (Fig. 2O–S)

Material. 13 cephala and 6 pygidia (MLP 32331, 32337, 32357, 32358, 32385, 32400, 32424, 32425, 32495, 32505), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. *Lejopyge* is a genus with distally effaced axial furrows and importance in biostratigraphy (e.g., Robison 1984; Laurie 1989; Peng & Robison 2000; Axheimer *et al*. 2006; Høyberget & Bruton 2008). It is cosmopolitan in late middle Cambrian open-marine lithofacies (e.g., Peng & Robison 2000 and references therein; Axheimer *et al*. 2006; Høyberget & Bruton 2008). It was first reported in Cerro El Solitario by Tortello & Bordonaro (1997), and additional specimens are illustrated herein.

The presence or absence of pygidial marginal spines constitutes a feature of systematic value to the species level. Because the material from the Borrello collections is not particularly well preserved, it is left under open nomenclature.

Tomagnostella Kobayashi, 1939

Type species. Agnostus exsculptus Angelin, 1851.

Tomagnostella nepos (Brøgger, 1878) (Fig. 3A–H)

Synonymy. See Høyberget & Bruton (2008).

Material. 40 cephala and 53 pygidia (MLP 32291, 32292, 32301, 32305, 32308, 32309, 32320, 32321, 32331, 32337, 32346, 32349, 32350, 32353, 32356, 32360–32372, 32387–32392, 32396, 32397, 32399, 32428, 32429, 32435–32442, 32473, 32495, 32498, 32499), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. *Tomagnostella* Kobayashi is the most abundant agnostoid in the outcrop. Tortello & Bordonaro (1997) illustrated several specimens from Cerro El Solitario, which were assigned to *T. exsculpta* (Angelin) *sensu* Robison (1988) and Peng & Robison (2000). The specimens described herein seem to have undergone minor tectonic deformation (compare Fig. 3C and F). They are characterised by having a smooth cephalic acrolobe and a tumid pygidial axis, which is moderately wide posteriorly. According to the systematic revision of Høyberget & Bruton (2008, p. 44-46), this material is assignable to *Tomagnostella nepos* (Brøgger, 1878).

Two cephala from Cerro El Solitario originally designated as *T. exsculpta* (Bordonaro & Liñán 1994, pl. 2, figs 10, 11) were tentatively reassigned to *Hypagnostus* by Peng & Robison (2000, p. 86). However, the presence of a wide border furrow and a straight F3 suggests *Kormagnostus* affinities (see above, *Kormagnostus* sp.).

Other agnostoids (not figured)

Some small, poorly preserved specimens assignable to *Diplagnostus planicauda* (Angelin, 1851) (two pygidia, MLP 32333, 32386) and *Ptychagnostus aculeatus* (Angelin, 1851) (one fragmentary cephalon, MLP 32427) are rare in the assemblages of Cerro El Solitario.

Order PTYCHOPARIIDA Swinnerton, 1915
Suborder PTYCHOPARIINA Swinnerton, 1915
Family CEDARIIDAE Raymond, 1937

Cedaria Walcott, 1924

1960 *Williamsina*; C. Poulsen, p. 18, 19.

Type species. Cedaria prolifica Walcott, 1924.

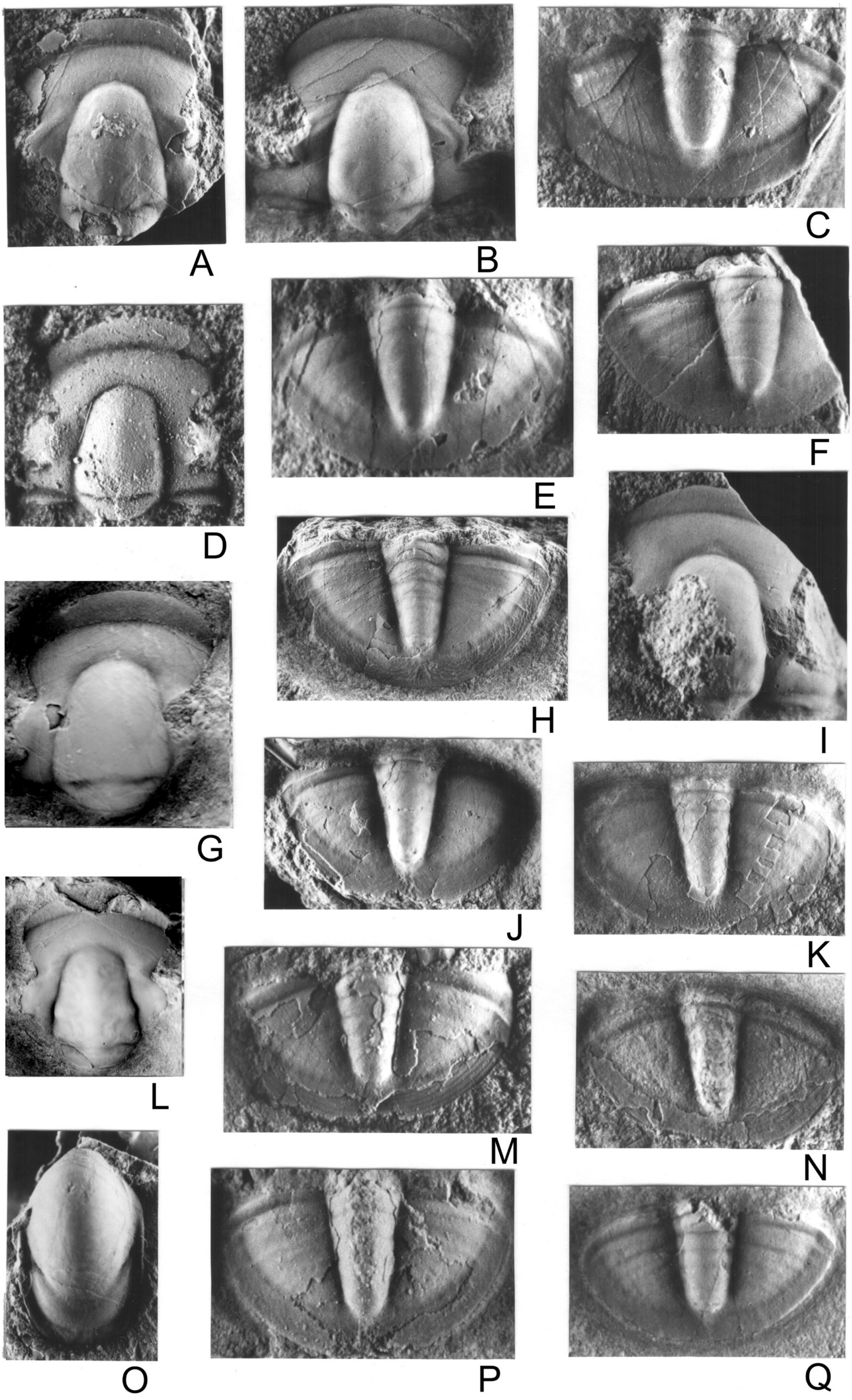
Remarks. Palmer (1962, p. 25) reviewed the scope of *Cedaria* Walcott and listed the following characters as diagnostic for the genus: subisopygous, "pseudoproparian" trilobites with cranidum having well defined border, unfurrowed glabella tapered and strongly rounded anteriorly, narrow fixed cheeks, and distally expanded posterior limbs; pygidium subsemicircular in outline, nearly as large as cephalon with broad or narrow border of nearly constant width, and axis prominent, narrow, reaching to inner part of border. As stated by Robison (1988), the degree of effacement of pleural fields is variable. *Williamsina* Poulsen, 1960, based on material from Cerro El Solitario, is characterised by the features cited above, so it is suppressed here as a subjective junior synonym of *Cedaria*. Similarly, part of the material from Cerro El Solitario assigned by Rusconi (1950a) to *Canotiana* Rusconi is assignable to *Cedaria* (see below, *C. calensis*).

Cedaria calensis (Rusconi, 1950a) (Figs 4A–F, 5, 9A

1950a *Canotiana calensis*; Rusconi, p. 75, fig. 6.
1960 *Williamsina mikkelseni*; C. Poulsen, p. 21, 22, pl. 1, figs 25–28.

Material. 29 cranidia, 3 incomplete librigenae, 28 pygidia (MLP 32281, 32289, 32290, 32294, 32299, 32302, 32306, 32311, 32317, 32324, 32327, 32330, 32339, 32342, 32345, 32347, 32374, 32407, 32411, 32414, 32417–32419, 32422, 32449, 32450, 32464–32466, 32474, 32479, 32484, 32490, 32491, 32511, 32513, 32515, 32519, 32521–32524, 32526, 32527, 32530, 32533, 32534, 32536, MCNAM 7519) and several additional fragmentary specimens, from

Fig. 4. **A-F**, *Cedaria calensis* (Rusconi, 1950a); **A**, cranidium, MLP 32302, x5; **B**, cranidium, MLP 32465, x6.3; **C**, pygidium, MLP 32294, x8.9; **D**, cranidium, latex mould, MLP 32345, x6.4; **E**, pygidium, MLP 32450, x9.3; **F**, pygidium, MLP 32342, x8.6. **G-N**, **P-Q**, *Cedaria cortesi* (Poulsen, 1960); **G**, cranidium, MLP 32421, x7; **H**, pygidium, MLP 32493, x5; **I**, cranidium, MLP 32526, x5.7; **J**, pygidium, MLP 32493, x5.1; **K**, pygidium, MLP 32379, x6; **L**, cranidium, MLP 32344, x4.5; **M**, pygidium, MLP 32477, x7.1; **N**, pygidium, MLP 32332, x6; **P**, pygidium, MLP 32384, x7; **Q**, pygidium, MLP 32382, x7.6. **O**, hypostome indet., MLP 32490, x8.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the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Diagnosis. Species of *Cedaria* with cranidium having flat border and narrow, shallow border furrow; glabella conical in outline, tapered forwards, rounded anteriorly, unfurrowed or with weak indications of two pairs of lateral furrows, occupying 65–70% of cephalic length; ocular ridge faintly marked, oblique; pygidial axis strongly convex, proportionately short and wide, tapered backwards, lateral sides straight or having slight outward bow; maximum axial width (tr.), at midlength of first axial ring, 28–32% of maximum pygidial width; pygidial border moderately wide; ring furrows and pleural furrows on the pygidium nearly effaced.

Remarks. C. Poulsen (1960, p. 21, 22) provided a description of *Williamsina mikkelseni* based only on a cranidium and a slightly distorted pygidium. The latter does not differ from the single pygidium referred to *Canotiana calensis* by Rusconi (1950a, fig. 6; see Fig. 9A). On the basis of additional specimens, a complementary diagnosis of the species is presented above. Length of largest cranidium is 5.5 mm. Some well preserved cranidia show a forwardly expanded preglabellar furrow on the sagittal plane (Fig. 4B), as well as a minute occipital node that is well back from the anterior margin of the occipital ring. Free cheeks are characterised by a wide, flat border and a slender genal spine.

Cedaria calensis differs from the type species *C. prolifica* Walcott, from the upper middle Cambrian (upper *Lejopyge laevigata* Zone to the *Glyptagnostus stolidotus* Zone) of Greenland and North America (e.g., Palmer 1962, pl. 3, figs 9, 10, 14–16, 20, pl. 6, fig. 14; Pratt 1992, pl. 30, figs 1–4, text-fig. 31.C), in having a flat cephalic border, a less diverging anterior facial suture, a wider and shorter pygidial axis, nearly effaced pleural fields, and a wider pygidial border. *Cedaria major* Robison, from the upper middle Cambrian (upper *Lejopyge laevigata* Zone) of Greenland (Robison 1988, figs 14.1–14.7), has a cranidium and a pygidium of similar proportions, but with a convex, narrower cephalic border, a weak occipital furrow and a slightly longer, narrower pygidial axis. *Cedaria minor* (Walcott, 1916), from the *Cedaria* Zone of USA, Canada and Greenland (e.g., Robison 1988, figs 14.8–14.14, 26.3; see Pratt 1992, p. 81, pl. 30, figs 5–18, text-fig. 31.A), differs by possessing deep pygidial pleural furrows.

Both *C. calensis* and *C. nixonia* Lochman in Lochman & Duncan, from the upper middle Cambrian-lower Furongian of North America (Lochman & Duncan 1944, pl. 10, figs 2–7), have similar pygidia, but the former is mainly distinguished from *C. nixonia* by having a flat cephalic border, an anteriorly rounded glabella, and more oblique eye ridges.

Cedaria calensis further differs from *C. tumicephala* Robison, from the upper middle Cambrian of Greenland (Robison 1988, figs 15.1–15.5), by having a shorter glabella, better defined axial and occipital furrows, and a wider, shorter pygidial axis. Similarly, *C. brevifrons* Palmer, from the upper middle Cambrian of North America (Palmer 1962, pl. 3, figs 8, 11–13; Pratt 1992, pl. 31, figs 1–6, text-fig. 31.D), is clearly distinguished by its shorter preglabellar field and its deep pleural furrows on the pygidium. *Cedaria eurycheilos* Palmer, from the upper middle Cambrian-lower Furongian of Texas (Palmer 1954a, pl. 80, figs 5–7), is characterised by having wider cephalic and pygidial borders, as well as deep furrows on the pleural fields. *Cedaria gaspensis* Rasetti (1946, pl. 67, figs 26–29) also differs by possessing deep pygidial furrows.

Comparisons with the closely related species *C. cortesi* and *C. harringtoni* are provided below.

Cedaria cortesi (Poulsen, 1960) (Figs 4G-N, P-Q, 5, 6A)

1960 *Williamsina cortesi*; C. Poulsen, p. 19, 20, pl. 1, figs 19–24.
1963 *Williamsina cortesi* Poulsen; Castellaro, p. 31, 32.

Material. 12 cranidia, 2 thoracopyga and 11 pygidia (MLP 32303, 32311, 32315, 32319, 32325, 32328, 32332, 32344, 32379, 32382, 32384, 32420, 32421, 32423, 32433, 32445, 32477, 32485, 32493, 32501, 32526), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Diagnosis. Species of *Cedaria* with cranidium having flat border and narrow, shallow border furrow; glabella strongly convex, conical to subtrapezoidal in outline, slightly tapered forwards, broadly rounded anteriorly, unfurrowed or with faint indications of two pairs of lateral furrows, occupying about 70% of cephalic length; eye ridge weak; seven thoracic segments; pygidial axis well defined, slightly convex, proportionately narrow, slightly tapered backwards, lateral sides straight or having slight inward bow, with 6 to 7 axial rings and a terminal piece extending slightly onto posterior border; maximum axial width (tr.), at midlength of first axial ring, 21–24% of maximum pygidial width; pleural fields smooth or showing up to 5 pairs of pleural furrows, all

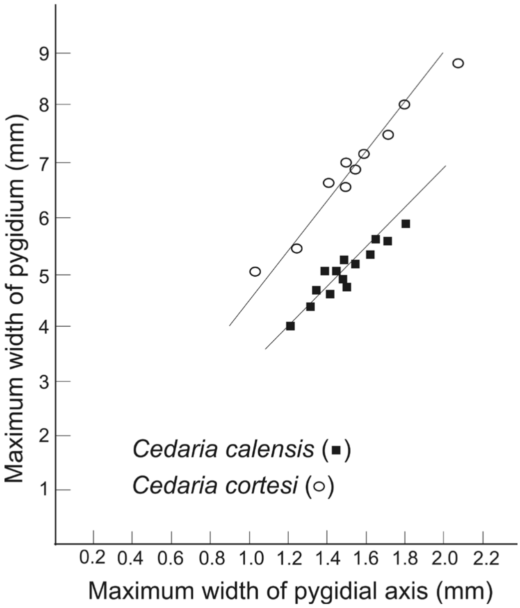


Fig. 5. Graph of maximum width (tr.) of pygidium vs. maximum width (tr.) of pygidial axis for *Cedaria calensis* and *C. cortesi*.

weakly defined; pygidial border moderately wide, slightly concave, with its internal surface caecate; doublure wide, carrying 5-6 terrace lines.

Remarks. The largest cranidium and pygidium are 7.5 mm and 5 mm long, respectively. C. Poulsen (1960) provided a description of *C. cortesi*, which is partially emended by the above diagnosis. Although C. Poulsen (1960) restricted to this species specimens with a smooth pygidial border, pygidia studied herein show a greater variability. Larger, well preserved internal moulds possess three to four delicate transverse ridges on the pleural fields, which are associated with a complex network of anastomosed raised lines on the border. Some pygidia show well developed venation in both the lateral and posterior borders (Fig. 4H), whereas in other specimens the caeca are poorly preserved and restricted to the postaxial region (Fig. 4J, P).

Cedaria cortesi mostly resembles *C. calensis* (Rusconi), from Cerro El Solitario (Rusconi 1950a, fig. 6; C. Poulsen 1960, pl. 1, figs 25–28; herein, Fig. 4A–F), by showing a flat cephalic border, a narrow, shallow cephalic border furrow, a similar glabellar length, and a moderately wide pygidial border. However, the former can be differentiated by its slightly wider, broadly rounded glabellar anterior, a narrower (tr.) pygidial axis (see Fig. 5), and a caecate pygidial border. Vestiges of fine venation on the pygidium was also described in *C. major* Robison, from the upper middle Cambrian of Greenland (Robison 1988, figs 14.1–14.7), but the latter differs mainly in having a convex, shorter (sag.) cephalic border. *Cedaria prolifica* Walcott, from the upper middle Cambrian-lower Furongian of Greenland and North America (e.g., Palmer 1962, pl. 3, figs 9, 10, 14–16, 20, pl. 6, fig. 14; Pratt 1992, pl. 30, figs 1–4, text-fig. 31.C), also differs from *C. cortesi* in having a convex cephalic border, less effaced pleural fields, and a narrower pygidial border. *Cedaria minor* (Walcott, 1916), from the *Cedaria* Zone of the USA, Canada and Greenland (e.g., Robison 1988, figs 14.8–14.14, 26.3; see Pratt 1992, p. 81, pl. 30, figs 5–18, text-fig. 31.A), mainly differs by having well defined pygidial pleural furrows.

Cedaria nixonia Lochman in Lochman & Duncan, from the upper middle Cambrian-lower Furongian of North America (Lochman & Duncan 1944, pl. 10, figs 2–7), is also distinguished from *C. cortesi* by having an anteriorly truncated glabella, a slightly convex cephalic border, and a wider, shorter pygidial axis. *Cedaria tumicephala* Robison, from the upper middle Cambrian of Greenland (Robison 1988, figs 15.1–15.5), clearly differs by showing a longer glabella, partially effaced axial and occipital furrows, a longer pygidial axis, and a prominent, sharply pointed postaxial ridge.

Cedaria brevifrons Palmer, from the upper middle Cambrian of North America (Palmer 1962, pl. 3, figs 8, 11–13; Pratt 1992, pl. 31, figs 1–6, text-fig. 31.D), is characterised by its reduced preglabellar field, its narrower, convex cephalic border, and deeper pleural furrows on the pygidium. *Cedaria eurycheilos* Palmer, from the upper middle Cambrian-lower Furongian of Texas (Palmer 1954a, pl. 80, figs 5–7), differs from *C. cortesi* mainly by possession of wider cephalic and pygidial borders, a shorter preglabellar field, a shorter pygidial axis and deep furrows on the pleural fields.

Cedaria gaspensis Rasetti, from the lower Furongian of Quebec (Rasetti 1946, pl. 67, figs 26–29), is distinguished from *C. cortesi* because the pygidium of the former has deep dorsal furrows and a narrower border. *Cedaria tennesseensis* Walcott, from the lower Furongian of North America (e.g., Resser 1938, pl. 11, figs 3–5; Rasetti 1965, pl. 5, figs 4–8), further differs in having a narrower cranidial border, a longer (exsag.) posterior area of fixigenae, a reduced pygidial axis, almost flat pleural fields, three or four curved pleural furrows, and a wider pygidial border.

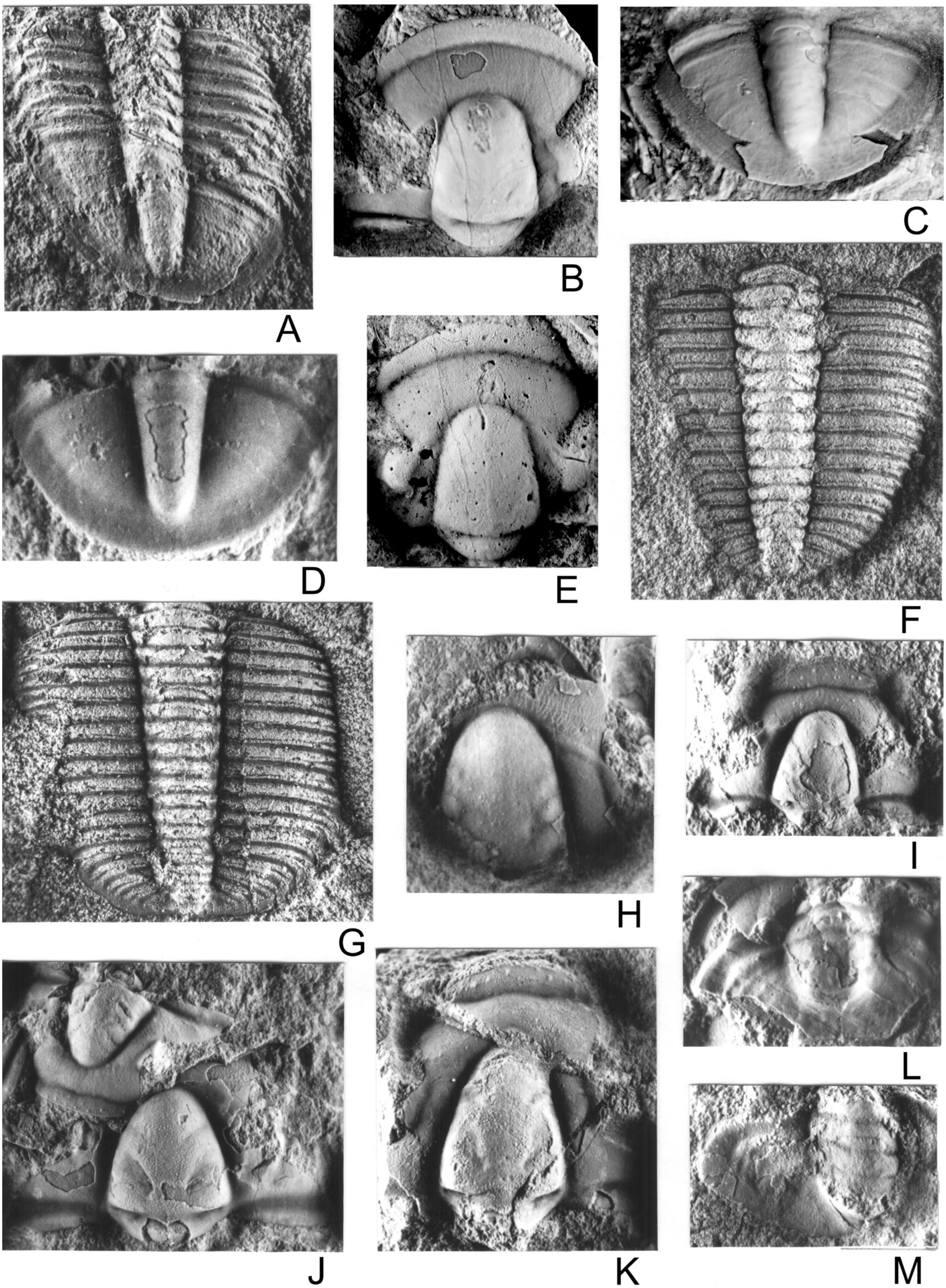


Fig. 6. **A**, *Cedaria cortesi* (Poulsen, 1960), thorax and pygidium, latex mould, MLP 32315, x5.1. **B-E**, *Cedaria harringtoni* (Poulsen, 1960); **B**, cranidium, MLP 32509, x5.8; **C**, pygidium, MLP 32336, x5; **D**, pygidium, MLP 32326, x8.5; **E**, cranidium, latex mould, MLP 32483, x8.5. **F-H**, *Elrathia hornensis* (Rusconi, 1951); **F**, thorax and pygidium, latex mould, MLP 32508, x2.1; **G**, thorax and pygidium, latex mould, MLP 32335, x2.8; **H**, fragmentary cranidium, MLP 32312, x5.6. **I-M**, *Talbotinella communis* Poulsen, 1960; **I**, small cranidium, MLP 32473, x5.9; **J**, two cranidia, MLP 32318, x4.5; **K**, cranidium, MLP 32381, x4.6; **L**, fragmentary pygidium, MLP 32527, x5.2; **M**, fragmentary pygidium, MLP 32486, x5.

Cedaria harringtoni (Poulsen, 1960) (Fig. 6B-E)

1960 *Williamsina harringtoni*; C. Poulsen, p. 20, 21, pl. 1, fig. 29.

1960 *Williamsina ornata*; C. Poulsen, p. 22, 23, pl. 2, fig. 1, pl. 3, fig. 1.

Material. Eleven cranidia and 4 pygidia (MLP 32316, 32326, 32327, 32329, 32336, 32338, 32342, 32343, 32483, 32491, 32509, 32512, 32516, 32539), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Diagnosis. Species of *Cedaria* with cranidium having well rounded anterior margin; cranidial border convex, which is defined by a conspicuous border furrow bearing closely spaced pits; preglabellar field much wider (sag.) than cranidial border; glabella subconical in outline, broadly rounded anteriorly; occipital furrow clearly marked throughout; ocular ridge oblique; pygidium having a very convex, long, subparallel-sided to weakly tapered axis, which is smooth or with very faint indications of segmentation; pleural fields nearly smooth; pygidial border moderately developed, fairly concave, becoming slightly wider posteriorly, smooth or with the internal surface caecate.

Description. Anterior margin of cranidium well rounded; glabella moderately large, subconical in outline and broadly rounded anteriorly, unfurrowed; it rises above level of genae and is surrounded by well defined axial furrows, occupying 67–70% of the total cranidial length; occipital furrow straight to slightly bowed backwards, marked throughout; occipital ring with a small median node near anterior edge; cephalic border convex, represents about 11–12% of the total length of the cranidium, clearly defined by a conspicuous border furrow bearing closely spaced pits; preglabellar field well developed, much wider (sag.) than cranidial border, slightly convex, with lateral margins moderately divergent; ocular ridge faint, oblique; palpebral lobe strongly arcuate, slightly elevated above surface of fixed cheek, situated slightly anterior to midlength of glabella; posterior fixigena straplike, frontal margin transverse.

Pygidium semicircular in outline, moderately convex; axis well defined, convex, long, occupies about 85% of the total pygidial length, subparallel-sided to weakly tapered backwards, smooth or with very faint indications of 5–6 rings and a terminal piece; pleural fields smooth or with vestiges of venation; border moderately developed, fairly concave, becoming slightly wider posteriorly, smooth or with the internal surface caecate; doublure carrying 5-6 terrace lines.

Remarks. The presence of a long, fairly convex, subparallel-sided to slightly tapered pygidial axis is a character that enables the specimens to be assigned to *C. harringtoni* (C. Poulsen 1960, pl. 1, fig. 29). Some pygidia have no ornamentation (Fig. 6D), whereas others show fine venation on the pleural fields and the posterior border (Fig. 6C). Associated cranidia of this species are described herein for the first time.

C. Poulsen (1960, p. 22, 23, pl. 2, fig. 1, pl. 3. fig. 1) erected *Williamsina ornata* on the basis of six fragmentary pygidia from Cerro El Solitario having a prominent, weakly tapering axis, five to six axial rings followed by a terminal axial piece, and a fairly wide, concave, caecate border. Thus, *C. harringtoni*, as interpreted here, is regarded as a senior synonym of *W. ornata*.

The pygidium of *C. harringtoni* is rather similar to that of *C. cortesi* (Poulsen), from Cerro El Solitario (C. Poulsen 1960, pl. 1, figs 19–24; herein Fig. 4G–N, P, Q, 6A); the former differs slightly in its more convex, less tapered pygidial axis. In addition, *C. harringtoni* possesses a convex cranidial border, more clearly defined anterior border furrow and occipital furrow, and a longer preglabellar field. Similarly, it is distinguished from *C. calensis* (Rusconi), from Cerro El Solitario (Rusconi 1950a, fig. 6; C. Poulsen 1960, pl. 1, figs 25–28; herein Fig 4A–F), in having a convex cranidial border, a deeper anterior border furrow, a slightly longer preglabellar field and also, a less conical glabella, a longer, narrower, subparallel-sided pygidial axis and pygidial venation.

Cedaria harringtoni mostly resembles *C. selwyni* Pratt, from northwestern Canada (Pratt 1992, pl. 31, figs 9–16, text-fig. 31.B), but the former is barely distinguished by its longer pygidial axis. It mainly differs from the type species *C. prolifica* Walcott, from the upper middle Cambrian-lower Furongian of Greenland and North America (e.g., Palmer 1962, pl. 3, figs 9, 10, 14–16, 20, pl. 6, fig. 14; Pratt 1992, pl. 30, figs 1–4, text-fig. 31.C), because the latter has a pygidium with a tapering axis and furrowed pleural fields. *Cedaria major* Robison, from the upper middle Cambrian of Greenland (Robison 1988, figs 14.1–14.7), has, in addition, an effaced occipital furrow. The long, tube-like pygidial axis of *C. harringtoni* strongly contrasts with that of *C. tennesseensis* Walcott, *C. eurycheilos* Palmer, and *C. nixonia* Lochman in Lochman & Duncan.

Family ALOKISTOCARIDAE Resser, 1939 emend. Sundberg, 1999

Talbotinella Poulsen, 1960

Type species. *Talbotinella communis* Poulsen, 1960.

Remarks. *Talbotinella* is characterised by having an extremely tapered, raised, granulose glabella, an adaxially bifurcated S1 glabellar furrow, a preglabellar field that is longer (sag.) than anterior border, caecal markings on the preglabellar field, a moderately divergent anterior facial suture, a moderately developed palpebral area of fixigena, a short pygidium, pleural and interpleural furrows joining near the pygidial margin, and posteriorly located anterolateral corners of the pygidium (cf. C. Poulsen 1960).

C. Poulsen (1960) originally assigned this genus to the family Lonchocephalidae Hupé, 1953, pointing out that it appears to be closely related to *Talbotina* Lochman, especially when compared with "*Talbotina*" *jeweli* Lochman, from the Pilgrim Formation of Montana (Lochman & Duncan 1944, pl. 12, figs 6–12) [=*Modocia*? *jeweli* (Lochman) (see Westrop 1992)]. The glabella of the genotype *Talbotinella communis* is, however, much more tapering than that of *Modocia*? *jeweli* (C. Poulsen, 1960). In this respect, *Talbotinella communis* is superficially similar to the marjumiids *Ithyektyphus* Shaw, 1956 (e.g., see Miller 1936; Shaw 1956) and *Syspacheilus* Resser, 1938 (e.g., see Lochman & Hu 1961; Robison 1988), but the former clearly differs in having a more developed preglabellar field.

Talbotinella was tentatively included in the superfamily Olenacea by Öpik (1963, p. 72), who erected the "Family Talbotinellidae" to accommodate '*Talbotinella' notulata* from the *Glyptagnostus stolidotus* Zone of Australia (Öpik 1963, pl. 6, fig. 9; text-figs 23, 24), as well as *T. communis* Poulsen, *T. leanzai* Poulsen and *T. rusconii* Poulsen from Cerro El Solitario. These taxa share a strongly tapered glabella. However, since the cranidium of '*T.*' *notulata* is also characterised by possessing a thin, smooth test, deep lateral glabellar furrows, a nonspinose occipital ring, a much reduced anterior cranidial border, and a narrow palpebral area of fixigena, it is regarded herein as an olenid trilobite that is not assignable to *Talbotinella*.

Following the familiar diagnosis of Sundberg (1999), *Talbotinella* may belong to Alokistocaridae Resser, 1939. This genus belongs to a group of closely related 'ptychopariid' taxa (e.g., *Ehmania* Resser, 1935; *Ehmaniella* Resser, 1937; *Elrathia* Walcott, 1924; *Elrathiella* Poulsen, 1927; *Parehmania* Deiss, 1939; *Utaspis* Robison, 1964a) with a conical, anteriorly rounded glabella carrying poorly defined lateral furrows. Although many members of this large group may prove to be synonyms (with *Elrathia* as the senior name, see Westrop 1992, p. 251), a full re-evaluation of these genera is beyond the scope of this study.

Talbotinella communis Poulsen, 1960 (Figs 6I–M, 7A, ?B, C, D, ?E, F, H, 9E)

1951 *Pseudolevinia macropyge*; Rusconi (part), p. 16 (paratype only).
1960 *Talbotinella communis*; C. Poulsen, p. 24, 25, pl. 2, figs 2–8, pl. 3, fig. 2.
1960 *Talbotinella leanzai*; C. Poulsen, p. 25, 26, pl. 2, figs 9–12.
1963 *Talbotinella communis* Poulsen; Castellaro, p. 29, 30.
1963 *Talbotinella leanzai* Poulsen; Castellaro, p. 30, 31.

Material. 14 cranidia, 1 librigena and 8 pygidia (MLP 32287, 32306, 32310, 32318, 32344, 32381, 32382, 32407, 32408, 32413, 32473, 32474, 32478, 32486, 32506, 32527–32529, MCNAM 8929), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. Christian Poulsen (1960) provided an accurate description of *Talbotinella communis*, which is partially emended herein on the basis of additional specimens. The glabellar furrow S1 bifurcates adaxially in larger individuals. The cranidium shows a slightly convex anterior border, which occupies 10–12% of the cranidial length and is separated from the preglabellar field by a slightly rounded border furrow. Both anterior cranidial border and border of librigena are ornamented with pointed pustules, which vary in their degree of expression (compare Fig. 7A and F). Well preserved pygidia show pleural and interpleural furrows joining near the pygidial margin. The anterior pleural furrow is more conspicuous than the posterior furrows.

The incomplete cranidia illustrated in Figure 7B and E are assigned to *Talbotinella communis* with question, because they bear a slightly longer preglabellar field, and seem to have a more tapered glabella.

Talbotinella leanzai Poulsen (C. Poulsen 1960, pl. 2, figs 9–12), from the Solitario Olistolith, share a glabellar outline, relative development of glabellar furrows and surface markings, and proportions of fixigenae with *Talbotinella communis*. Therefore, the former is suppressed here as a junior synonym. Equally, the paratype

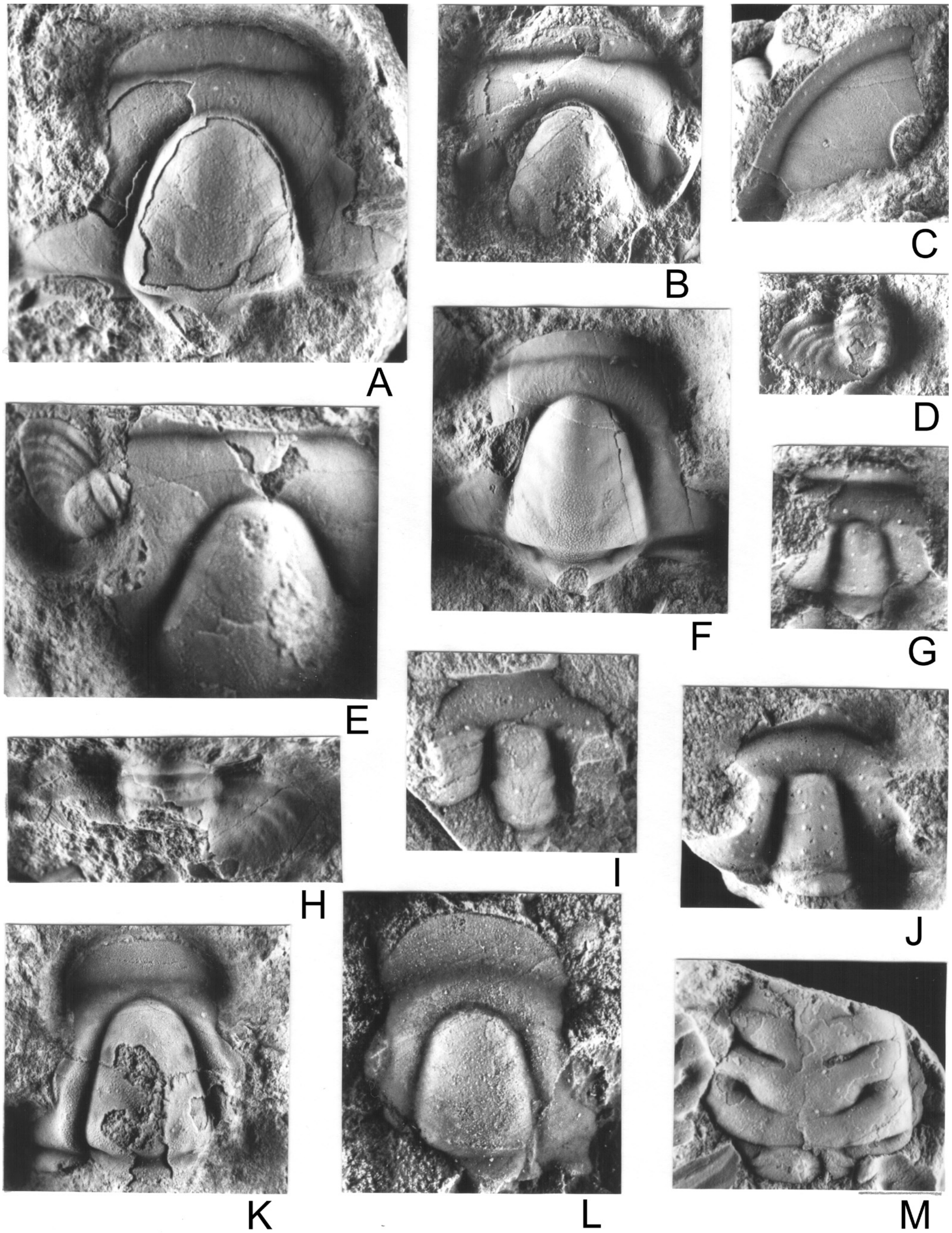


Fig. *7*. **A, C-D, F, H**, *Talbotinella communis* Poulsen, 1960; **A**, cranidium, MLP 32506, x4.4; **C**, free cheek, MLP 32529, x3.5; **D**, pygidium, MLP 32474, x5.6; **F**, cranidium, MLP 32306, x4.3; **H**, pygidium, MLP 32382, x6. **B, E**, *Talbotinella communis*? Poulsen, 1960; **B**, cranidium, MLP 32494, x4.2; **E**, cranidium and pygidium, MLP 32407, x5. **G, I-J**, *Bolaspidella lucieae* Poulsen, 1960; **G**, cranidium, MLP 32313, x7.6; **I**, cranidium, latex mould, MLP 32304, x8.3; **J**, cranidium, MLP 32314, x6.5. **K**, *Marjumia*? sp., cranidium, MLP 32488, x4.5. **L**, *Modocia*? sp., cranidium, latex mould, MLP 32373, x5.1. **M**, *Parabolina*? sp., incomplete cranidium, MLP 32288, x5.6.

pygidium of *Pseudolevinia macropyge* Rusconi (1951, p. 16) from Cerro El Solitario has a short axis, well developed pleural furrows and a reduced border (see Fig. 9E), and is regarded as conspecific with *Talbotinella communis*.

Many aspects of the cranidial and pygidial patterns of *Elrathia* sp., from the March Point Formation (Newfoundland) (Westrop 1992, figs 18.3, 18.4, 18.6–18.9), are similar to those of *Talbotinella* Poulsen. In many respects, it resembles *Talbotinella communis*, for example, in the strongly conical, raised glabella, the adaxially bifurcated S1 glabellar furrow and the caecal markings on the preglabellar field, but differs from the latter in having a more conspicuous, smooth anterior cranidial border, and a wider (sag.), nonspinose occipital ring.

Elrathia Walcott, 1924

Type species. *Conocoryphe (Conocephalites) kingii* Meek, 1870.

Elrathia hornensis (Rusconi, 1951) (Figs 6F-H, 9F)

1951 *Levinia hornensis*; Rusconi, 1951, p. 18, fig. 28.

Material. Three fragmentary cranidia, 3 thoracopyga, 1 pygidium and 5 pygidial fragments (MLP 32287, 32312, 32333–32335, 32343, 32344, 32375, 32376, 32480, 32493, 32508, MCNAM 8370), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Description. Glabella well defined by deep axial furrows, straight sided, slightly tapered and rounded anteriorly, with 2 to 3 pairs of incipient lateral furrows; the latter are posteriorly deflected and disconnected in the middle; anterior border slightly convex, separated from the preglabellar field by a narrow, shallow border furrow; preglabellar field slightly convex, about twice as long as anterior border, crossed by caecal pattern; anterior facial suture slightly divergent; palpebral area of fixigena moderately wide (tr.); ocular ridge distinct, oblique, confluent with palpebral lobe; palpebral lobe of moderate length, little elevated above fixigenae, anterior glabellar midpoint; palpebral furrow well developed.

Thorax with 14 segments; axial lobe prominent, narrow, width less than half that of pleural lobes; pleural lobe of each segment sub-equally divided by deep pleural furrows; pleural tips extended into short, sharp points.

Pygidium alate, more than 3 times as wide as long; axial lobe prominent, narrow, slightly tapered, containing 4 rings and terminal piece, extended almost to posterior margin; pleural region characterised by 4 reflexed, deep, wide pleural furrows and 3 weaker interpleural furrows; border narrow, slightly flattened, poorly defined by a shallow marginal furrow; posteromedian margin having a broad, shallow indentation.

Remarks. Despite the poor preservation of the cranidia examined, the material is referred to *Elrathia* Walcott because of the presence of an elongate, slightly tapered, anteriorly rounded glabella showing faint indications of lateral furrows, a well developed preglabellar field, 14 thoracic segments with sharp reflexed pleural tips, and a wide pygidium having a long, slightly tapered axis and four conspicuous pleural furrows (see Palmer 1954b; Robison 1964a, 1988; Schwimmer 1989).

The material is assignable to "*Levinia*" *hornensis* Rusconi, a species originally described on the basis of two pygidia from Cerro El Solitario (Rusconi 1951, p. 18, fig. 18) (Fig. 9F). *Amphoton*? *costatus* Rusconi (1950a, p. 84) is represented by one tiny, poorly preserved pygidium from the Solitario Olistolith that may be conspecific. However, the poor preservation of the latter precludes any detailed comparison.

Some aspects of *Elrathia hornensis* are similar to those of *E. omega* Robison, from the upper middle Cambrian of Greenland (Robison 1988, figs 26.1–26.10). Both taxa share incipient glabellar furrows, 14 thoracic segments, an alate pygidium with four axial rings plus terminal piece, and a similar posteromedian margin. However, the material from Argentina can be differentiated by its more conspicuous anastomosing vascular prosopon on the preglabellar field. It is also comparable to *Elrathia antiquata* (Salter) as revised by Schwimmer (1989, figs 3.1–3.5, 3.8, 3.9), from the upper middle Cambrian (*Bolaspidella* Zone) of North America, but differs in possessing a longer preglabellar field, and an alate pygidium. *Elrathia marjumi* Robison, 1964a, *E. kingii* (Meek, 1870), and *E. alapyge* Robison, 1964a, are mainly distinguished from *Elrathia hornensis* by having 12, 13 or 15 thoracic segments, respectively.

'*Talbotinella' rusconii*, erected by C. Poulsen (1960, pl. 2, figs 13–15) on the basis of a fragmentary, isolated cranidium from the Solitario Olistolith, has a very long, little tapered glabella, and therefore is not assignable to *Talbotinella*. It is very similar to *Elrathia hornensis*, but differs in its shorter preglabellar field.

Family MENOMONIIDAE Walcott, 1916

Bolaspidella Resser, 1937

1950b *Notocoryphe*; Rusconi, p. 92, 93.

Type species. Ptychoparia housensis Walcott, 1886.

Bolaspidella lucieae Poulsen, 1960 (Fig. 7G, I, J)

1960 *Bolaspidella lucieae*; C. Poulsen, p. 28, 29, pl. 2, figs 16, 17.
1963 *Bolaspidella lucieae* Poulsen; Castellaro, p. 32.

Material. 13 cranidia (MLP 32287, 32304, 32313, 32314, 32327, 32330, 32455, 32474–32476, 32482, 32525), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. Christian Poulsen (1960) described in great detail *Bolaspidella lucieae* from Cerro El Solitario, a species characterised by having a well developed preglabellar field, palpebral lobes that are slightly anterior to the glabellar midpoint, and a nonspinose occipital ring.

Bolaspidella lucieae is most similar to the widespread species *B. wellsvillensis*, from the upper middle Cambrian of Arizona, Nevada, Utah, Montana and Texas (Lochman & Duncan 1944, pl. 15, figs 14–20; see Palmer 1954a, p. 741, pl. 83, fig. 11), but the latter possesses a shorter (sag.) preglabellar field. *Bolaspidella lucieae* differs from *B. andina* (Rusconi), from the Solitario Olistolith (Rusconi 1950b, p. 92, 93, fig. 11; see Fig. 9C) in having a better developed preglabellar field, a narrower glabella and a narrower palpebral area. The type species, *B. housensis* (Walcott) (Palmer 1954b, pl. 16, fig. 3; Robison 1964a, pl. 88, figs 16–21, pl. 89, figs 1–11) is distinguished by its shorter (sag.) preglabellar field and its spinose occipital ring.

Family MARJUMIIDAE Kobayashi, 1935

Marjumia Walcott, 1916

Type species. Marjumia typa Walcott, 1916.

Marjumia? sp. (Fig. 7K)

Material. A partially exfoliated cranidium and 2 cranidial fragments (MLP 32410, 32412, 32488), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. These cranidia are characterised by a long, tapered, anteriorly rounded glabella showing three pairs of faint muscle scars instead of lateral furrows, a well developed anterior border, and a reduced preglabellar field, which indicate a relationship with the Family Marjumiidae Kobayashi (Robison 1964a, 1988; Pratt 1992). Within this family, the closely related genera *Modocia* Walcott, 1924 and *Marjumia* Walcott, 1916 are mainly distinguished on the basis of pygidia. However, the presence of a relatively narrow palpebral area of the fixigena suggests that the cranidia studied may belong to *Marjumia* Walcott (see generic diagnosis in Robison 1964a, 1988; but see also Pratt 1992).

Marjumia sp. is similar to *Marjumia spinosa* Robison from the upper middle Cambrian of Greenland, which has been described only on the basis of cranidia (Robison 1988, figs 20.8–20.12), as well as *Modocia* sp., from the *Cedaria minor* Zone of northwestern Canada (Pratt 1992, pl. 20, figs 11–13, 15–19). The former slightly differs in lacking an occipital spine. As stated by Pratt (1992, p. 61), '*Prometeoraspis*' *canotensis* Poulsen (C. Poulsen 1960, pl. 1, figs 16, 17) from Cerro El Solitario represents a marjumiid trilobite reassignable to *Marjumia*/*Modocia*. It differs from *Marjumia*? sp. by its more posteriorly located palpebral lobe, and its narrower (exsag.) posterior fixigena.

Modocia Walcott, 1924

Type species. Arionellus (Crepicephalus) oweni Meek & Hayden, 1861.

Modocia? sp. (Fig. 7L)

Material. One cranidium (MLP 32373), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. No pygidia were collected from the Solitario Olistolith that could be assigned confidently to this marjumiid species. The cranidium studied has a long, moderately tapered glabella, and a relatively wide (tr.) palpebral area of the fixigena, which suggests close affinities with *Modocia* Walcott *sensu* Robison (1988). The material is very similar to cf. *Modocia*? *spinosa* Rasetti, from the middle Cambrian of Canada (Rasetti 1963, pl. 70, figs 24, 25; Pratt 1992, pl. 20, figs 3–5), but the former seems to differ in having a slightly longer (sag.) preglabellar field. *Modocia*? sp. is distinguished from all other *Modocia* species in possessing a distinct anterior cranidial border.

Family ASAPHISCIDAE Raymond, 1924

Asaphiscus Meek, 1873

1950a *Canotiana*; Rusconi, p. 74, 75.

Type species. Asaphiscus wheeleri Meek, 1873.

Remarks. The genotype of *Canotiana* Rusconi, *C. villavicencis* Rusconi, 1950a (Jell & Adrain 2003), was based on a single, partially exfoliated pygidium from Cerro El Solitario characterised by having a prominent, tapered axis, very shallow pleural furrows, and a wide flat border which seems to become wider posterolaterally (Fig. 9B). Very similar pygidia from El Solitario are described below, in association with cranidia with a conspicuous anterior border, a tapered, unfurrowed, anteriorly rounded glabella, and downsloping fixed cheeks. Because these specimens agree with the concept of *Asaphiscus* Meek, 1873 (see diagnosis of Palmer 1954b), *Canotiana* Rusconi is regarded herein as a junior synonym of *Asaphiscus*.

Asaphiscus cf. villavicencis (Rusconi, 1950a) (Fig. 8A–D, G)

cf. 1950a *Canotiana villavicencis*; Rusconi, p. 74, 75, fig. 5.

Material. Three cranidia and 8 pygidia (MLP 32297, 32300, 32307, 32462, 32469, 32481), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Description. Cranidium convex, with downsloping fixed cheeks; glabella moderately large, subconical in outline and broadly rounded anteriorly, unfurrowed, surrounded by shallow axial furrows; occipital furrow slightly bowed backwards, marked medially; occipital ring with a small median node; cranidial border slightly convex, representing about 15% of the total length of the cranidium, defined by a shallow border furrow; preglabellar field shorter (sag.) than anterior border, with lateral margins moderately divergent; palpebral area of fixigena proportionately wide (tr.), with palpebral lobe anterior of glabellar midpoint; eye ridge faint, slightly oblique; posterior facial suture strongly divergent, sinuous; deep posterior border furrow widens laterally.

Pygidium subrectangular in outline; axis slightly tapered backwards, smooth, elevated well above level of pleural fields, surrounded by narrow axial furrows, variable in length, occupying about 82-88% of the total pygidial length; pleural fields moderately convex, smooth; border wide and poorly defined, fairly convex to flat, becoming wider posterolaterally; middle part of posterior margin having slight forwards deflection.

Remarks. Some of the cranidia and pygidia described above are found together in a rock specimen (MLP 32307), so they are probably conspecific. The pygidia mostly resemble that from Cerro El Solitario originally assigned by Rusconi (1950a) to *Canotiana villavicencis* Rusconi (1950a, p. 74, 75, fig. 5; herein, Fig. 9B), but the pygidia differ slightly in having a less tapering axis.

Asaphiscus cf. *villavicencis* is distinguished from the type species *Asaphiscus wheeleri* Meek, 1873, from the middle Cambrian of North America (Palmer 1954b, pl. 16, fig. 7, and references therein), in having a slightly longer (sag.) anterior border, a broader (tr.) ocular area of the fixigena, a backwardly curved occipital ring, and a subrectangular pygidium. *Asaphiscus laeviceps* (Walcott, 1884), from the uppermost middle Cambrian of North America (Palmer 1954b, pl. 16, figs 4, 6), mostly resembles *A.* cf. *villavicencis* in having a subrectangular pygidium and a posterior pygidial margin with a slight deflection. However, the former can be differentiated by its narrower (tr.) ocular area of the fixigena and its convex pygidial border.

Asaphiscus cf. *villavicencis* further differs from '*Canotiana*' *lasherensis* Rusconi (1950a, p. 75, 76, fig. 7), originally based on an imperfectly preserved exoskeleton and two pygidia (Fig. 9D, G), because the former has a subconical glabella, which is broadly rounded anteriorly.

Goycoia Rusconi, 1950a

Type species. Goycoia tellecheai Rusconi, 1950a.

Diagnosis. Exoskeleton partially effaced; cephalic anterior border long (sag.) and flat; preglabellar field subequal to slightly shorter than anterior border; glabella subtrapezoidal in outline, not very convex, lacking lateral and occipital furrows; palpebral lobe short, located opposite anterior third of the glabella; pygidium with a long, subparallel-sided to slightly tapered axis, extended to posterior border; pleural fields crossed by very shallow to effaced pleural furrows; pygidial border wide and concave.

Remarks. The pygidium of *Goycoia* is closely similar to that of some species of *Blountia* Walcott, 1916 (e.g., Lochman & Duncan 1944; Rasetti 1946, 1956, 1965; Shaw 1952; Palmer 1962;

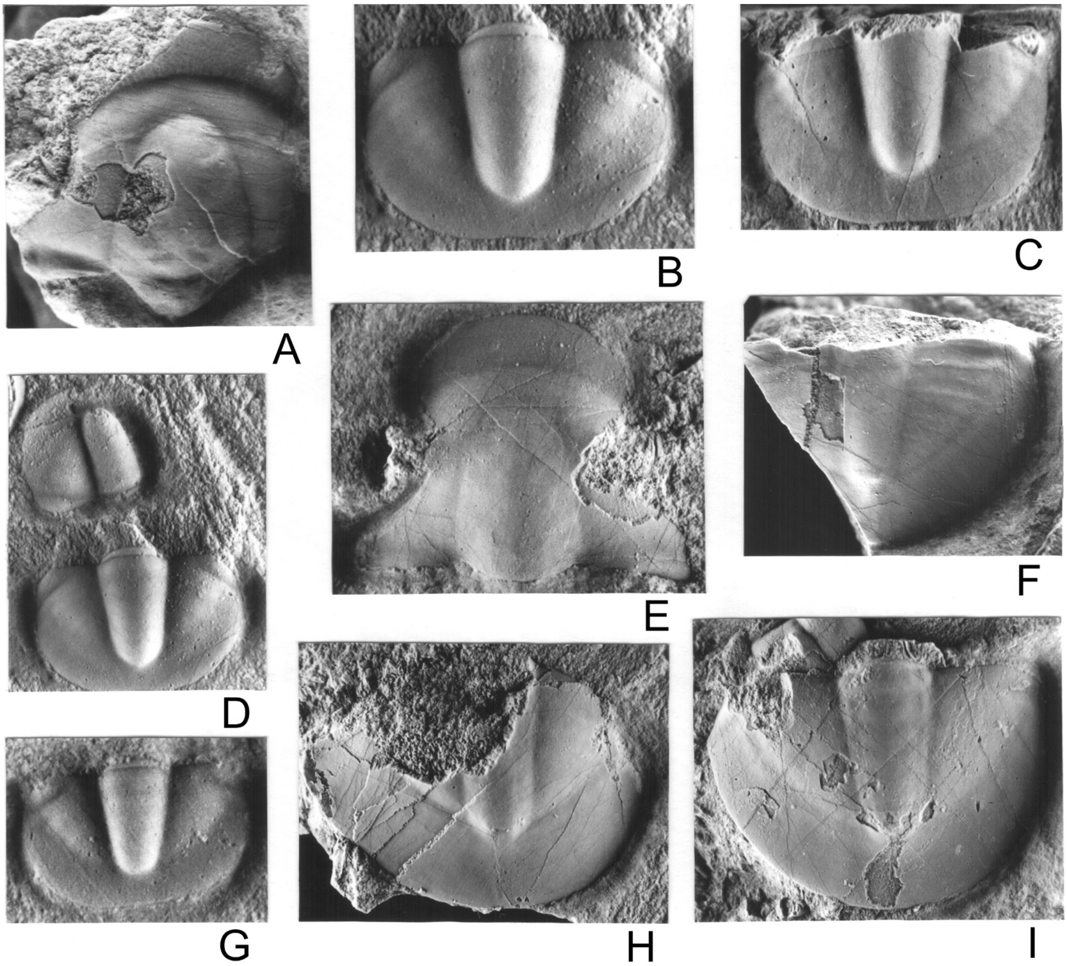


Fig. 8. **A-D, G**, *Asaphiscus* cf. *villavicencis* (Rusconi, 1950a); **A**, cranidium, MLP 32469, x5.2; **B**, pygidium (see also Fig. 8D), MLP 32297, x7.2; **C**, pygidium, MLP 32307, x5.3; **D**, two pygidia, MLP 32297, x4.5; **G**, tiny pygidium, MLP 32307, x8. **E-F, H-I**, *Goycoia tellecheai* Rusconi, 1950a; **E**, cranidium, MLP 32514, x4.5; **F**, pygidium, MLP 32443, x4; **H**, pygidium, MLP 32507, x3.4; **I**, pygidium, MLP 32492, x3.1.

Pratt 1992; Westrop 1992) such as *B. imitatrix* (Raymond) (Rasetti 1946, pl. 69, figs 8–13; Shaw 1952, pl. 57, figs 25–28), which exhibits five to seven axial rings and a distinct border. However, the cranidium of *Goycoia*, which is described herein for the first time, does differ from that of *Blountia* in having an uninflated glabella, and nearly straight axial furrows. Although the structure of the glabella of the material studied is obscured by effacement, the occipital ring seems to lack the posterior rim-like band diagnostic of the family Kingstoniidae Kobayashi, 1933 (Westrop 1992; Westrop *et al*. 2007).

Goycoia differs from *Asaphiscus* Meek, 1873 by its flat anterior cranidial border and its more prominent pygidial border. *Blainia* Walcott, 1916 is distinguished from *Goycoia* because the former has a convex cranidial border and well defined pygidial pleural furrows, which are extended to the pygidial margin. *Kaninia* Walcott & Resser, 1925 can be differentiated by its shorter (sag.) cranidial border, its well defined cranidial border furrow and occipital furrow, and its longer (exsag.) palpebral lobes, whereas *Lioparia* Lorenz, 1906 is different because the glabella is conical, and the palpebral lobes are large.

Goycoia tellecheai Rusconi, 1950a (Figs 8E-F, H-I, 9H-L)

1950a *Goycoia tellecheai*; Rusconi, p. 76, 77, fig. 8.

1952 *Goycoia cerrillensis*; Rusconi, p. 7, pl. 1, figs 3, 4.

1952 *Asaphellus catamarcensis solitariensis*; Rusconi, p. 5, 6, fig. 1.

1960 *Goycoia tellecheai* Rusconi; C. Poulsen, p. 30, 31, pl. 2, fig. 24.
1960 *Goycoia pecoralis*; C. Poulsen, p. 32, pl. 2, fig. 25.

Material. Three cranidia and 10 pygidia (MLP 32443, 32492, 32504, 32507, 32514, 32532, MCNAM 7623, 7624, 8459, 8934, 11709), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Description of cephalon. Cranidium of moderate convexity; glabella slightly elevated above genae, weakly defined by narrrow, shallow axial furrows; it is subtrapezoidal in outline, moderately tapered forwards, rounded anteriorly, unfurrowed, and occupies about 2/3 of total cephalic length; occipital furrow effaced; occipital node almost imperceptible; anterior border long (sag.), flat, rounded anteriorly, comprising about 18% of total cranidial length, defined by a very shallow anterior border furrow; preglabellar field a little shorter (sag.) than anterior border; anterior facial suture divergent; palpebral area of fixigena narrow (tr.), with a short crescentic palpebral lobe that is located opposite anterior third of the glabella; posterior facial suture divergent, sinuous; posterior fixigena slightly downsloping; with a shallow border furrow and a narrow (exsag.) posterior border.

Remarks. Rusconi (1950a, 1952) originally described three species of *Goycoia* Rusconi (*G. tellecheai*, *G. cerrillensis*, *G. limpida*) based on collections of pygidia from the Solitario Olistolith. The type species, *G. tellecheai* Rusconi (1950a, p. 76, 77, fig. 8; emended by C. Poulsen 1960, p. 30, 31, pl. 2, fig. 31) has a proportionately small, semicircular pygidium, which shows a slightly tapered axis, narrow and shallow axial furrows, faint indications of six to seven axial rings, poorly defined pleural furrows, a very wide, concave border, and a weak postaxial ridge. According to Rusconi (1952), *G. cerrillensis* Rusconi (1952, p. 7, pl. 1, figs 3, 4) differs from the type species in having a longer axis and some variation in the degree of expression of the pleural furrows. However, revision of the type specimens suggests that these apparent differences may have no specific significance. The slightly distorted types of *G. cerrillensis* (Fig. 9J-K) are much bigger than those of *G. tellecheai* (Fig. 9H-I), so both the former and the latter may represent different ontogenetic stages of a single species. Similarly, the huge, fragmentary holotype of *Asaphellus catamarcensis solitariensis* Rusconi, from the Solitario Olistolith (Rusconi 1952, p. 5-6, fig. 1; see Fig. 9L), has a morphlogy which appears indistinguishable from that of the specimens cited above. Thus, *G. cerrillensis* and *A. catamarcensis solitariensis* are suppressed here as junior synonyms of *G. tellecheai*. In addition, *G. pecoralis*, erected by C. Poulsen (1960, p. 32, pl. 2, fig. 25) on the basis of an isolated, distorted pygidium from Cerro El Solitario, is also included in the synonymy list of *G. tellecheai* because of morphological similarities.

Pygidia of *G. tellecheai* from the Borrello collections represent different ontogenetic stages. Small specimens can be distinguished from the late holaspides in having greater convexity and a slightly more tapered axis.

Suborder OLENINA Burmeister, 1843
Family OLENIDAE Burmeister, 1843
Subfamily OLENINAE Burmeister, 1843

Parabolina Salter, 1849

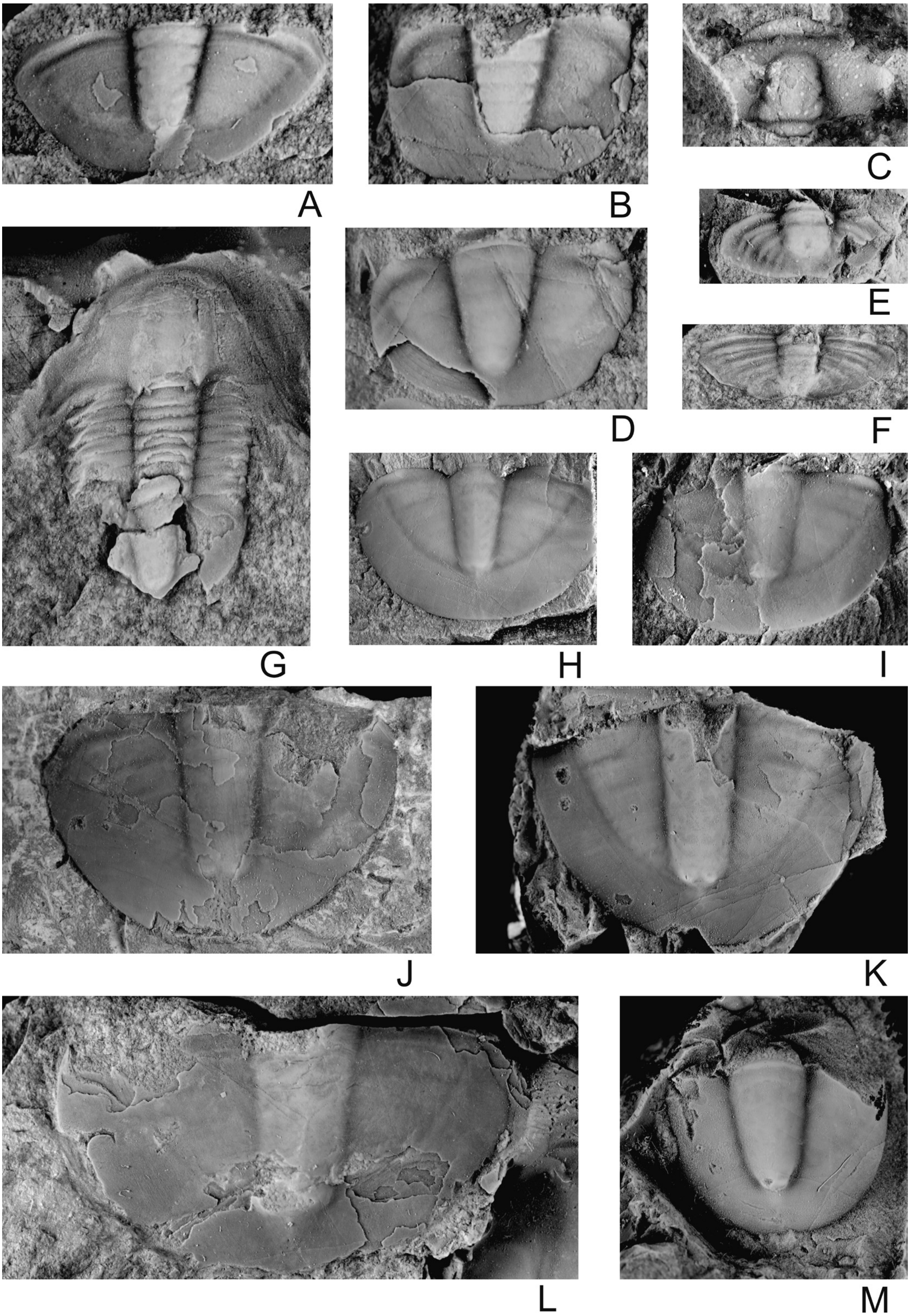
Type species. *Entomostracites spinulosus* Wahlenberg, 1818.

Parabolina? sp. (Fig. 7M)

Material. Two incomplete cranidia (MLP 32288), from the Solitario Olistolith, upper middle Cambrian (*Lejopyge laevigata* Zone).

Remarks. These incomplete cranidia resemble both *Parabolina*? *naomi* Pratt, 1992, from the lower Furongian of northwestern Canada (Pratt 1992, pl. 10, figs 1–8, text-fig. 29), and *P.*? *palmeri* Pratt, 1992 (= *Simulolenus quadrisulcatus* Palmer, 1965, pl. 8, figs 1–4) from the Furongian of Nevada (USA), in sharing a similar glabellar outline and a comparable pattern of lateral

Fig. 9. Type specimens of selected species from Cerro El Solitario described by Rusconi (1950a, 1950b, 1951, 1952). **A**, *Cedaria calensis* (Rusconi, 1950a), pygidium, MCNAM 7519, *Canotiana calensis* Rusconi, 1950a holotype, x6.5. **B**, *Asaphiscus villavicensis* (Rusconi, 1950a), pygidium, MCNAM 7516, *Canotiana villavicensis* Rusconi, 1950a holotype, x5.5. **C**, *Bolaspidella andina* (Rusconi, 1950b), cranidium, MCNAM 8132, *Notocoryphe andinus* Rusconi, 1950b holotype, x6.8. **D**, "*Canotiana*" *lasherensis* Rusconi, 1950a, pygidium, MCNAM 7508, paratype, x5.2. **E**, *Talbotinella communis* Poulsen, 1960, pygidium, MCNAM 8929, *Pseudolevinia macropyge* Rusconi, 1951 paratype, x4.8. **F**, *Elrathia hornensis* (Rusconi, 1951), pygidium, MCNAM 8370, *Levinia hornensis* Rusconi, 1951 holotype, x3.6. **G**, "*Canotiana*" *lasherensis* Rusconi, 1950a, exoskeleton, MCNAM 7507, holotype, x3.6. **H-L**, *Goycoia tellecheai* Rusconi, 1950a, pygidium; **H**, MCNAM 7623, holotype, x3.1; **I**, MCNAM 7624, paratype, x3.1; **J**, MCNAM 8459, (*continued opposite*)



Goycoia cerrillensis Rusconi, 1952, paratype, x2.7; **K**, MCNAM 11709, *Goycoia cerrillensis* Rusconi, 1952 holotype, x2.7; **L**, MCNAM 8934, *Asaphellus catamarcensis solitariensis* Rusconi, 1952 holotype, x2.3. **M**, "*Goycoia*" *limpida* Rusconi, 1950a, MCNAM 7510, holotype, x3.

glabellar furrows. However, *Parabolina*? sp. is distinguished by its more sinuous S1. The material is referred to under open nomenclature pending the recovery of more specimens.

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REFERENCES

Angelin, N.P., 1851. *Palaeontologia Suecica. Pars I: Iconographia Crustaceorum Formationis Transitionis*. Weigel, Lund, 24 p.

Axheimer, N., Eriksson, M.E., Ahlberg, P. & Bengtsson, A., 2006. The middle Cambrian cosmopolitan key species *Lejopyge laevigata* and its biozone: new data from Sweden. *Geological Magazine 143*, 447–455.

Babcock, L.E., Peng, S., Geyer, G. & Shergold, J.H., 2005. Changing perspectives on Cambrian chronostratigraphy and progress toward subdivision of the Cambrian System. *Geosciences Journal 9*, 101–106.

Bordonaro, O.L., 1985. El Cámbrico de San Isidro, Mendoza, en facies de borde externo y talud de la plataforma calcárea de Precordillera. *Actas de las Primeras Jornadas sobre Geología de Precordillera (San Juan)*, 12–17.

Bordonaro, O.L., 2000. Review of the Cambrian Stratigraphy of the Argentine Precordillera. *Geologica Acta 1*, 11–21.

Bordonaro, O.L., 2003. Evolución paleoambiental y paleogeográfica de la cuenca cámbrica de la Precordillera argentina. *Revista de la Asociación Geológica Argentina 58*, 329–346.

Bordonaro, O.L. & Banchig, A.L., 1995. Trilobites lauréntidos en el Cámbrico de la Precordillera Argentina. *6° Congreso Argentino de Paleontología y Bioestratigrafía (Trelew), Actas,* 59–65.

Bordonaro, O.L. & Banchig, A.L., 1996. Estratigrafía de los olistolitos cámbricos de la Precordillera argentina. *13° Congreso Geológico Argentino y 3° Congreso de Exploración de Hidrocarburos (Buenos Aires), Actas 5*, 471–479.

Bordonaro, O.L., Beresi, M. & Keller, M., 1993. Reinterpretación estratigráfica del Cámbrico del área de San Isidro, Precordillera de Mendoza. *12° Congreso Geológico Argentino y 2° Congreso de Exploración de Hidrocarburos (Mendoza), Actas 2*, 12–19.

Bordonaro, O.L. & Liñán, E., 1994. Some Middle Cambrian agnostoids from the Precordillera argentina. *Revista Española de Paleontología 9*, 105–114.

Bordonaro, O.L. & Pratt, B.R., 2008. Middle Cambrian trilobites of La Laja Formation, western Argentina. 55-56 in Rábano, I., Gozalo, R. & García-Bellido, D. (eds.), *Advances in trilobite research*. Cuardernos del Museo Geominero 9, Instituto Geológico y Minero de España, Madrid.

Borrello, A.V., 1962. Caliza La Laja (Cámbrico Medio de San Juan). *Notas Comisión de Investigaciones Científicas de la Provincia de Buenos Aires 1(2)*, 3–8.

Borrello, A.V., 1963. *Fremontella inopinata* n. sp. del Cámbrico de la Argentina. *Ameghiniana 3*, 51–55.

Borrello, A.V., 1964. Sobre la presencia del Cámbrico Inferior Olenellidiano en la sierra de Zonda, Precordillera de San Juan. *Ameghiniana 3*, 313–318.

Borrello, A.V., 1965. Sobre el desarrollo bioestratigráfico del Cámbrico de la Precordillera. *Acta Geológica Lilloana 7*, 39–46.

Borrello, A.V., 1967. El género *Elrathina* (Trilobita) en el Cámbrico de San Juan. *Ameghiniana 5*, 158–159.

Borrello, A.V., 1971. The Cambrian of South America. 385–438 in Holland, C. (ed.), *Cambrian of the New World*. Wiley Interscience, London.

Borrello, A.V. & Pernas, R.D., 1965. Sobre la presencia del género *Kootenia* en el Cámbrico de San Juan. *Actas Segundas Jornadas Geológicas Argentinas 1*, 57–62.

Brøgger, W.C., 1878. Om Paradoxidesskifrene ved Krekling. *Nyt Magazin for Naturvidenskaberne 24*, 18–88.

Brongniart, A., 1822. Les trilobites. 1–65 in Brongniart, A. & Desmarest, A.G. (eds), *Histoire naturelle de crustacés fossils, sous les raports zoölogiques et géologiques*. Lavrault, Paris.

Burmeister, H., 1843. *Die Organisation der Trilobiten, aus ihren lebenden Verwandten entwickelt; nebst einer systematischen übersicht aller zeither beschriebenen Arten*. Berlin, 147 p.

Castellaro, H.A., 1963. Faunas cámbricas. 13–37 in Amos, A.J., Camacho, H.H., Castellaro, H.A. & Menéndez, C.A. (eds.), *Guía Paleontológica Argentina*. Publicación del Consejo Nacional de

Investigaciones Científicas y Técnicas (Argentina), Buenos Aires.

Cerdeño, E., 2005. La colección de Paleontología del Museo de Ciencias Naturales y Antropológicas "J. C. Moyano" (Mendoza) y sus ejemplares tipo. *Contribuciones del MACN 2*, 61 p.

Daily, B. & Jago, J.B., 1975. The trilobite *Lejopyge* Hawle and Corda and the Middle-Upper Cambrian boundary. *Palaeontology 18*, 527–550.

Dalman, J.W., 1828. Årsberättelse om myare zoologiska arbeten och upptäcker. *Kongliga Svenska Vetenskaps-Akademiens Handlingar*, 138 p.

Deiss, C., 1939. Cambrian stratigraphy and trilobites of northwestern Montana. *The Geological Society of America, Special Paper 18*, 135 p.

Gallardo, G., Heredia, S. & Maldonado, A, 1988. Depósitos carbonáticos alóctonos, Miembro superior de la Formación Empozada, Ordovícico Superior de la Precordillera de Mendoza, Argentina. *5° Congreso Geológico Chileno, Actas 1*, 37–53.

Geyer, G. & Shergold, J.H., 2000. The quest for internationally recognized divisions of Cambrian time. *Episodes 23*, 188–195.

Harrington, H.J. & Leanza, A.F., 1943. Paleontología del Paleozoico inferior de la Argentina. 1. Las faunas del Cámbrico Medio de San Juan. *Revista del Museo de La Plata 2(11)*, 207–223.

Hawle, I. & Corda, A.J.C., 1847. Prodom einer Monographie der bohmischen Trilobiten. *Abhandlungen der Kongligischen Bohemischen Gessellschaft der Wissenschaften 5*, 1–176.

Heredia, S., 1996. El Cámbrico y Ordovícico de la Cuchilla del cerro Pelado, Precordillera de Mendoza, Argentina. *13° Congreso Geológico Argentino y 3° Congreso de Exploración de Hidrocarburos (Buenos Aires), Actas 1*, 591–600.

Heredia, S. & Beresi, M.S., 2004. La Formación Empozada y su relación estratigráfica con la Formación Estancia San Isidro (nom. nov.), Ordovícico de la Precordillera de Mendoza. *Revista de la Asociación Geológica Argentina 59*, 178–192.

Holm, G. & Westergård, A.H., 1930. A Middle-Cambrian fauna from Bennet Island. *Zapiski Akademii Nauk soyuza SSR, po Otdeleniyu Fiziko-Matematicheskikh Nauk 21(8)*, 25 p.

Howell, B.F., 1937. Cambrian *Centropleura vermontensis* fauna of northwestern Vermont. *Geological Society of America Bulletin 48*, 1147–1210.

Høyberget, M. & Bruton, D.L., 2008. Middle Cambrian trilobites of the suborders Agnostina and Eodiscina from the Oslo Region, Norway. *Palaeontographica A 286*, 1–87, pls. 1–12.

Hu C.-H., 1971. Ontogeny and sexual dimorphism of lower Paleozoic Trilobita. *Palaeontographica Americana 7(44)*, 27–155.

Hupé, P., 1953. Classe des Trilobites. 44–246, figs 1–140 in Piveteau, J. (ed.), *Traité de Paléontologie III*. Masson et Cie, Paris.

Jago, J.B., Bao, J.-S. & Baillie, P.W., 2004. Late Middle Cambrian trilobites from St Valentines Peak and Native Track Tier, northwestern Tasmania. *Alcheringa 28*, 21–52.

Jago, J.B. & Daily, B., 1974. The trilobite *Clavagnostus* Howell from the Cambrian of Tasmania. *Palaeontology 17*, 95–109.

Jago, J.B. & Webers, G.F., 1992. Middle Cambrian trilobites from the Ellsworth Mountains, West Antarctica. 101–124 in Webers, G.F., Craddock, C. & Splettstoesser, J.F. (eds.), *Geology and Paleontology of the Ellsworth Mountains, West Antarctica*. Geological Society of America, Memoir 170.

Jell, P.A. & Adrain, J.M., 2003. Available generic names for trilobites. *Memoirs of the Queensland Museum 48*, 331–553.

Keller, M., 1999. Argentine Precordillera. Sedimentary and Plate Tectonic History of a Laurentian Crustal Fragment in South America. *Geological Society of America, Special Paper 341*, 131 p.

Kobayashi, T., 1933. Upper Cambrian of the Wuhutsui Basin, Liaotung, with special reference to the limit of the Chaumitien (or Upper Cambrian) of eastern Asia and its subdivision. *Japanese Journal of Geology and Geography 11*, 55–155.

Kobayashi, T., 1935. The Cambro-Ordovician formations and faunas of South Chosen. Palaeontology. Part 3. Cambrian faunas of South Chosen with a special study on the Cambrian trilobite genera and families. *Journal of the Faculty of Science, Imperial University of Tokyo, Section II, 4(2)*, 49–344, pls. 1–24.

Kobayashi, T., 1939. On the agnostids. Part 1. *Journal of the Faculty of Science, Imperial University of Tokyo, Section II (Geology, Mineralogy, Geography, Seismology) 5*, 69–198.

Laurie, J.R., 1989. Revision of species of *Goniagnostus* Howell and *Lejopyge* Corda from Australia (Agnostida, Cambrian). *Alcheringa 13*, 175–191.

Leanza, A.F., 1947. El Cámbrico Medio de Mendoza. *Revista del Museo de La Plata (Nueva Serie), Sección Paleontología 3*, 223–235.

Lochman, C. & Duncan, D., 1944. Early Upper Cambrian faunas of Central Montana. *Geological Society of America Special Paper 54*, 181 p.

Lochman, C. & Hu C.-H., 1960. Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming. Part 1. *Journal of Paleontology 34*, 793–834.

Lochman, C. & Hu C.-H., 1961. Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming, Part II. *Journal of Paleontology 35*, 125–146.

Lorenz, T., 1906. Bieträge zur geologie und palaeontologie von Ostasien unter besonderer

Berücksichtigung der Provinz Schantung in China, Part 2, Palaeontologischer Teil. *Zeitschrift der Deutschen Geologischen Gesellschaft 58*, 67–122, pls. 1–6.

Lu Y-H. & Lin H.-L., 1989. The Cambrian trilobites of western Zhejiang. *Palaeontologia Sinica 178, new series B, 25*, 287 p.

M'Coy, F., 1849. On the classification of some British fossil Crustacea with notices of some new forms in the University collection at Cambridge. *Annals and Magazine of Natural History, series 2, 4*, 161–179, 330–335, 392, 414.

Meek, F.B., 1870. Descriptions of fossils collected by the U.S. Geological Survey. *Academy of Natural Sciences, Philadelphia, Proceedings for 1870*, 56–64.

Meek, F.B., 1873. Preliminary palaeontology report, consisting of list and descriptions of fossils, with remarks on the age of the rocks in which they are found. *Annual Report of the United States Geological Survey of Territories 6*, 429–518.

Meek, F.B. & Hayden, F.V., 1861. Descriptions of new Lower Silurian (Primordial), Jurassic, Cretaceous and Tertiary fossils collected in Nebraska by the exploring expedition under the command of Capt. Wm. F. Reynolds, U.S. Top. Engrs; with remarks on the rocks from which they were obtained. *Proceedings of the Academy of Natural Science, Philadelphia 2, 5*, 415–447.

Miller, B.M., 1936. Cambrian trilobites from northwestern Wyoming. *Journal of Paleontology 10*, 23–34.

Öpik, A.A., 1963. Early Upper Cambrian fossils from Queensland. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics 64*, 133 p.

Öpik, A.A., 1967. The Mindyallan fauna of northwestern Queensland. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics 74*, vol. 1, 404 p., vol. 2, 167 p.

Palmer, A.R., 1954a. The faunas of the Riley Formation in Central Texas. *Journal of Paleontology 28*, 709–786.

Palmer, A.R., 1954b. An appraisal of the Great Basin Middle Cambrian Trilobites Described Before 1900. *Geological Survey Professional Paper 264-D*, 55–86, pls. 13–17.

Palmer, A.R., 1962. *Glyptagnostus* and associated trilobites in the United States. *Geological Survey Professional Paper 374-F*, 1–49, pls. 1–6.

Palmer, A.R., 1965. Trilobites of the Late Cambrian Pterocephaliid Biomere in the Great Basin, United States. *Geological Survey Professional Paper 493*, 1–105, pls. 1–20.

Peng, S. & Robison, R.A., 2000. Agnostid biostratigraphy across the middle–upper Cambrian boundary in Hunan, China. *Journal of Paleontology 74 (supplement)*, 104 p.

Poulsen, C., 1927. The Cambrian, Ozarkian and Canadian faunas of Northwest Greenland. *Meddelelser om Grønland 70(2)*, 233–343, pls. 14–21.

Poulsen, C., 1960. Fossils from the late Middle Cambrian *Bolaspidella* Zone of Mendoza, Argentina. *Matematisk-fysiske Meddelelser, Det Kongelige Danske Videnskabernes Selskab 32(11)*, 42 p.

Poulsen, V., 1958. Contributions to the Middle Cambrian paleontology and stratigraphy of Argentina. *Matematisk-fysiske Meddelelser, Det Kongelige Danske Videnskabernes Selskab 31(8)*, 23 p.

Pratt, B.R., 1992. Trilobites of the Marjuman and Steptoean stages (Upper Cambrian), Rabbitkettle Formation, southern Mackenzie Mountains, northwest Canada. *Palaeontographica Canadiana 9*, 179 p.

Rasetti, F., 1946. Early Upper Cambrian trilobites from western Gaspé. *Journal of Paleontology 20*, 442–462.

Rasetti, F., 1948. Middle Cambrian trilobites from the Conglomerates of Quebec (exclusive of the Ptychopariidea). *Journal of Paleontology 22*, 315–339.

Rasetti, F., 1956. Revision of the trilobite genus *Maryvillia* Walcott. *Journal of Paleontology 30*, 1266–1269.

Rasetti, F., 1963. Middle Cambrian ptychoparioid trilobites from the conglomerates of Quebec. *Journal of Paleontology 37*, 575–594.

Rasetti, F., 1965. Upper Cambrian trilobites faunas of northeastern Tennessee. *Smithsonian Miscellaneous Collections 148*, 1–127, pls. 1–21.

Raymond, P.E., 1924. New Upper Cambrian and Lower Ordovician trilobites from Vermont. *Proceedings of the Boston Society of Natural History 37*, 389–466.

Raymond, P.E., 1937. Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont. *Bulletin of the Geological Society of America 48*, 1079–1146.

Resser, C.E., 1935. Nomenclature of some Cambrian trilobites. *Smithsonian Miscellaneous Collections 93 (5)*, 46 p.

Resser, C.E., 1937. Third contribution to nomenclature of Cambrian trilobites. *Smithsonian Miscellaneous Collections 95 (3)*, 29 p.

Resser, C.E., 1938. Cambrian System (restricted) of the southern Appalachians. *Geological Society of America Special Paper 15*, 140 p.

Resser, C.E., 1939. The *Ptarmigania* Strata of the Northern Wasatch Mountains. *Smithsonian Miscellaneous Collections 98*, 1–72, pls. 1–14.

Robison, R.A., 1964a. Late Middle Cambrian faunas from western Utah. *Journal of Paleontology 38*, 510–566.

Robison, R.A., 1964b.Upper Middle Cambrian stratigraphy of western Utah. *Bulletin of the*

Geological Society of America 75, 995–1010.

Robison, R.A., 1976. Middle Cambrian trilobite biostratigraphy of the Great Basin. *Brigham Young University Geology Studies 23*, 93–109.

Robison, R.A., 1984. Cambrian Agnostida of North America and Greenland, Part 1, Ptychagnostidae. *University of Kansas Paleontological Contributions 109*, 59 p.

Robison, R.A., 1988. Trilobites of the Holm Dal Formation (late Middle Cambrian), central North Greenland. *Meddelelser om Grønland, Geoscience 20*, 23–103.

Rusconi, C., 1945. Nuevos trilobites del Cámbrico de Mendoza. *Boletín Paleontológico de Buenos Aires 19*, 1–3.

Rusconi, C., 1950a. Trilobitas y otros organismos del Cámbrico de Canota. *Revista del Museo de Historia Natural de Mendoza 4*, 71–84.

Rusconi, C., 1950b. Nuevos trilobitas y otros organismos del Cámbrico de Canota. *Revista del Museo de Historia Natural de Mendoza 4*, 85–94.

Rusconi, C., 1951. Más trilobitas cámbricos de San Isidro cerro Pelado y Canota. *Revista del Museo de Historia Natural de Mendoza 5*, 3–30.

Rusconi, C., 1952. Varias especies de trilobitas del Cámbrico de Canota. *Revista del Museo de Historia Natural de Mendoza 6*, 5–18.

Rusconi, C., 1954. Las piezas “tipos” del Museo de Mendoza. *Revista del Museo de Historia Natural de Mendoza 7*, 81–155.

Rusconi, C., 1955. Formaciones y horizontes geológicos fundados por Carlos Rusconi. *Revista del Museo de Historia Natural de Mendoza 8*, 65–84.

Rusconi, C., 1956a. Lista de los géneros y especies fundadas por Carlos Rusconi. *Revista del Museo de Historia Natural de Mendoza 9*, 121–156.

Rusconi, C., 1956b. Correlaciones Cambro–Ordovícicas entre Mendoza y Norteamérica. *20° Congreso Geológico Internacional, Simposio Cámbrico, 2, Mexico*, 751–762.

Rusconi, C., 1962. Correlación de organismos Cambro–Ordovícicos de varias localidades de Mendoza. *Revista del Museo de Historia Natural de Mendoza 14*, 85–97.

Rushton, A.W.A., 1978. Fossils from the Middle-Upper Cambrian transition in the Nuneaton District. *Palaeontology 21*, 245–283.

Salter, J.W., 1849. Figures and descriptions illustrative of British organic remains. *Memoirs of the Geological Survey 2*, 1–39.

Salter, J.W., 1864. A monograph of British trilobites. Part 1. *Monograph of the Palaeontographical Society*, 1–80, pls. 1–6.

Schrank, E., 1975. Kambrische Trilobiten der China-Kollektion v. Richthofen, Teil 2: Die Fauna mit *Kaolishania*? *quadriceps* von Saimaki. *Zeitschrift für Geologische Wissenschaften 3*, 591–619.

Schwimmer, D.R., 1989. Taxonomy and biostratigraphic significance of some Middle Cambrian trilobites from the Conasauga Formation in western Georgia. *Journal of Paleontology 63*, 484–494.

Shaw, A.B., 1952. Paleontology of northwestern Vermont. II. Fauna of the Upper Cambrian Rockledge Conglomerate near St. Albans. *Journal of Paleontology 26*, 458–483.

Shaw, A.B., 1956. Notes on *Modocia* and Middle Cambrian trilobites from Wyoming. *Journal of Paleontology 30*, 141–145.

Shergold, J.H., 1997. Explanatory notes for the Cambrian correlation chart. 303–311 in Kaesler, R.L. (ed.), *Treatise on Invertebrate Paleontology, Part O, Arthropoda 1, Trilobita (revised) vol. 1*. Geological Society of America, Boulder and University of Kansas Press, Lawrence.

Shergold, J.H. & Webers, G.F., 1992. Late Dresbachian (Idamean) and other trilobite faunas from the Heritage Range, Ellsworth Mountains, West Antarctica. 125–168 in Webers, G.F., Craddock, C. & Splettstoesser, J.F. (eds), *Geology and Paleontology of the Ellsworth Mountains, West Antarctica*. Geological Society of America, Memoir 170.

Shergold, J.H., Bordonaro, O.L. & Liñán, E., 1995. Late Cambrian agnostoid trilobites from Argentina. *Palaeontology 38,* 241–257.

Sundberg, F.A., 1999. Redescription of *Alokistocare subcoronatum* (Hall and Whitfield, 1877), the type species of *Alokistocare*, and the status of Alokistocaridae Resser, 1939b (Ptychopariida: Trilobita, Middle Cambrian). *Journal of Paleontology 73*, 1126–1143.

Swinnerton, H.H., 1915. Suggestions for a revised classification of trilobites. *Geological Magazine (New Series) 6*, 487–496, 538–545.

Tortello, M.F. & Bordonaro, O.L., 1997. Cambrian agnostoid trilobites from Mendoza, Argentina: a systematic revision and biostratigraphic implications. *Journal of Paleontology 71*, 74–86.

Wahlenberg, G., 1818. Petrificata Telluris Svecanae. *Nova Acta Regiae Societatis Scientiatum Upsaliensis 8*, 1–116.

Walcott, C.D., 1884. The paleontology of the Eureka district, Nevada. *United States Geological Survey Monograph 8*, 298 p.

Walcott, C.D., 1886. Second contribution to the studies on the Cambrian faunas of North America. *United States Geological Survey Bulletin 30*, 369 p.

Walcott, C.D., 1916. Cambrian geology and paleontology III, Nº 5, Cambrian trilobites. *Smithsonian Miscellaneous Collections 64(5)*, 301–488.

Walcott, C.D., 1924. Cambrian geology and paleontology V, Nº 2, Cambrian and Lower Ozarkian trilobites. *Smithsonian Miscellaneous Collections 75*, 53–60.

Walcott, C.D. & Resser, C.E., 1925. Trilobites from the Ozarkian sandstones of the Island of Nowaya Zemlya. *Reports of the Scientific Results of the Norwegian Expedition to Nowaya Zemlya, 1921, 24*, 1–14, pls. 1–2.

Westrop, S.R., 1992. Upper Cambrian (Marjuman-Steptoean) trilobites from the Port au Port Group, western Newfoundland. *Journal of Paleontology 66*, 228–255.

Westrop, S.R., Ludvigsen, R. & Kindle, C.H., 1996. Marjumian (Cambrian) agnostoid trilobites of the Cow Head Group, Western Newfoundland. *Journal of Paleontology 70*, 804–829.

Westrop, S.R., Waskiewicz, R.A. & Adrain, J.M., 2007. The Late Cambrian (Steptoean) trilobite genus *Bynumina* Resser, 1942, in North America. *Memoirs of the Association of Australasian Palaeontologists 34*, 357–376.

Whitehouse, F.W., 1939. The Cambrian faunas of north-eastern Australia. Pt. 3, the polymerid trilobites. *Memoirs of the Queensland Museum 40*, 179–282.