


Elviniid trilobites from the *Elvinia* Zone (late Cambrian, Furongian) of Mendoza, western Argentina

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Abstract.—In the 1950s, Carlos Rusconi reported the biostratigraphically important Furongian trilobites *Elvinia* Walcott and *Irvingella* Ulrich and Resser from an exotic limestone block (La Cruz Olistolith) of the San Isidro area, Precordillera of Mendoza, western Argentina. Although several local species were erected by Rusconi at that time, most of them were later listed as junior synonyms of *E. roemeri* (Shumard) or *I. major* Ulrich and Resser, and this was followed in subsequent studies. A systematic revision of all the available specimens of *Elvinia* and *Irvingella* from the Rusconi collection at the Museo de Ciencias Naturales y Antropológicas J.C. Moyano (Mendoza) is provided herein. The occurrence of *E. roemeri* is supported by the present study, while the associated *Irvingella* species include *I. jorusconii* Rusconi, *I. platycephala* Rusconi, and *Irvingella* sp. The latter represent “advanced” forms in terms of morphological development in the *Irvingella* lineage, and these, together with *E. roemeri*, are typical of the uppermost part of the *Elvinia* Zone (uppermost Steptoean). *Irvingella jorusconii*, *I. platycephala*, and *Irvingella* sp. appear to be endemic to the Argentinian Precordillera, but are related to species from central Texas and northwest Canada.

Introduction

Irvingella Ulrich and Resser in Walcott, 1924 is a biostratigraphically significant Furongian (upper Cambrian) trilobite that was recorded from paleocontinents as diverse as Laurentia, Siberia, Kazakhstan, Baltica, Gondwana, Avalonia, North China, and South China (Geyer and Shergold, 2000; Hong et al., 2003; Peng et al., 2012; Westrop and Adrain, 2016). In Laurentia, it occurs in both the upper Steptoean *Elvinia* Zone (in association with *Elvinia* Walcott, 1924) and the basal Sunwaptan *I. major* Zone. The *Irvingella-Elvinia* assemblage has been reported from numerous locations throughout North America, including northwest Canada, British Columbia, Alberta, Montana, Wyoming, Nevada, Utah, Oklahoma, Texas, Missouri, Arkansas, Wisconsin, and Pennsylvania, in shelf to outer shelf facies (e.g., Chatterton and Gibb, 2016 and references therein; Westrop and Adrain, 2016).

As is generally known, the Cambrian trilobites from the Precordillera of western Argentina have a clear Laurentian aspect (e.g., Rusconi, 1954a, 1962; Borrello, 1971; Bordonaro and Banchig, 1995; Bordonaro, 2003a, 2016; Tortello, 2011, 2014). In the 1950s, Carlos Rusconi (Museum of Natural History of Mendoza) made enormous contributions to the paleontology of the Precordillera of Mendoza, including the discovery of *Elvinia* and *Irvingella* in an exotic limestone block of the San Isidro area. Rusconi (1953, 1954a) pointed out both the biostratigraphic and the paleobiogeographic implications of this finding. He also studied the collection at the species level and proposed *Elvinia obliquoensis* Rusconi, 1953, *Irvingella jorusconii* Rusconi, 1953, *I. platycephala* Rusconi, 1953, and *I. obliquoensis* Rusconi, 1953.

In the absence of new findings, the *Elvinia* Zone in Argentina is known only from the collection mentioned above.

Although the Rusconi species were not illustrated with sufficient detail, Palmer (1965) studied replicas of the type specimens and identified *Elvinia roemeri* (Shumard, 1861) and *Irvingella major*, and since then, these assignments have been cited frequently in the literature (Westrop, 1986; Pratt, 1992; Bordonaro and Banchig, 1995, 1996; Bordonaro, 1999, 2003a, 2003b; Hong et al., 2003; Peng et al., 2012; Chatterton and Gibb, 2016).

Recently, Westrop and Adrain (2016) provided a comprehensive systematic revision of *Irvingella* and discussed helpful criteria for defining its species. Westrop and Adrain (2016) proposed new diagnoses for several taxa of North America and Australia, and demonstrated that the type species *I. major* Ulrich and Resser in Walcott, 1924, which has been reported throughout Laurentia and other Cambrian continents (Pegel, 2000; Hong et al., 2003; Lazarenko et al., 2008; Rushton and Weidner, 2010; Peng et al., 2012), should actually be restricted to Walcott’s poorly preserved type cranidia from Wisconsin, U.S.A.

In order to provide updated systematic information on the trilobites from the *Elvinia* Zone of Argentina, specimens of the Rusconi collection at the Museo de Ciencias Naturales y Antropológicas J.C. Moyano (Mendoza, Argentina) are fully revised herein. They represent three valid forms of Rusconi’s *Irvingella* and, as noted by Palmer (1965), the Laurentian species *Elvinia roemeri*. The best-preserved specimens allow comparison with material from North America and other parts of the world. The *Irvingella* species appear to be endemic to the southern Precordillera, but are related to species from central Texas and northwest Canada.

Geologic setting

The Cambrian of the Precordillera of Mendoza is characterized by open-marine limestone allochthonous blocks (olistoliths) of

different sizes, ranging from centimeters to hundreds of meters in thickness, occurring chaotically within the Middle and Upper Ordovician shales of the Estancia San Isidro and Empoza formations (Bordonaro et al., 1993; Keller, 1999; Heredia and Beresi, 2004). One of the most outstanding fossil-collecting areas is San Isidro, which comprises a number of hills and creeks ~15 km west of Mendoza City (Rusconi, 1952, fig. 1; Fig. 1). There, the carbonate-dominated San Martín, San Isidro, and La Cruz olistoliths (= La Cruz Limestones sensu Keller, 1999), as well as other minor exotic blocks, contain trilobites of middle and late Cambrian age. The oldest olistoliths yield trilobites of the *Glossopleura* Zone (early middle Cambrian), whereas the youngest blocks are assignable to the late Furongian *Saukia* Zone (e.g., Rusconi, 1956a and references therein; Borello, 1971; Shergold et al., 1995; Bordonaro and Banchig, 1996; Keller, 1999; Bordonaro, 2003a, 2014; Bordonaro and Fojo, 2011; Tortello, 2014, 2017, 2018).

The material studied herein was found by Carlos Rusconi and Manuel Tellechea (Museo de Historia Natural de Mendoza) in the Quebrada Oblicua (=“Quebradita Oblicua” of Rusconi,

1953, 1954a) in the early 1950s. This fossil locality is located on the right side of the Quebrada La Cruz, which runs along the southern flank of the Cerro Áspero (Fig. 1). In a field sketch of the succession, Rusconi (1954a) stated the occurrence of light- and dark-colored limestone bearing trilobites of different ages. Specimens of *Elvinia* and *Irvingella*, the focus of the present revision, are relatively abundant (Rusconi, 1954a, p. 3) and come from a Furongian dark block, which stratigraphically belongs to the La Cruz olistolith (Bordonaro, 1992; Bordonaro and Banchig, 1996).

Biostratigraphy

Biostratigraphic significance of Elvinia and Irvingella.—*Elvinia roemeri* (Shumard) is a long-ranging middle Furongian taxon that is widely distributed over North America. Together with species of *Camaraspis* Ulrich and Resser in Ulrich, 1924, *Cliffia* Wilson, 1951, *Pterocephalia* Roemer, 1849, *Housia* Walcott, 1916, *Dellea* Wilson, 1949, and *Irvingella* among others, it defines the widely recognized late Steptoean *Elvinia* Zone (e.g., Frederickson, 1949; Wilson, 1949; Lochman, 1950, 1964; Nelson, 1951; Bell et al., 1952; Lochman and Hu, 1960; Grant, 1965; Palmer, 1965, 1982; Kurtz, 1975; Taylor, 1976; Stitt, 1977; Westrop, 1986; Hohensee and Stitt, 1989; Pratt, 1992; Stitt et al., 1994; Loch and Taylor, 1995, 2004; Taylor et al., 1999; Westrop and Adrain, 2007; Chatterton and Gibb, 2016). A basal Sunwaptan faunule at the top of the unit, the “*Irvingella major* Subzone” of Palmer (1979) (= *I. major* coquina of Wilson and Frederickson, 1950), has been formalized as a separate zone by Chatterton and Ludvigsen (1998). The latter is largely dominated by *Irvingella* “*major*” and is typically associated with *Comanchia* Frederickson in Wilson and Frederickson, 1950. As is the case with the *Elvinia* Zone, the *I. major* Zone is a widespread unit in North America (see a synthesis in Hohensee and Stitt, 1989, p. 860–861), although is only a few feet thick (Lochman and Wilson, 1958; Palmer, 1965; Loch and Taylor, 1995; Westrop and Adrain, 2007).

While *Elvinia* Walcott, 1924 is confined to Laurentia, *Irvingella* has been recorded from diverse paleocontinents at different latitudes (Żylińska et al., 2015). Such a cosmopolitan distribution may have been facilitated by the development of pelagic habits at some point of the life cycle (Rushton, 1967; Fortey, 1985; Żylińska et al., 2015; Chatterton and Gibb, 2016). Most of the *Irvingella* occurrences lie at or near the base of the Jiangshanian global stage; in Laurentia it ranges from the upper Steptoean to the basal Sunwaptan; in Australia it defines the base of the Iverian stage; in China it comes from the middle and late Changshanian; and in Kazakhstan and Siberia, from the late Sakian (Geyer and Shergold, 2000; Peng et al., 2012). In the absence of other cosmopolitan taxa, *Irvingella* proved to be crucial for biostratigraphic correlation of Avalonia, Baltica, and the Sino-Korean block with other parts of the world (Rushton, 1967, 1983; Hong et al., 2003; Choi et al., 2008; Rushton and Weidner, 2010). A helpful global correlation chart indicating *Irvingella* records was provided by Peng et al. (2012, fig. 2).

As shown by Palmer (1965) and Hong et al. (2003), there appears to be a succession of *Irvingella* species through the lower Jiangshanian. Species with a preglabellar field and a

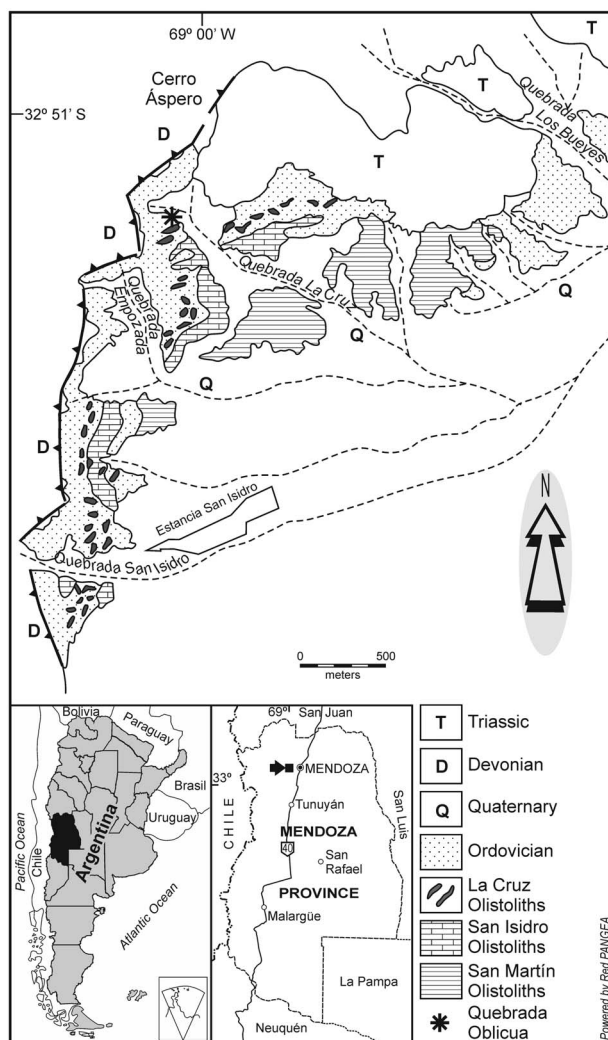


Figure 1. Map of the San Isidro area, Mendoza Province, Argentina (after Bordonaro et al., 1993 and Tortello, 2014). The Quebrada Oblicua is indicated by an asterisk.

distinct anterior border on mature cranidia, such as *I. tya* (Kobayashi, 1935), *I. megalops* (Kobayashi, 1962), *I. tropica* Öpik, 1963, and *I. angustilimbata* Kobayashi, 1938, predate those species like *I. fohri* Resser, 1942, *I. nuneatonensis* (Sharman, 1886), and *I. major* whose large holaspides lack a prelabellar field and have only a trace of a frontal border. The primitive forms also show distinct eye-ridges, which are barely visible or imperceptible in the derived species.

The Elvinia Zone in Argentina.—The first report of *Elvinia* and *Irvingella* from the Quebrada Oblicua of Mendoza was well received by the international scientific community. In a congratulatory letter addressed to Carlos Rusconi in 1954, Dr. B.F. Howell (Princeton University) welcomed the discovery in Argentina of these “North American” age-diagnostic genera (Rusconi, 1954a, p. 3). Rusconi (1953, 1954a, 1954b) used the name “*Irvingella jorusconii* Zone” for this fossil locality and, based on the occurrence of *Elvinia obliquoensis*, *Irvingella jorusconii*, *I. platycephala*, *I. obliquoensis* and “*Triarthropsis pampanus*” Rusconi, 1953, assigned it to the upper Cambrian; however, no further details were provided on the zone, and it was not mentioned in subsequent papers. A few years later, Wilson (1957, fig. 2) correlated the Quebrada Oblicua section with the lower Franconian *Elvinia* Zone of the standard North America trilobite zonation (see also Borrello, 1971).

As stated above, Palmer (1965) revised replicas of the type specimens of the Rusconi collection and recognized *Elvinia roemeri* and *Irvingella major*, confirming an assignment to the *Elvinia* Zone. The occurrence of *E. roemeri* in the Argentinian Precordillera is supported by the present study, while the associated *Irvingella* forms, as here revised include *Irvingella jorusconii* Rusconi, *I. platycephala* Rusconi, and *Irvingella* sp. Species diversity in Mendoza is relatively high; other records of three co-occurring species of *Irvingella* have so far only been reported from the *Elvinia* Zone (*Wujiajiania sutherlandi* Subzone) of southeastern British Columbia, Canada (Clay Creek and “Site 7” of Chatterton and Gibb, 2016, p. 4, 6) and, though subject to revision, the Morgan Creek Member of the Wilberns Formation of central Texas (Cold Creek Canyon, San Saba County; Resser, 1942).

Adult specimens of *Irvingella* from Mendoza are characterized by their imperceptible ocular ridges and their reduced frontal area, which lacks a prelabellar field and exhibits barely a trace of an anterior border. Thus, *I. jorusconii*, *I. platycephala*, and *Irvingella* sp. represent “advanced” forms in terms of morphological development in the *Irvingella* lineage, and these are typical of the uppermost part of the *Elvinia* Zone.

Although *Irvingella* species from Mendoza seem to be endemic to the southern Precordillera, they display a strong resemblance with poorly documented material from the Wilberns Formation of central Texas, originally assigned by Resser (1942) to *I. oblonga* and *I. abrupta* (= *I. “major”* sensu Palmer, 1965), as well as with *I. “major”* from the Rabbitkettle Formation of the southern Mackenzie Mountains (Pratt, 1992) (see below, Systematic paleontology). Such similarities further suggest an uppermost Steptoean age (upper *Elvinia* Zone), and strengthen the Laurentian aspect of the fauna studied. It is worth noting that the exotic Argentine Precordillera was possibly part of or close to southeastern Laurentia during the late Cambrian, around

the Ouachita embayment (Astini et al., 1995; Ramos, 1995; Keller et al., 1998; Keller, 1999 and references therein).

Materials and methods

Materials and preservation.—The collection studied consists of ~50 disarticulated specimens that are mostly preserved as internal molds or partly exfoliated sclerites. Before photography, the material was coated with vapors of magnesium oxide. The best-preserved specimens are illustrated in dorsal, frontal, lateral, and posterior views.

Repository and institutional abbreviation.—Types, figured, and other specimens examined in this study are deposited in the Museo de Ciencias Naturales y Antropológicas “Juan Cornelio Moyano” (Mendoza, Argentina) with the prefix MCNAM.

Systematic paleontology

Terminology.—The morphological terms used below have been mostly defined by Whittington and Kelly (1997). Abbreviations: sag, sagittally; exs, exsagittally; long, longitudinally; tr, transversally.

Order Ptychopariida Swinnerton, 1915
Suborder Ptychopariina Swinnerton, 1915
Family Elviniidae Kobayashi, 1935
Subfamily Elviniinae Kobayashi, 1935
Genus *Elvinia* Walcott, 1924

Type species.—*Dikelocephalus roemeri* Shumard, 1861 from the Furongian of North America, by original designation.

Remarks.—Palmer (1960, 1965) revised the scope of this genus and provided diagnoses of its two valid species, *E. roemeri* and *E. granulata* Resser, 1942.

Elvinia roemeri (Shumard, 1861)
Figure 2.1–2.9, ?2.10

- 1861 *Dikelocephalus roemeri* Shumard, p. 220.
1953 *Elvinia obliquoensis* Rusconi, p. 1, text-fig. 1.
1954a *Elvinia obliquoensis*; Rusconi, p. 23, text-fig. 14, pl. 2, fig. 1.
1954a *Irvingella obliquoensis* Rusconi; Rusconi, pl. 2, fig. 9 (only).
1956b *Elvinia obliquoensis*; Rusconi, pl. 4, fig. 1.
1956b *Irvingella obliquoensis*; Rusconi, pl. 4, fig. 9 (only).
1963 *Elvinia obliquoensis*; Castellaro, p. 36.
1965 *Elvinia roemeri* (Shumard); Palmer, p. 44, pl. 3, figs. 9, 11, 14, 16 (see for further synonymy).
2016 *Elvinia roemeri*; Chatterton and Gibb, p. 55, pl. 33, figs. 1–11, pl. 34, figs. 1–8, pl. 35, figs. 1–3, pl. 80, fig. 8 (see for further synonymy).

Neotype.—Cranidium (U.S. Nat. Mus. 70259) from the Wilberns Formation of Texas (Walcott, 1925, pl. 17, figs. 9, 10; Bridge and Girty, 1937, pl. 69, fig. 9).

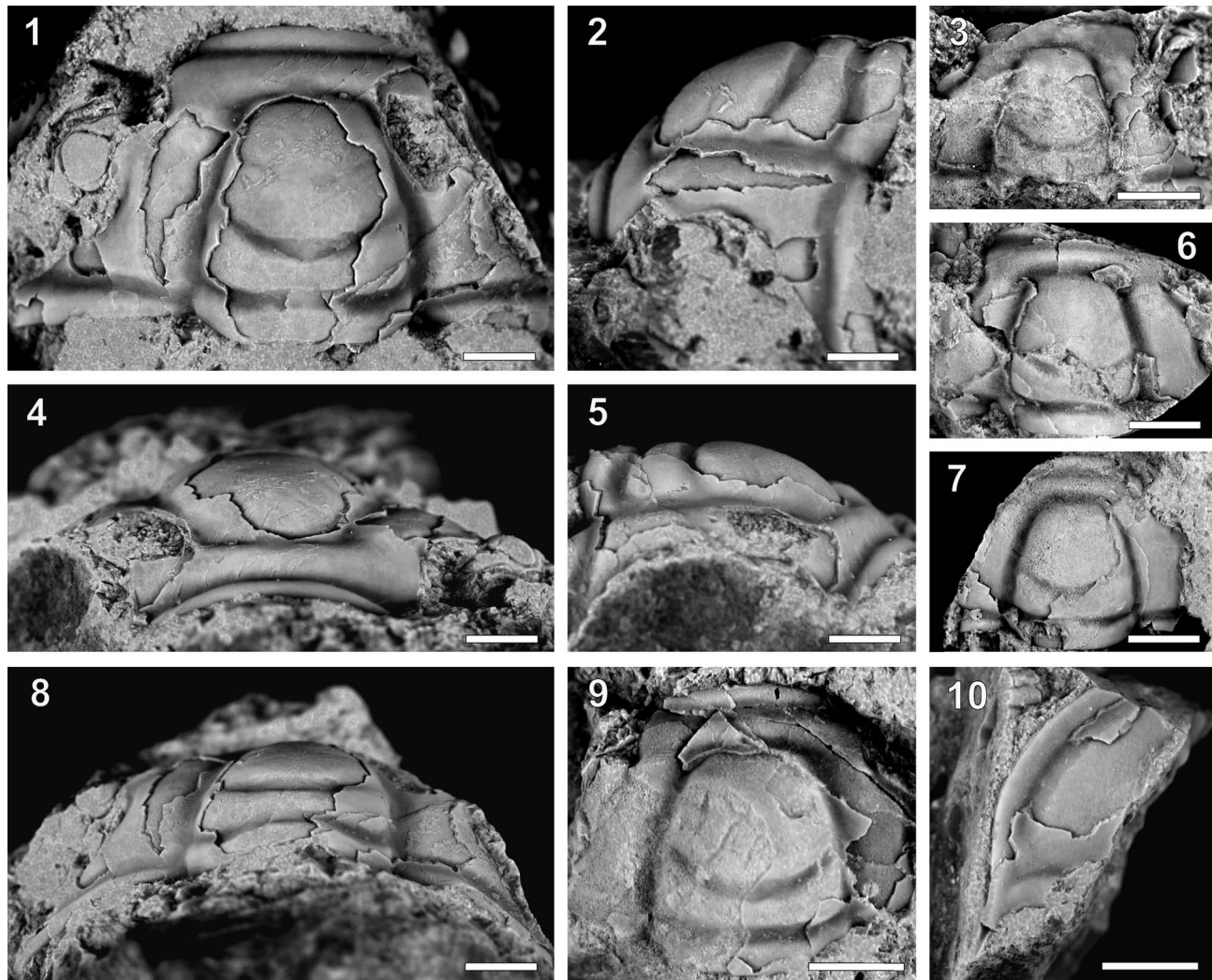


Figure 2. (1–9) *Elvinia roemeri* (Shumard, 1861) from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza. (1, 2, 4, 5, 8) Cranidium in dorsal, lateral-dorsal, anterior, and posterior views, MCNAM 17012. *Elvinia obliquoensis* Rusconi, 1953 holotype (illustrated previously by Rusconi, 1953, text-fig. 1; Rusconi, 1954a, text-fig. 14, pl. 2, fig. 1; Rusconi, 1956b, pl. 4, fig. 1; Castellaro, 1963, p. 36); (3) cranidium, MCNAM 17014; (6) cranidium, MCNAM 17015; (7) cranidium, MCNAM 17013, *Elvinia obliquoensis* Rusconi, 1953 paratype; (9) cranidium, MCNAM 17047b. (10) *Elvinia roemeri*? (Shumard, 1861) from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza, librigena, MCNAM 17028. Scale bars = 3 mm.

Materials.—Seven cranidia and one librigena (MCNAM 17012–17017, 17047b, 17028) from the Quebrada Oblicua, San Isidro area, Mendoza, Argentina. La Cruz Olistolith, Furongian, *Elvinia* Zone.

Remarks.—*Elvinia roemeri* is widely distributed in the Furongian *Elvinia* Zone of North America (e.g., Palmer, 1965; Westrop, 1986; Pratt, 1992; Chatterton and Ludvigsen, 1998; Chatterton and Gibb, 2016). The cranidium of this species is characterized by a truncato-conical glabella bearing a distinct, transglabellar lateral furrow S1, a moderately developed frontal area, a convex and laterally narrowing (exsag.) anterior border, a slightly divergent anterior facial suture, faint ocular ridges, broad fixigenae, and a smooth external surface of exoskeleton (e.g., Kobayashi, 1938; Frederickson, 1949; Lochman, 1950; Palmer, 1965, 1982; Kurtz, 1975). It is distinguished from *E. granulata*, from the *Elvinia* Zone of Nevada, Utah, Indiana, and New York (Palmer, 1965, pl. 3,

fig. 12; Palmer, 1982, pl. 1, figs. 2, 3; Ludvigsen and Westrop, 1983, pl. 3, figs. 1–11, pl. 4, figs. 17, 18, pl. 5, figs. 10–13) mainly because the latter shows fine granules on the external surface of the test.

Palmer (1965) examined replicas of the types of *Elvinia obliquoensis* from the Precordillera of Mendoza and concluded that they are conspecific with *E. roemeri*. The *E. obliquoensis* holotype, which is reillustrated herein (Fig. 2.1, 2.2, 2.4, 2.5, 2.8), compares most closely with a similarly sized cranidium from Missouri (Kurtz, 1975, pl. 1, fig. 12). Additional cranidia from Mendoza (Fig. 2.3, 2.6, 2.7, 2.9) display preglabellar fields of variable length; a variation that is also seen in collections from southeastern British Columbia, Montana, Wyoming, Texas, and Pennsylvania (Bridge and Girty, 1937; Wilson, 1951; Lochman and Hu, 1960; Lochman, 1964; Chatterton and Ludvigsen, 1998).

A fragmentary librigena from the Rusconi collection (Fig. 2.10) is moderately wide (tr.) and has a genal spine that is bent outward from curvature of lateral margin. Although

this sclerite was originally identified as *Irvingella jorusconii*, it may belong to *Elvinia roemeri*. Similarly, a pygidium regarded by Rusconi (1954a, pl. 2, fig. 9; see also Rusconi, 1956b, pl. 4, fig. 9) as *Irvingella obliquoensis* is characterized by having a transversely semielliptical outline; a raised, broad and subparallel-sided axis reaching the posterior border furrow; noticeable anterior pleural furrows; and a narrow (sag.) but distinct border. Such features accord with *Elvinia roemeri* (e.g., Westrop, 1986; Chatterton and Gibb, 2016), even though unfortunately the specimen was not found in the collection for further analysis.

Genus *Irvingella* Ulrich and Resser in Walcott, 1924

Type species.—*Irvingella major* Ulrich and Resser in Walcott, 1924 from the Lone Rock Formation of Wisconsin, U.S.A., by original designation.

Remarks.—The concept of *Irvingella* has been comprehensively reviewed by Palmer (1960, 1965), Ivshin (1962), and Öpik (1963). Zhang (2000) and Hong et al. (2003) demonstrated that *Komaspis* Kobayashi, 1935 (type species *K. typa* Kobayashi, 1935 from the Furongian of Korea) is a synonym of *Irvingella*, and Palmer (1954, 1965) discontinued recognition of *I. (Irvingellina)* Kobayashi, 1938—type species, *I. (I.) protuberans* Kobayashi, 1938—and *I. (Parairvingella)* Kobayashi, 1938—type species, *I. (P.) angustilimbatus* Kobayashi, 1938—from the Furongian of British Columbia, Canada, as valid subgenera.

Resser (1942) proposed a large number of species of *Irvingella* from North America, which were later synonymized with the type species *Irvingella major* (Frederickson, 1949; Gaines, 1951; Palmer, 1965). Recently, Westrop and Adrain (2016) revised in detail most of the Laurentian and Australian species of the genus, counting, among others, a pair of valid forms (*I. media*; *I. deckeri* Resser, 1942) originally proposed by Resser (1942). That review showed that several supposedly widespread species have, in fact, narrower geographic distributions (e.g., *I. major*; *I. angustilimbata*; *I. flohri*). *Irvingella major* has been reported from various Cambrian paleocontinents and used widely in the literature (Walcott, 1925; Ivshin, 1962; Ergaliev, 1980; Pratt, 1992; Pegel, 2000; Hong et al., 2003; Lazarenko et al., 2008; Rushton and Weidner, 2010; Peng et al., 2012; Chatterton and Gibb, 2016; among many others), but Westrop and Adrain (2016) suggested that it would be better restricted to the imperfectly preserved original type lot from Wisconsin, U.S.A.; a systematic decision that is followed herein.

Clearly, the best-documented taxa are described on the basis of more than one single sclerite type, but unfortunately to date there are several species of *Irvingella* without pygidia available for study (e.g., *I. major* sensu Westrop and Adrain, 2016; *I. deckeri*; *I. tumifrons* [Hall and Whitfield, 1877], *I. suecica* Westergård, 1947), and when the latter are present in the collections, they are commonly few in number (e.g., see *I. tropica*; *I. angustilimbata*; *I. flohri*; *I. media* Resser, 1942; *I. orrensis* Westrop and Adrain, 2016). It is interesting to note that known pygidia of *Irvingella* show a high range of interspecific variation regarding both the general outline of the sclerite and the size of the axis (e.g., see Chatterton and Gibb, 2016, text-figs. 11, 12).

Meanwhile, cranidial characters are common and essential components of the diagnoses at specific level, and involve mainly the contour of anterior margin, sagittal length of frontal area, presence or absence of anterior border furrow, relative development of anterior border and preglabellar field, outline and convexity of glabella, degree of expression of glabellar lateral furrows, width and shape of fixigena, presence or absence of ocular ridge, and size and curvature of palpebral furrow and palpebral lobe. To illustrate adequately these features, it is highly recommended to provide different views (e.g., frontal, lateral) of the cranidia examined and not just dorsal ones (Westrop and Adrain, 2016).

Articulated specimens of *Irvingella* are known only from a few fossil localities (Rushton, 1967; Chatterton and Ludvigsen, 1998). Chatterton and Gibb (2016, p. 58) showed that the thorax also changes markedly from species to species, especially in the location and number of the longest macropleural spines, the direction of projection of the marginal spines, and even in the number of segments.

Irvingella jorusconii Rusconi, 1953
Figures 3, 4.1–4.10, ?4.11–4.12, 4.13, ?4.14–4.17

- 1953 *Irvingella jorusconii* Rusconi, p. 2, text-fig. 2a, b.
?1953 *Irvingella obliquoensis* Rusconi, p. 2, text-figs. 4, 5.
1954a *Irvingella jorusconii*; Rusconi, p. 28, text-fig. 15a, b, pl. 2, fig. 6.
?1954a *Irvingella obliquoensis*; Rusconi, p. 31, text-figs. 17, 18, pl. 2, fig. 8 (only).
1956b *Irvingella jorusconii*; Rusconi, pl. 4, fig. 6.
?1956b *Irvingella obliquoensis*; Rusconi, pl. 4, fig. 8 (only).
1963 *Irvingella jorusconii*; Castellaro, p. 35.
1965 *Irvingella major* Ulrich and Resser; Palmer, p. 46.

Holotype.—Cranidium (MCNAM 17000) from the Quebrada Oblicua, San Isidro area, Mendoza, Argentina (Rusconi, 1954a, text-fig. 15, pl. 2, fig. 6; Fig. 3.1–3.5).

Diagnosis.—Glabella inflated, slightly tapered beyond S1 and gently rounded anteriorly, strongly elevated above level of fixigenae; axial furrows conspicuous, remarkably wide (tr.); frontal area very short (sag.), lacking preglabellar field; fixigenae narrow (tr.), with maximum width of palpebral area (excluding palpebral lobe) equal to less than one-quarter of maximum cranidial width, narrowing strongly anteriorly; palpebral furrow deep, strongly arcuate; pygidium semioval in outline, with acuminate anterolateral corners and convergent lateral margins; pygidial axis occupying about three-quarters of total pygidial length (excluding articulating half ring); pleural field narrowed backward, crossed by a well-marked anterior pleura; pygidial border furrow indistinct.

Description.—Cranidium convex, subtrapezoidal in outline, with straight to slightly curved anterior margin and steeply downsloping fixigenae, length ~68% of maximum width between palpebral furrows; anterior arch weak (Fig. 3.7) to absent (Fig. 3.2); axial furrows conspicuous, remarkably wide (tr.), incised on both testate specimens and internal molds

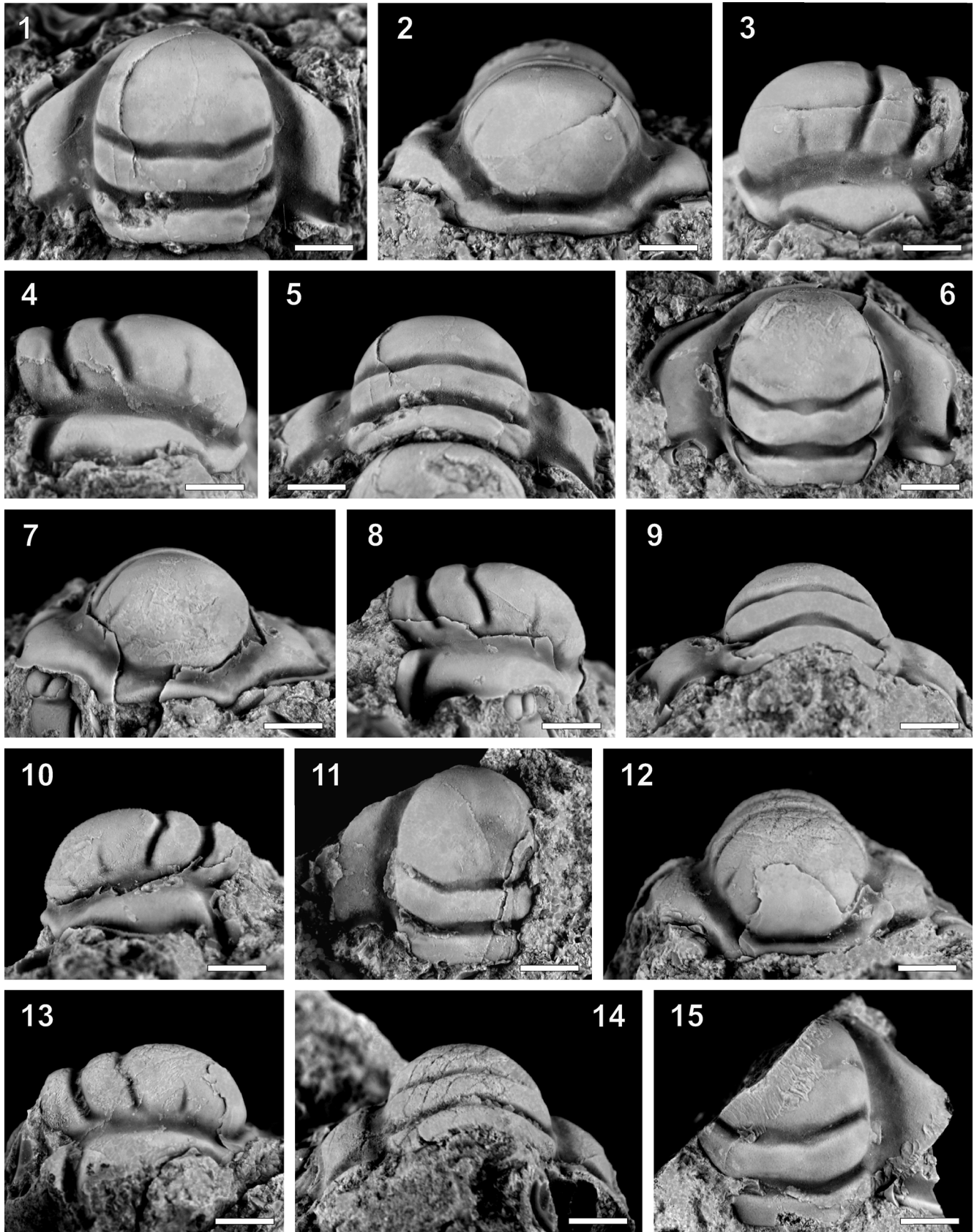


Figure 3. *Irvingella jorusconii* Rusconi, 1953 from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza. (1–5) Cranium in dorsal, anterior, lateral, and posterior views, MCNAM 17000, holotype (illustrated previously by Rusconi, 1953, text-fig. 2; Rusconi, 1954a, text-fig. 15, pl. 2, fig. 6; Rusconi, 1956b, pl. 4, fig. 6; Castellaro, 1963, p. 35); (6–10) cranium in dorsal, anterior, lateral, and posterior views, MCNAM 17001a, paratype; (11) cranium, MCNAM 17001b, paratype; (12–14) cranium in anterior, lateral, and posterior views, MCNAM 17002; (15) fragmentary cranium lacking collection number. Scale bars = 3 mm.

(e.g., Fig. 3.5, 3.15); glabella large, inflated, much longer than wide, strongly elevated above level of fixigenae, occupying ~95–99% of total cranial length (sag.) and 56–58% of cranial width (tr.) between palpebral furrows at level of abaxial tip of S1; glabellar margins subparallel at L0 and L1, becoming slightly convergent beyond S1 and gently rounded anteriorly; glabellar width at S2 equal to ~85% of width at S1; lateral profile of glabella slightly convex between L0 and S2, then strongly curved downward toward preglabellar furrow; L0 and L1 of similar size, clearly delimited by deep S0 and S1; S0 and S1 transglabellar, with a transverse medial portion and forwardly oblique lateral portions that reach axial furrows; L0 and L1 occupy, together, ~41–42% of total glabellar length; S2 faint, gently curved, transverse, expressed only abaxially; some specimens show indications of a delicate S3 (Fig. 3.7); frontal area of cranium very short (sag.), with weakly inflated anterior border, lacking preglabellar field; because the glabella overhangs the frontal region, the anterior cranial border is either invisible (Fig. 3.1) or hardly seen (Figs. 3.6, 4.6) in dorsal view; anterior border furrow very delicate in small holaspides (Fig. 4.2) and absent in large specimens (e.g., Fig. 3.1); fixigenae narrow (tr.), with maximum width of palpebral area (excluding palpebral lobe) equal to less than one-quarter of maximum cranial width, narrowing strongly anteriorly; ocular ridge indistinct; palpebral furrow strongly arcuate, deep, of even width (tr.); palpebral lobe very long (exsag.), extended from level of S0 to frontal glabellar lobe; posterior fixigena with deeply incised posterior border furrow, as developed as axial furrow; external surface of cuticle smooth. Small cranidia (Fig. 4.2) show a frontal area that, in contrast with that of late holaspides, is perfectly visible in dorsal view.

Pygidium semioval in outline, wider than long, length ~60% of maximum width, with acuminate anterolateral corners and convergent lateral margins, obtusely rounded posteriorly; axis convex, strongly elevated above level of pleural fields, a little tapered backward, rounded at posterior end, composed of three rings and a terminal piece that are defined by transverse ring furrows (first ring furrow more distinct than the second one; third represented only by a faint groove); axis occupies about three-quarters of total pygidial length (excluding articulating half ring) and 35% of maximum pygidial width; axial furrows discrete, becoming very shallow behind posterior tip of axis; articulating half ring narrow (sag.), delimited by a deep and wide (sag.) articulating furrow; pleural field narrowed backward, only slightly downslowing, crossed by an anteriormost pleura which is equally divided by a firmly impressed pleural furrow, and a very delicate second pleural furrow; border furrow indistinct; pygidial border undifferentiated; posterior margin of pygidium lacks a medial arch in posterior view.

Materials.—Thirteen cranidia and two pygidia (MCNAM 17000 [holotype], 17001a [paratype], 17001b [paratype], 17002, 17008, 17010 [*Irvingella obliquoensis* paratype], 17043, 17059, 17060, and five numberless specimens; ? MCNAM 17009 [*Irvingella obliquoensis* holotype], 17137) from the Quebrada Oblicua, San Isidro area, Mendoza, Argentina. La Cruz Olistolith, Furongian, *Elvinia* Zone.

Remarks.—Although the holotype cranium of *Irvingella jorusconii* was previously illustrated only with a sketch and a small, retouched photograph (Rusconi, 1954a, text-fig. 15, pl. 2, fig. 6), Rusconi (1953, p. 2; 1954a, p. 28–29) clearly stated that a tumid glabella, a short (sag.) frontal area, and a proportionately narrow (tr.) fixigena, are among the distinguishing features of this species. Together with other characters listed above, an emended diagnosis is provided here.

Palmer (1965) revised replicas of the types of *I. jorusconii* and reassigned them to the type species *I. major* Ulrich and Resser in Walcott, 1924. However, the type material of the latter (Walcott, 1925, pl. 15, figs. 26–29; Westrop and Adrain, 2016, p. 413–418, fig. 14A–E), although poorly preserved, clearly differs from the Argentinian specimens in having a longer (sag.) frontal area, a less tumid frontal glabellar lobe, as well as wider (tr.) fixigenae. *Irvingella jorusconii* is thus restated here as a diagnosable, valid taxon.

The only available pygidium of the type series of *I. jorusconii* (Fig. 4.8–4.10, 4.13) is tentatively kept in this species; its general morphology bears some resemblance to that of *Irvingella* sp. from the Orr Formation of Utah (Westrop and Adrain, 2016, fig. 14A, B, F–H), though the former differs by its distinctive anterior pleura and its imperceptible border furrow. The presence of a well-defined anterior pleural furrow is shared with *Bartonaspis* Westrop and Adrain, 2007, from the *Irvingella major* Zone of Nevada, Utah, and Oklahoma (e.g., Westrop and Adrain, 2007, figs. 4r–t, 8a–f, 11m–n), but the pygidium of *Bartonaspis* is distinguished in the transversely subelliptical outline and smaller number of axial segments.

In addition, three specimens catalogued as *Irvingella obliquoensis* in the Rusconi collection are closely comparable with the material described above. The paratype cranium of *I. obliquoensis* (Fig. 4.5), despite the fact that it is incomplete, clearly shows very wide (tr.) axial furrows and conspicuous, similarly developed S0 and S1, so it is indistinguishable from *I. jorusconii*. Likewise, the holotype cranium of *I. obliquoensis* (Rusconi, 1954a, pl. 2, fig. 8; Fig. 4.11, 4.12, 4.16, 4.17) may also be conspecific, although it is exceptionally large and, unfortunately, very fragmentary for further analysis (cf., Palmer, 1965). The latter is associated with a large pygidium (Fig. 4.14, 4.15), which, like that illustrated in Figure 4.8–4.10, 4.13, is semioval in outline and exhibits a proportionately long axis, a well-defined anterior pleural furrow, and an undifferentiated border.

Besides restricting the concept of *I. major* to the type material from Wisconsin, Westrop and Adrain (2016, p. 415, 418) made preliminary observations on several specimens attributed to that species in Laurentia and other Cambrian continents. Unfortunately, some sclerites are scarce or too poorly documented to be evaluated properly (Westrop and Adrain, 2016, p. 415). Among them, there is one occurrence that strongly resembles the material studied herein. *Irvingella oblonga* Resser, 1942 (= *I. "major"*) (see Gaines, 1951; Palmer, 1965), which was described by Resser (1942, pl. 3, figs. 1–3) on one incomplete cranium from the Morgan Creek Member of the Wilberns Formation of central Texas, exhibits, like *I. jorusconii*, a slightly tapered, strongly elevated anterior half of glabella, wide (tr.) axial furrows, a short (sag.) frontal area, and a relatively narrow (tr.) fixigena showing a similar width throughout its posterior

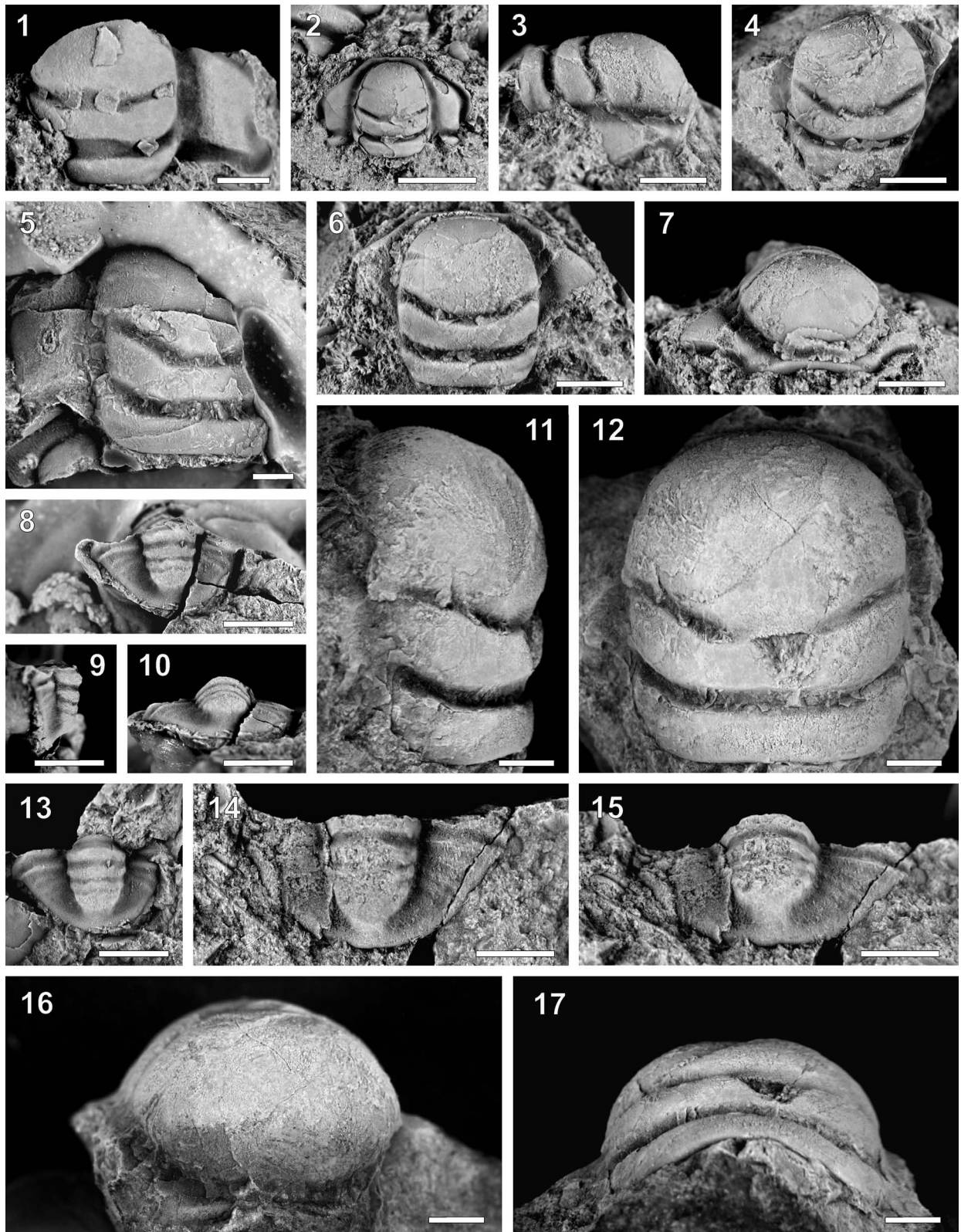


Figure 4. (1–10, 13) *Irvingella jorusconii* Rusconi, 1953 from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza. (1) Fragmentary cranidium lacking collection number; (2) small cranidium lacking collection number; (3, 6, 7) cranidium lacking collection number in lateral, dorsal, and anterior views; (4) fragmentary cranidium, MCNAM 17043; (5) fragmentary cranidium, MCNAM 17010. *Irvingella obliquoensis* Rusconi, 1953 paratype; (8–10) pygidium in dorsal, lateral, and posterior views, MCNAM 17059; (13) pygidium, latex cast of specimen illustrated in Fig. 4.8–4.10. (11, 12, 14–17) *Irvingella jorusconii*? Rusconi, 1953 from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza. (11, 12, 16, 17) Fragmentary cranidium in lateral, dorsal, anterior, and posterior views, MCNAM 17009. *Irvingella obliquoensis* Rusconi, 1953 holotype (illustrated previously by Rusconi, 1953, text-fig. 4; Rusconi, 1954a, text-fig. 17, pl. 2, fig. 8; Rusconi, 1956b, pl. 4, fig. 8); (14, 15) pygidium in dorsal and posterior-dorsal views, MCNAM 17137 (illustrated previously by Rusconi, 1953, text-fig. 5; Rusconi, 1954a, text-fig. 18). Scale bars = 3 mm.

half; however, further specimens are needed to improve this comparison.

Irvingella “major”, from the upper Steptoean-basal Sunwaptan of the southern Canadian Rocky Mountains, Alberta (Westrop, 1986, pl. 30, figs. 8–13), is comparable with *I. jorusconii* in sharing a similarly outlined glabella, which is laterally bounded by wide (tr.) axial furrows, a small frontal area, and relatively narrow (tr.) fixigenae. Additionally, the pygidium of the former preserves indications of one pair of pleural furrows. However, the material from Canada is separated on the basis of its less-tumid frontal glabellar lobe, and its transverse rather than obtusely rounded posterior pygidial margin.

A single cranidium of *Irvingella* “major” from the Furongian (*Parabolina brevispina* Subzone, *P. spinulosa* Zone) of Sweden (Rushton and Weidner, 2010, fig. 3A–D) differs from *I. jorusconii* mainly in having a strong anterior arch and more developed fixigenae. Comparable material from the *Elvinia* Zone of the Great Basin, U.S.A. (e.g., Palmer, 1965, pl. 6, fig. 10) includes cranidia showing somewhat narrower axial furrows and pygidia with a subtrapezoidal rather than a semioval outline, two axial rings instead of three, and a distinct border (Palmer, 1965, pl. 6, fig. 9).

Some complete exoskeletons of *I. “major”* from the *Elvinia* Zone (*Wujiajiania sutherlandi* Subzone) of southeastern British Columbia, Canada (Chatterton and Gibb, 2016, pl. 38, figs. 3, 6, pl. 39, figs. 4, 5, 7) bear pygidia that have, like that of *I. jorusconii*, three axial rings and terminal piece, convergent lateral sides, curved posterior margins, and vestiges of an anterior, distally curved pleura; however, these specimens are distinguished from the Argentinian species mainly by their wider fixigenae. Similarly, *Irvingella dawnae* Chatterton and Gibb, 2016, from the *Wujiajiania sutherlandi* Subzone of British Columbia (Chatterton and Gibb, 2016, pl. 39, figs. 1, 2, 10, pl. 83, fig. 3, text-fig. 12A), possesses a proportionately elongated, semioval pygidium showing a long axis, a clearly marked anterior pleural furrow, and an obscure border furrow; however, this taxon is differentiated from *I. jorusconii* in the presence of a subparallel sided glabella, wider fixigenae, and a narrower pygidial axis.

The material examined herein shares proportions of the palpebral area of the fixigenae with those of *I. deckeri*, from the Honey Creek Formation of central Oklahoma (Resser, 1942, pl. 3, figs. 19–27; Westrop and Adrain, 2016, fig. 15A–I); however, late holaspides of *I. jorusconii* differ in having a more globose frontal glabellar lobe, wider (tr.) axial furrows, strongly downslowing fixigenae that are very narrow (tr.) anteriorly, and a shorter (sag.) frontal area in dorsal view.

Irvingella tumifrons was based on two cranidia from the Dunderberg Formation of Pogonop Ridge, Nevada (Hall and Whitfield, 1877, pl. 2, figs. 38, 39; Resser, 1942, pl. 4, figs. 42, 43; Westrop and Adrain, 2016, fig. 18A–F) that resemble *I. jorusconii* in having a tumid frontal glabellar lobe and wide axial furrows, and in lacking a distinct preglabellar field; however, they are easily distinguished from the Argentinian species by their much wider (tr.) fixigenae. This comparison also applies to *I. “tumifrons”* from the Furongian of central Kazakhstan (Ivshin, 1962, pl. 3, figs. 1–4).

Three cranidia and one pygidium of *Irvingella* “major” from the Ogon’or Formation of the northeastern Siberian Platform (Lazarenko et al., 2008, pl. 17, figs. 9–12, 12a) share a

tumid glabella, a reduced frontal area, relatively narrow fixigenae, and arcuate palpebral furrows with *I. jorusconii*, but the former have narrower axial furrows and a subtrapezoidal pygidium. Partially flattened sclerites of *I. “major”* from the Machari Formation (*Agnostotes orientalis* Zone) of Korea (Hong et al., 2003, pl. 2, figs. 21–27) are differentiated from *I. jorusconii* in showing vestiges of a distinctive anterior cranial border, broader fixigenae, and a shorter pygidial axis.

Both *I. jorusconii* and *I. orrensis*, from the Orr Formation of Utah (Westrop and Adrain, 2016, figs. 19–23, 24B, C, E, I–T), exhibit a very short frontal area lacking preglabellar field, but the latter species is distinguished mainly in the presence of a subrectangular glabella that is delimited by more delicate furrows, a broader palpebral area of fixigena, and a transversely elongate pygidium. Large holaspides of *Irvingella suecica*, from the Alum Shale Formation of Sweden (Westergård, 1947, pl. 3, figs. 1–3; Rushton and Weidner, 2010, fig. 8A–K), also lack a preglabellar field, but differ from *I. jorusconii* in showing wider fixigenae and a better defined anterior cranial border.

Irvingella flohri, from the Dunderberg Formation of Nevada and British Columbia (Resser, 1942, pl. 4, figs. 12–14; Palmer, 1965, pl. 6, figs. 16, 19, 20, 24; Chatterton and Gibb, 2016, pl. 9, fig. 7, pl. 37, figs. 2, 3, pl. 40, figs. 1–9, pl. 41, figs. 1–9, pl. 42, figs. 1–4, pl. 77, fig. 4; Westrop and Adrain, 2016, figs. 9A–K, 10A–C, H–J), differs from the material studied herein because the former exhibits a little longer frontal area, a nearly transverse anterior glabellar margin, and wider fixigenae. As in *I. jorusconii*, the pygidium of *I. flohri* shows a distinct anterior pleural furrow (see Palmer, 1965, pl. 6, fig. 24), but is separated by having only two axial rings and less-convergent lateral margins.

Specimens from the Jiangshanian of Zhejiang, Southeast China, regarded by Peng et al. (2012, fig. 90–R) as *I. major*, are clearly differentiated from the sclerites from Argentina in having more delicate axial furrows, a longer (sag.) frontal area, and much wider (tr.) fixigenae. Similarly, *Irvingella angustilimbata* Kobayashi, 1938 sensu Westrop and Adrain (2016), from western Utah, eastern Nevada, and northern Canada (e.g., Resser, 1942, pl. 4, figs. 18–22; Palmer, 1965, pl. 6, figs. 17, 18, 21–23; Pratt, 1992, pl. 11, figs. 7–13, 16; Westrop and Adrain, 2016, figs. 1–8 and references therein), as well as *I. media*, from central Texas and Oklahoma (Resser, 1942, pl. 3, figs. 46–54; Wilson, 1951, pl. 10, fig. 7, pl. 11, figs. 16, 17, 19, 20; Westrop and Adrain, 2016, figs. 16, 17), are distinguished from *I. jorusconii* in the presence of short but distinct preglabellar fields and different fixigenal proportions. *Irvingella angustilimbata* has, in addition, a transversely elongate pygidium with more convergent lateral margins, and *I. media* bears a pygidium that is subtrapezoidal in outline.

Other species of *Irvingella* further differ from the material studied herein in possessing extremely broad fixigenae (*I. transversa* Palmer, 1965, from the *Elvinia* Zone of the Great Basin [Palmer, 1965, pl. 6, figs. 7, 8]; *I. lata* Chatterton and Gibb, 2016, from the *Wujiajiania lyndasmithae* Subzone of *Elvinia* Zone of British Columbia [Chatterton and Gibb, 2016, pl. 44, figs. 1–9, pl. 45, figs. 1, 2, text-fig. 11B]) or a well-developed preglabellar field (e.g., *I. tropica*, from the *I. tropica* Zone of Queensland, Australia [Öpik, 1963, pl. 4, figs. 5–8, text-fig.

36; Shergold, 1982, pl. 7, figs. 4–7, pl. 8, fig. 10; Westrop and Adrain, 2016, figs. 11, 12, 13A–D]; *I. tupa*, from the *Eugonocare longifrons* Zone of Korea [Hong et al., 2003, pl. 1, figs. 1–11]; *I. megalops* from Korea [*Eochuangia hana* Zone], Kazakhstan [*Pseudagnostus “curtare”* Zone], and eastern Siberia [latest Paibian] [Ergaliev, 1980, pl. 12, figs. 12, 13; Hong et al., 2003, pl. 1, figs. 12–23; Lazarenko et al., 2008, pl. 17, fig. 7]).

Comparisons of *I. jorusconii* with the co-occurring *I. platycephala* and *Irvingella* sp. are provided below.

Irvingella platycephala Rusconi, 1953

Figure 5.1–5.6

1953 *Irvingella platycephala* Rusconi, p. 2, text-fig. 3a,b.

1954a *Irvingella platycephala*; Rusconi, p. 29, text-fig. 16a, b, pl. 2, fig. 7.

1956b *Irvingella platycephala*; Rusconi, pl. 4, fig. 7.

Holotype.—Cranidium (MCNAM 17004) from the Quebrada Oblicua, San Isidro area, Mendoza, Argentina (Rusconi, 1954a, text-fig. 16a, b, pl. 2, fig. 7; Fig. 5.1–5.6).

Diagnosis.—A species of *Irvingella* having a barrel-shaped glabella with rounded anterolateral and anterior margins; maximum glabellar width at L2; S0–S3 distinct; L1, L2, and L3 of similar length (exsag.); frontal glabellar lobe overhangs cranial frontal area; frontal area very short (sag.), lacking preglabellar field; anterior border furrow almost imperceptible; in anterior view, there is a perceptible change in slope between fixigena and glabella.

Materials.—One cranidium (MCNAM 17004, holotype) from the Quebrada Oblicua, San Isidro area, Mendoza, Argentina. La Cruz Olistolith, Furongian, *Elvinia* Zone.

Remarks.—As stated above, Palmer (1965, p. 46) examined replicas of type specimens of the Rusconi collection, although he indicated that the holotype cranidium of *Irvingella platycephala* was not available for study. Rusconi (1954a, pl. 2, fig. 7; 1956b, pl. 4, fig. 7) provided a small photograph of the latter, in a view that seems to be posterodorsal (comparable with the view of Fig. 5.2 herein).

The holotype of *I. platycephala* (Fig. 5.1–5.6) clearly differs from the rest of the type series (paratypes MCNAM 17005, 17006; additional cranidia MCNAM 17007, 17047a, 17048, 17049; Figs. 5.7–5.11, 6.1–6.15) because the former exhibits a subparallel-sided, barrel-shaped glabella that is well elevated above level of fixigenae, a maximum glabellar width at L2 instead of L1, a proportionately long (exsag.) L3, and a rounded preglabellar furrow. Thus, the concept of *I. platycephala* is restricted herein to the holotype, and the remainder specimens of the type lot are redescribed separately below (see *Irvingella* sp.).

The glabellar outline of *Irvingella platycephala* contrasts with that of most species of *Irvingella*, which usually show, in varying degrees, tapered glabellae. As stated above, *I. platycephala* has a barrel-shaped glabella with its maximum width at

level of L2; a rare condition that is also present in a specimen from the Morgan Creek Member of the Wilberns Formation of Texas assigned to *I. abrupta* by Resser (1942) (= *I. “major”*, see Palmer, 1965). Resser (1942) regarded a glabella delimited by “circular” dorsal furrows, as well as distinct S0–S3, as typical characters of *I. abrupta*; in dorsal view, the paratype cranidium of the latter (Resser, 1942, pl. 3, fig. 45) hardly differs from *I. platycephala* in having slightly narrower fixigenae.

Irvingella major from the middle Furongian of Wisconsin (Walcott, 1925, pl. 15, figs. 26–29; Westrop and Adrain, 2016, fig. 14A–E) also has a subparallel-sided, anteriorly rounded glabella, but this species is separated from *I. platycephala* on the basis of its straighter axial furrows, its longer frontal area, and its obscure glabellar S2 and S3. *Irvingella deckeri*, from the Honey Creek Formation of central Oklahoma (Resser, 1942, pl. 3, figs. 19–27; Westrop and Adrain, 2016, fig. 15 A–I), differs, in addition, by possessing much narrower fixigenae.

Irvingella jorusconii (Rusconi, 1954a, pl. 2, fig. 6; Figs. 3, 4) is clearly distinguished from *I. platycephala* in having a glabella that is gently tapered in front of S1 and more elevated above level of genae, wider axial furrows, smaller fixigenae, and strongly arcuate palpebral furrows.

Irvingella sp.

Figures 5.7–5.11, 6

1954a *Irvingella platycephala* Rusconi; Rusconi, p. 29 (part).

1965 *Irvingella platycephala*; Palmer, p. 46 (mentioned as possibly distinct from *I. major*).

Description.—Cranidium convex, subtrapezoidal in outline, with straight (Fig. 5.7) to slightly curved anterior margin (Fig. 6.7, 6.12) and downsloping fixigenae, length ~62–66% of maximum width between palpebral furrows; anterior arch weak (Fig. 5.10) to almost imperceptible (Fig. 6.14); glabella large, slightly longer than wide, little elevated above genal region, occupying ~96–98% of total cranial length (sag.) and 48–52% of cranial width (tr.) between palpebral furrows at level of abaxial tip of S1, tapered strongly forward beyond middle-part of L1 and truncate anteriorly, delimited by narrow and deep axial and preglabellar furrows that are better incised on internal molds; in anterior view, there is not a marked change in slope between flanks of glabella and fixigenae (Figs. 5.10, 6.4); maximum glabellar width at L1; glabellar width at S2 equal to ~85% of width at S1; LO accounts for less than one-fifth of glabellar length; most specimens show indications of an occipital node (e.g., Fig. 6.1, 6.3); S0 transglabellar, deep, evenly curved backward, reaching axial furrows; L1 longer (exsag.) than L0, occupying ~21–25% of total glabellar length; S1 distinctive, transglabellar, reaching close to axial furrows, with a transverse medial portion and slightly curved, forwardly oblique lateral portions; S2 fainter than S1, short (tr.), oblique backward, expressed only abaxially; L3 much smaller than L2, occupying ~15–18% of total glabellar length (exsag.); S3 delicate, gently curved, transverse (Fig. 6.1) to oblique backward (e.g., Figs. 5.7, 6.7); frontal area of cranidium lacking preglabellar field; anterior cranial border minute (sag.), bounded by a weak anterior border furrow, which is more evident in exfoliated specimens;

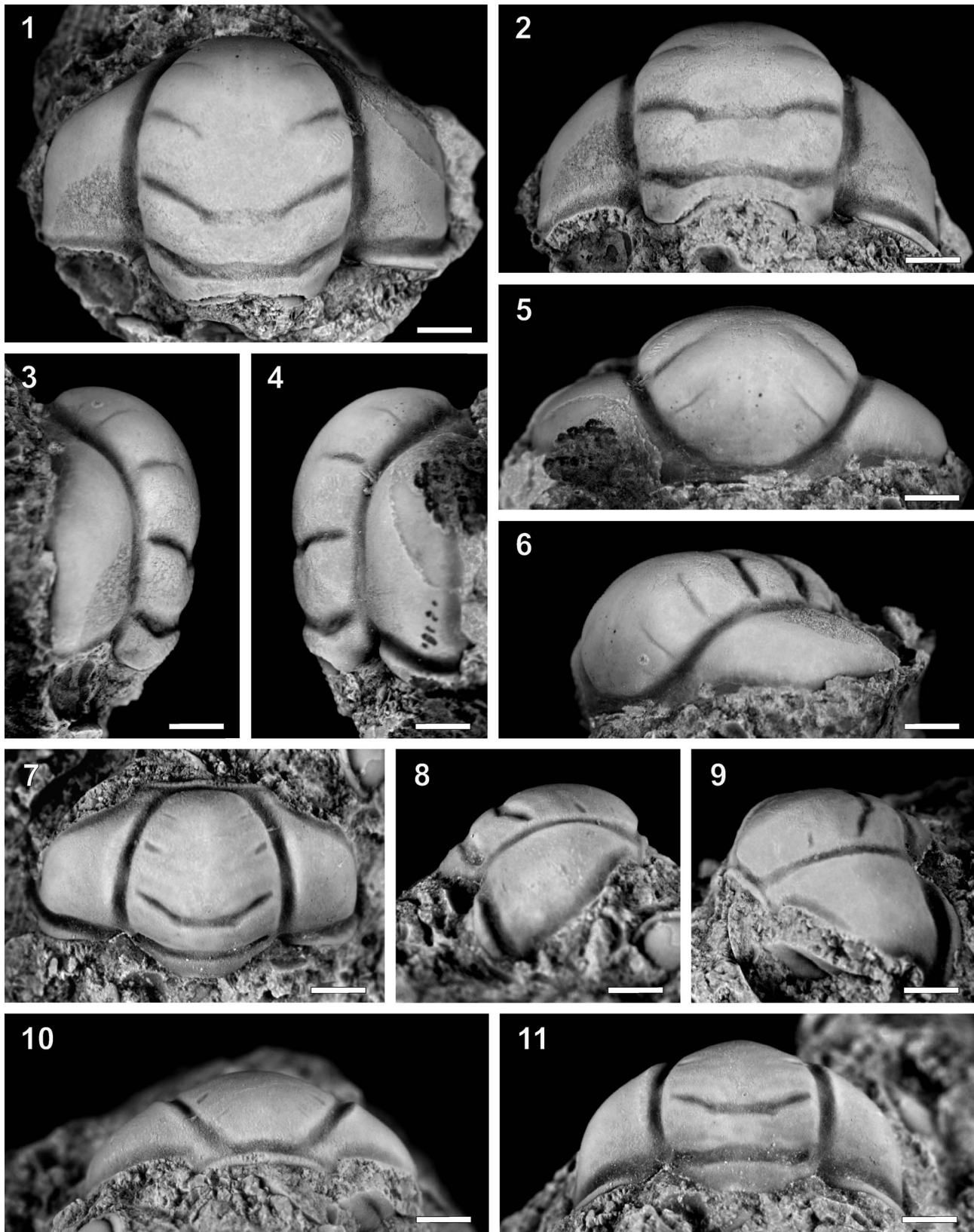


Figure 5. (1–6) *Irvingella platycephala* Rusconi, 1953 from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza, cranium in dorsal, posterior-dorsal, lateral, anterior, and anterior-oblique views, MCNAM 17004, holotype (illustrated previously by Rusconi, 1953, text-fig. 3a, b; Rusconi, 1954a, text-fig. 16a, b, pl. 2, fig. 7; Rusconi, 1956b, pl. 4, fig. 7). (7–11) *Irvingella* sp. from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza, cranium in dorsal, lateral, anterior-oblique, anterior, and posterior views, MCNAM 17005a, *Irvingella platycephala* Rusconi, 1953 paratype. Scale bars = 2 mm.

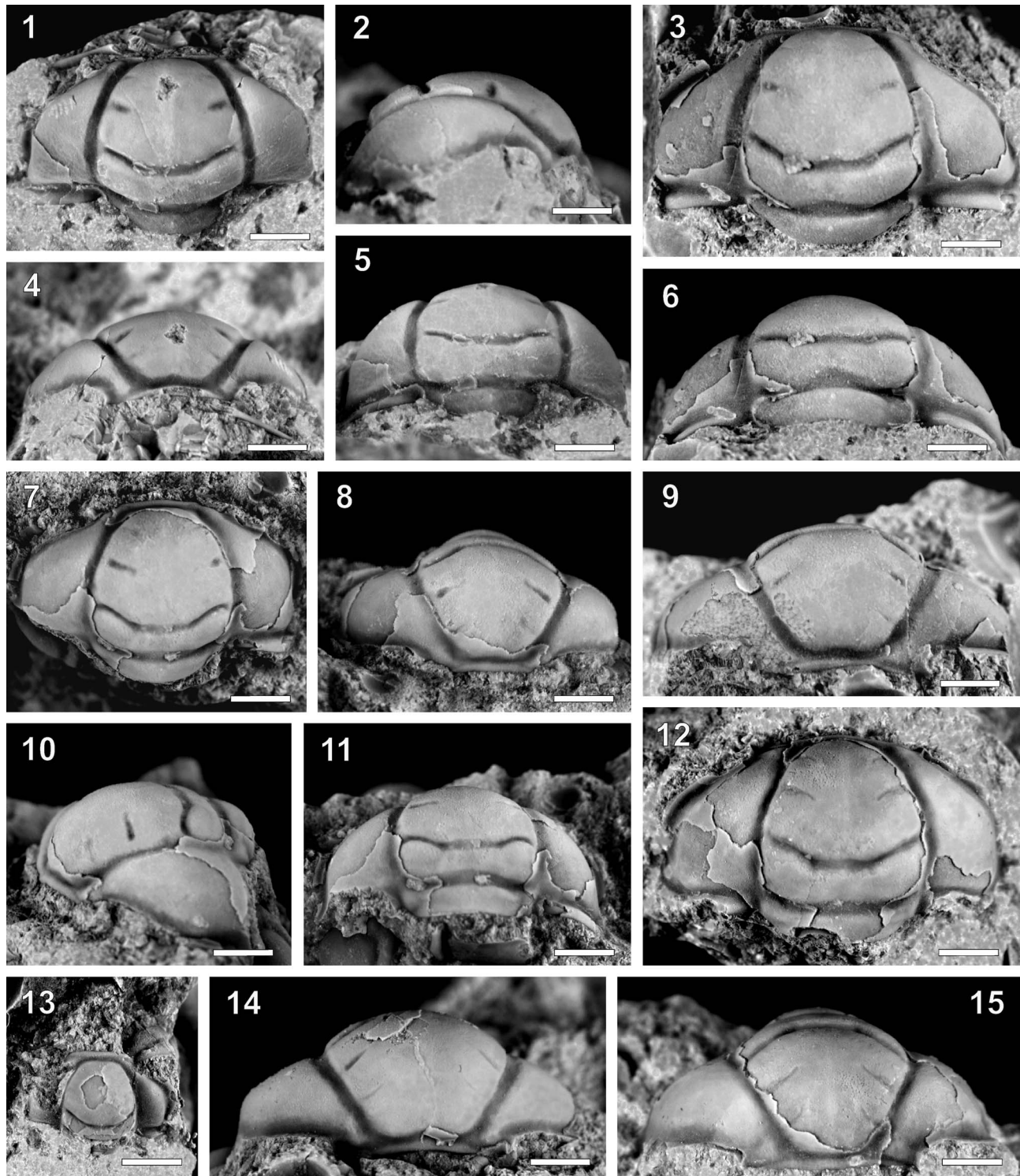


Figure 6. *Irvingella* sp. from the Furongian *Elvinia* Zone of the Quebrada Oblicua, San Isidro area, Precordillera of Mendoza. (1, 2, 4, 5) Cranium in dorsal, lateral, anterior, and posterior views, MCNAM 17049; (3, 6, 9) cranium in dorsal, posterior, and anterior-dorsal views, MCNAM 17048; (7, 8, 10, 11) cranium in dorsal, anterior-dorsal, anterior-oblique, and posterior views, MCNAM 17005b; (12, 15) cranium in dorsal and anterior-dorsal views, MCNAM 17047a; (13) small cranium, MCNAM 17007; (14) cranium in anterior-dorsal view, MCNAM 17006, *Irvingella platycephala* Rusconi, 1953 paratype. Scale bars = 2 mm.

palpebral area of fixigena wide (tr.), equal to ~25% of cranial width at L2, flexed downward in lateral view from axial furrow to palpebral furrow; ocular ridge absent; palpebral lobe very long (exsag.), narrow (tr.) and highly convex, evenly curved, extended from the level of mid-point of L1 to the frontal

glabellar lobe, delimited by a firmly impressed palpebral furrow of even width; posterior fixigena with deeply incised posterior border furrow and convex, narrow (exsag.) posterior border that widens slightly distally; external surface of cuticle smooth.

Materials.—Seven cranidia (MCNAM 17005a, 17005b, 17006, *Irvingella platycephala* paratypes; MCNAM 17007, 17047a, 17048, 17049) from the Quebrada Oblicua, San Isidro area, Mendoza, Argentina. La Cruz Olistolith, Furongian, *Elvinia* Zone.

Remarks.—As stated above, the specimens examined comprise the original type series of *I. platycephala*, excepting the holotype. These cranidia represent a separate species characterized by having a glabella that tapers strongly forward beyond L1 and is truncate anteriorly, a proportionately small glabellar lobe L3, a minute cranial frontal area, a frontal profile showing no change in slope between fixigenae and glabella, and relatively wide fixigenae. However, until the corresponding pygidium is available for analysis, the material is provisionally left in open nomenclature.

Small holaspides of *Irvingella* sp. exhibit a frontal area that is proportionately longer (sag.) than that of larger holaspides (compare Fig. 6.13 with Fig. 6.1, 6.3); an ontogenetic variation that was also documented in other species of *Irvingella* (e.g., *I. angustilimbata*; *I. nuneatonensis*; *I. media*; *I. orrensis*; *I. jorusconii*) (Rushton, 1967, p. 341; Westrop and Adrain, 2016, p. 406, 415, 427). Additionally, large specimens of *Irvingella* sp. bear an occipital node, which, as noted by Öpik (1963, p. 96), is an exceptional character in the genus. To date, this node has also been recognized in a few cranidia from Australia (Öpik, 1963, text-fig. 36; Shergold, 1982, pl. 7, fig. 6; Westrop and Adrain, 2016, figs. 11A, H, 12G), Siberia (Pegel, 2000, fig. 14.3; Lazarenko et al., 2008, pl. 17, fig. 9), Korea (Hong et al., 2003, pl. 2, fig. 13), and northwest Canada (Pratt, 1992, pl. 11, fig. 3).

Irvingella sp. compares most closely with a single cranidium from the Rabbitkettle Formation of the southern Mackenzie Mountains assigned by Pratt (1992, pl. 11, figs. 3, 4) to *I. "major"*. Pratt (1992, p. 49) described the latter as having an extremely conical, tumid glabella and a frontal area consisting of only a short (sag.), convex anterior border. It is also similar to *Irvingella* sp. in the presence of comparable glabellar lateral furrows, a relatively short L3, and indications of an occipital node. Unfortunately, the fixigena of the Canadian specimen is partially preserved and other sclerites are unknown, limiting further comparisons.

Although *Irvingella* sp. shares a strongly tapered glabella with several other species of the genus (e.g., *Irvingella kassini* Ivshin, 1960, from the upper Sakian of Kazakhstan; see Ivshin, 1962, pl. 4, fig. 2; *I. media*; *I. tropica*), the former is distinguished from all of them in lacking a marked change in slope between flanks of glabella and fixigenae in frontal view. In addition, large cranidia of *I. media* and *I. tropica* differ from *Irvingella* sp. in retaining a distinct preglabellar field. Similarly, *I. nuneatonensis*, from the upper *Olenus* Zone of England (Rushton, 1967, pl. 12, text-fig. 1), is differentiated by its proportionately longer frontal area.

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