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A late Furongian trilobite assemblage from the eastern Cordillera Oriental (Santa Rosita Formation; Jujuy, Argentina) and its biostratigraphic significance

M. Franco TORTELLO[1], Fernando J. ZEBALLO[2] & Daniela S. MONTI[3]

[1]CONICET - Universidad Nacional de La Plata, División Paleozoología Invertebrados, Museo de Ciencias Naturales, Paseo del Bosque s-n°, 1900 La Plata, Argentina. *tortello@fcnym.unlp.edu.ar* [2]Museo de Paleontología, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Av. Vélez Sarsfield 299, 5000 Córdoba, Argentina. *fzeballo@hotmail.com* [3]CONICET - Universidad de Buenos Aires, Instituto de Ecología, Genética y Evolución de Buenos Aires, Facultad de Ciencias Exactas y Naturales, UBA, Intendente Güiraldes 2160, Ciudad Universitaria, C1428EGA Buenos Aires, Argentina. *danielamonti@ege.fcen.uba.ar*

Abstract: The trilobite *Parabolina frequens argentina* Zone is widely represented in the upper Furongian of northwestern Argentina. A fossil assemblage from the lower Santa Rosita Formation at Quebrada de Abra Blanca, Jujuy Province, is described herein. *Parabolina frequens argentina* (Kayser) and *Parabolinella coelatifrons* Harrington & Leanza have previously been reported from other localities of the biozone, whereas *Lotagnostus hedini* (Troedsson) is here described from South America for the first time. The latter provides high resolution data on the age of the *P. frequens argentina* Zone in the eastern Cordillera Oriental, where conodont-bearing strata have not been found yet. *L. hedini* exhibits a short biostratigraphic range, restricted to the latest Furongian of China (Xinjiang, *Bulbolenus* Zone; western Zhejiang, *Lotagnostus hedini* Zone), Kazakhstan (*Euloma limitaris-Taoyuania* Zone) and ?Canada (western Newfoundland, *Phylacterus saylesi* Fauna). In China and Kazakhstan, it occurs in association with, or a few meters below, the first appearance of the conodont *Cordylodus proavus*; a fact that increases the potential for global correlation.

Key words: Trilobites, late Furongian, Santa Rosita Formation, Jujuy, Argentina.

Resumen: Una asociación de trilobites del Furongiano tardío del sector este de la Cordillera Oriental (Formación Santa Rosita; Jujuy, Argentina) y su significado bioestratigráfico. La Zona de trilobites de *Parabolina frequens argentina* está ampliamente representada en el Furongiano superior del noroeste argentino. En este trabajo se describe una asociación fosilífera del tramo inferior de la Formación Santa Rosita aflorante en la Quebrada de Abra Blanca, Provincia de Jujuy. *Parabolina frequens argentina* (Kayser) y *Parabolinella coelatifrons* Harrington & Leanza fueron previamente citados en otras localidades de la biozona, mientras que *Lotagnostus hedini* (Troedsson) es descripto aquí por primera vez para Sudamérica. Este último taxón aporta datos precisos sobre la edad de la Zona de *P. frequens argentina* en el sector este de la Cordillera Oriental, en donde aún no se han hallado rocas portadoras de faunas de conodontes. *Lotagnostus hedini* posee un rango bioestratigráfico corto, limitado al Furongiano más tardío de China (Xinjiang, Zona de *Bulbolenus*; oeste de Zhejiang, Zona de *Lotagnostus hedini*), Kazakstán (Zona de *Euloma limitaris-Taoyuania*) y ?Canadá (oeste de Newfoundland, Fauna de *Phylacterus saylesi*). En China y Kazakstán se registra asociado a, o unos pocos metros por debajo de la primera aparición del conodonte *Cordylodus proavus*, lo cual incrementa el potencial para realizar correlaciones globales.

Palabras clave: Trilobites, Furongiano tardío, Formación Santa Rosita, Jujuy, Argentina.

INTRODUCTION

The trilobite *Parabolina frequens argentina* Zone constitutes an emblematic biostratigraphic unit of the Lower Paleozoic of northwestern Argentina. It was erected by Harrington & Leanza (1957) for the Cordillera Oriental-Famatina and, after some amendments to its original definition, it is currently regarded as late late Cambrian (late Furongian) in age. The unit is principally characterized by olenids and agnostoids, and is widely distributed throughout Jujuy and Salta Provinces (e.g., Harrington & Leanza, 1957; Esteban & Tortello, 2007; Waisfeld & Vaccari, 2008 and references).

Parabolina frequens argentina (Kayser, 1876) clearly dominates the assemblages of the Biozone, whereas the associated faunas are somewhat variable in different localities. Sections of the western Cordillera Oriental (Lampazar Formation; Sierra de Cajas, Angosto del Moreno, Quebrada de Jueya) and the Iruya area (Santa Rosita Formation) contain various genera such as *Gymnagnostus*, *Micragnostus, Pseudorhaptagnostus*, *Lotagnostus*, *Parabolinella*, *Plicatolina*, *Beltella*, *Angelina*, *Akoldinioidia*, *Asaphellus* and *Onychopyge* (Tortello & Esteban, 2003; Esteban & Tortello, 2007, 2009), whereas other localities, especially around the Quebrada de Humahuaca (Santa Rosita Formation; Finca Soledad, Alfarcito, Purmamarca, Punta Corral, Volcán), show lower biodiversity values (Harrington & Leanza, 1957; Aceñolaza, 1996, unpublished; Zeballo & Tortello, 2005; Buatois *et al*., 2006; Zeballo, 2010, unpublished) (Fig. 1.A).

In addition, there are still some outcrops that require further sampling and comprehensive systematic and biostratigraphic studies. In this regard, the Huacalera region is of particular importance (Fig. 1.B). In Quebrada de La Huerta, Manca (1992) reported the occurrence of *P. frequens argentina* in association with fragmentary material of *Lotagnostus* Whitehouse, 1936, a key fossil of Furongian strata of different continents. In addition, Di Cunzolo (2006) and Zeballo (2010, unpublished) mentioned the presence of *P. frequens argentina* in Quebrada de Abra Blanca, although detailed systematic study was not achieved. Based on new collections, the present paper includes a description of the trilobite assemblages from Quebrada de Abra Blanca and a discussion on their biostratigraphic implications. The material studied provides precise information on the age of the *P. frequens argentina* Zone, which correlates with late Furongian successions of China, Kazakhstan and Canada.

GEOLOGICAL SETTING

The Cordillera Oriental is a high relief thrust system that is delimited to the east by the Sierras Subandinas and to the west by the Puna. Lower Paleozoic rocks are well represented in the mountain ranges of this geological province, including Cambrian quarzites of the Mesón Group and late Furongian–Early Ordovician shales and sandstones of the Santa Victoria Group (Santa Rosita and Acoite formations and equivalents), which are juxtaposed on Neoproterozoic–early Cambrian slates and meta-graywackes of the Puncoviscana Formation (e.g., Harrington & Leanza, 1957; Turner, 1960; Turner & Mon, 1979; Moya, 1988; Ramos, 1999, 2008; Astini, 2003, 2008).

The Santa Rosita Formation consists of a complex mosaic of late Furongian-late late Tremadocian shales and subordinate sandstones that represent a wide variety of sedimentary environments (Buatois & Mángano, 2003; Astini, 2003). The unit displays fluvio-estuarine (Tilcara and Pico de Halcón Members), shoreface and offshore sediments (Casa Colorada, Alfarcito, Rupasca and Humacha Members) which accumulated on a gently dipping shelf (Buatois & Mángano, 2003; Moya *et al*., 2003; Buatois *et al*., 2006 and references; Esteban *et al*., 2015).

The trilobites studied herein come from the discoloured siltstones and shales of the Casa Colorada Member exposed at the Abra Blanca creek (Fig. 2.A, B), about 3 km southeast of Huacalera village, Jujuy Province (Fig. 1.A, B). There, a 110 m-thick section displays thinly bedded yellowish and light brown shales with intercalations of sandstones, which overlie the sandstones of the Tilcara Member and are overlain by Quaternary deposits.

BIOSTRATIGRAPHIC IMPLICATIONS OF THE FAUNAS

The assemblage studied is clearly dominated by *Parabolina* (*Neoparabolina*) *frequens argentina* (Kayser, 1876), followed in abundance by *Parabolinella coelatifrons* Harrington & Leanza, 1957 and *Lotagnostus hedini* (Troedsson, 1937). *Parabolina frequens argentina* is a key taxon of the eponymous zone (cf. Harrington & Leanza, 1957); a unit that is widely exposed in northwestern Argentina (Esteban & Tortello, 2007; Waisfeld & Vaccari, 2008 and references). Although this biozone was originally assigned to the Lower Tremadocian (see Harrington & Leanza, 1957), subsequent studies confirmed the Cambrian aspect of the strata bearing *P. frequens argentina*, below the first appearance of the trilobite *Jujuyaspis keideli* Kobayashi, 1936 and the graptolite *Rhabdinopora flabelliformis* s.l. (Branisa, 1965; Benedetto, 1977; Rushton, 1982, p. 46; Ludvigsen, 1982, p. 150; Aceñolaza, 1983; Salfity *et al*., 1984; Shergold, 1988, p. 367).

The first evidence of the genus *Lotagnostus* in the Cordillera Oriental was provided by Manca (1992), who described one cephalon and one fragmentary pygidium (*Lotagnostus* sp.) associated with *Parabolina frequens argentina*

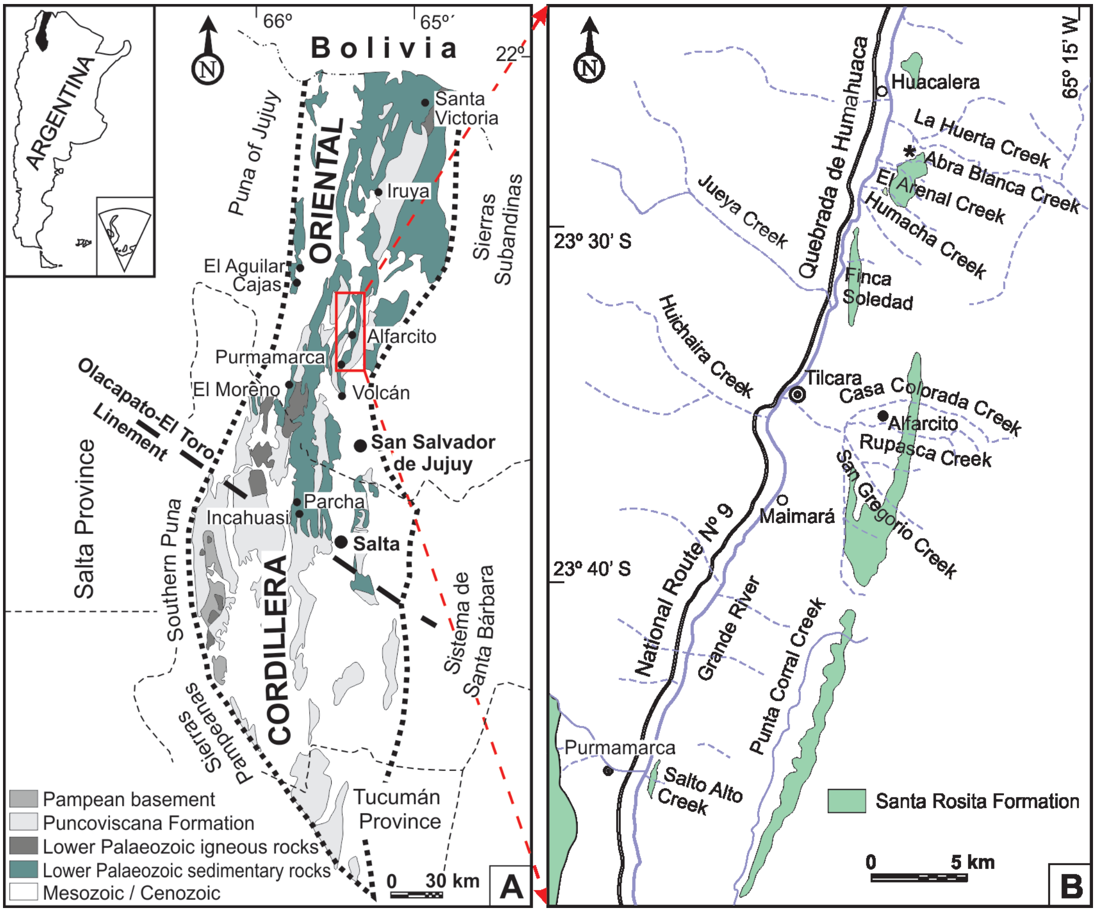


Fig. 1. Location map. **A**, Cordillera Oriental, northwestern Argentina. **B**, fossil locality (asterisk).

from Quebrada de la Huerta (Fig. 1). Because *Lotagnostus* is a cosmopolitan key fossil of late Furongian age, (e.g., Shergold & Laurie, 1997 and references), its finding in the *P. frequens argentina* Zone provided strong evidence in favor of a pre-Tremadocian age for this unit. Subsequently Esteban & Tortello (2007) described new material of *Lotagnostus* (*Lotagnostus shergoldi* Tortello; *L. llamaensis* Tortello), associated with *P. frequens argentina* and other species of the biozone, from different localities of the western Cordillera Oriental (Lampazar Formation; Sierra de Cajas, Angosto del Moreno, Quebrada de Jueya).

In addition, studies of conodont faunas supplied more precise information about the age of the *P. frequens argentina* Zone in the Lampazar Formation. At Sierra de Cajas and Angosto del Moreno, *P. frequens argentina* occurs in association with conodonts of the *Cordylodus proavus* Zone (*Hirsutodontus hirsutus* Subzone), which include, in particular, *C. proavus*, *C. primitivus*, *C. andresi*, *Eoconodontus notchpeakensis*, *Hirsutodontus hirsutus* and *Proconodontus muelleri* (Rao, 1999; Moya *et al*., 2003; Zeballo & Albanesi, 2013, fig. 2). Additionally, the lowest Ordovician index fossil *Iapetognathus fluctivagus* Nicoll, Miller, Nowlan, Repetski and Ethington occurs in the upper part of the overlying Cardonal Formation at Sierra de Cajas, defining the Cambrian-Ordovician boundary in that area (Albanesi *et al*., 2015).

The record of *Lotagnostus hedini* (Troedsson, 1937) in the Quebrada de Abra Blanca provides new high resolution data on the age of the *Parabolina frequens argentina* Zone within the late Furongian. This information is novel for the eastern part (Eastern Belt *sensu* Astini, 2003) of the Cordillera Oriental (lower Santa Rosita Formation, Casa Colorada Member), where conodont-bearing strata have not been found yet (Zeballo & Albanesi, 2013). *Lotagnostus hedini* is one of the youngest species of *Lotagnostus*

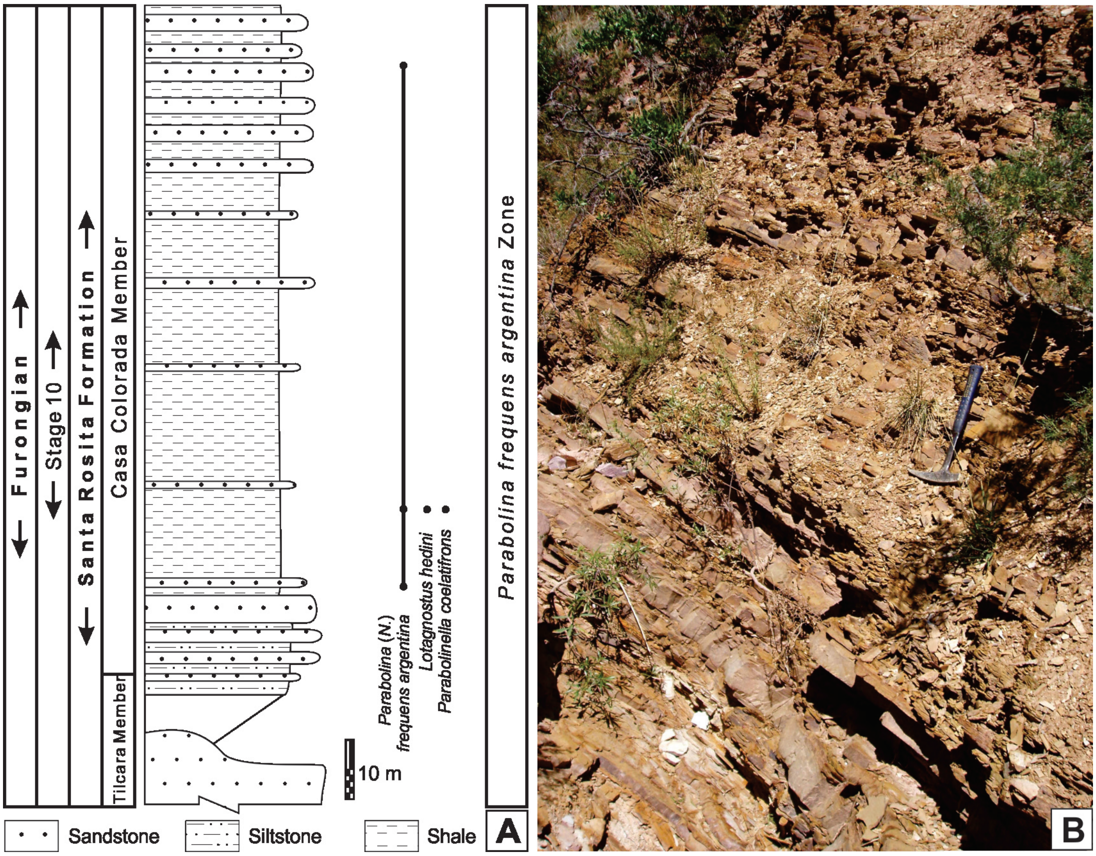


Fig. 2. Lower part of the Santa Rosita Formation at Quebrada de Abra Blanca, Huacalera area, Jujuy. **A**, stratigraphic section showing distributions of trilobites identified. **B**, photograph showing part of the outcrop.

and exhibits a short biostratigraphic range, restricted to the latest Furongian. It is known from the *Bulbolenus* Zone of Xinjiang, Northwest China (Troedsson, 1937), the *Lotagnostus hedini* Zone of western Zhejiang, China (Lu & Lin, 1980, 1981, 1983a–c, 1984, 1989), the *Euloma limitaris-Taoyuania* Zone of the Malyi Karatau Range of Kazakhstan (Apollonov *et al*., 1984), and, probably, the *Phylacterus saylesi* Fauna of western Newfoundland (Ludvigsen *et al*., 1989; see Westrop *et al*., 2011). In Zhejiang and Kazakhstan, *L. hedini* is recorded with, or a few meters below, the first appearance (FAD) of *Cordylodus proavus*.

The occurrence of *L. hedini* in the *P. frequens argentina* Zone is in line with the global upper Cambrian correlation chart of Shergold (1988, fig. 2). Strata with *L. hedini* correlate with the *Acerocare* Zone of Avalon and the Baltic region. Rushton (1982) and Żylińska (2001) recognized olenid faunas including *Parabolina frequens* in Wales and Poland, respectively, below the record of the graptolite *Rhabdinopora* (Rushton, 1982). Fragmentary material of *P. frequens* has also been described from the late Furongian of Mexico (Tiñu Formation), from levels of the *Cordylodus proavus* Zone (Robison & Pantoja-Alor, 1968; Landing *et al*., 2007).

As noted above, the trilobite assemblage of Quebrada de Abra Blanca is completed with *Parabolinella coelatifrons*. To date, this species is restricted to the *P. frequens argentina* Zone. Type specimens were collected from Cerro Colorado in the Iruya Department in Salta Province, in association with *P. frequens argentina*, the olenid *Plicatolina scalpta* Harrington & Leanza, 1957, and the agnostoids *Pseudorhaptagnostus* (*Machairagnostus*) *tmetus* Harrington & Leanza, 1957 and *Micragnostus vilonii* Harrington & Leanza, 1957 (Harrington & Leanza, 1957). In addition, *Parabolinella coelatifrons* is part of similar assemblages in Orán, Salta (Harrington & Leanza, 1957), Iruya, Salta (Esteban & Tortello, 2009), Sierra de Cajas and Quebrada de Jueya, Jujuy (Tortello & Esteban, 2003; Esteban & Tortello, 2007).

SYSTEMATIC PALEONTOLOGY

The material is housed in the Museo de Paleontología, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba (CORD-PZ), and the Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata (MLP). Specimens were whitened with magnesium oxide vapors before photographing. The morphological terms used below have been mostly defined by Robison (1964), Shergold *et al*. (1990) and Whittington & Kelly (1997).

Abbreviations: *sag* sagittally; *exs* exsagittally.

Order Agnostida Salter, 1864b
Family Agnostidae M'Coy, 1849
Subfamily Agnostinae M'Coy, 1849

Genus *Lotagnostus* Whitehouse, 1936

Type species. *Agnostus trisectus* Salter, 1864a.

Remarks. The diagnosis of *Lotagnostus* was discussed in detail by Shergold & Laurie (1997 and references) and Westrop *et al*. (2011). Westrop (1995) and Westrop *et al*. (2011) regarded the partially effaced taxon *Distagnostus* Shergold, 1972, as a junior synonym of *Lotagnostus*, a decision that is accepted herein.

Lotagnostus hedini (Troedsson, 1937)
Fig. 3.A, B, E, H

1937. *Agnostus hedini* sp. nov. Troedsson, p. 20, pl. 1, figs. 6–8.
2011. *Lotagnostus hedini* (Troedsson). Westrop, Adrain & Landing, p. 584, 586 (see for further synonymy).

Material. Three complete specimens and one fragmentary thoracopygon (MLP 35824–35826, CORD-PZ 32189).

Description. Exoskeleton of large size. Cephalon en grande tenue, subcircular to subelliptical in outline in dorsal view, slightly wider than long (maximum width at the posterior part of acrolobe). Glabella long, parallel-sided to gently tapered forward, faintly constricted at F2 and F3, pointed anteriorly, clearly defined by narrow, deep axial furrows, occupying about 73-74% of cephalic length (sag.); basal lobes large, entire, subtriangular in outline, longer than wide, clearly delimited by conspicuous basal furrows, length (exs.) equal to about 35–40% of glabellar length (sag.), with anterior tip reaching F2; glabellar rear rounded; F1 almost imperceptible; F2 shallow but better developed than F1, directed inward from the axial furrows and then curved strongly forward exsagittally, delimiting two lateral lobes (M3); median node posterior to the glabellar midpoint, elongate (sag.), better defined posteriorly (between F1 and F2); transglabellar furrow (F3) well-defined, curved forward exsagittally; anteroglabella ogival, occupying about 42–43% of glabellar length. Gena smooth (Fig. 3.B) or with weak indications of scrobiculation (Fig. 3.E), somewhat narrower (sag.) in front of the glabella; median preglabellar furrow slightly shallower than axial furrows, extending fully from the anterior tip of the glabella to the border furrow. Cephalic border narrow (sag.) and convex, separated from the gena by a well-defined border furrow; sagittally, the border and border furrow combined occupy about 7–8% of the total length of the cephalon; posterior border with a tiny intergenal spine.

Pygidium en grande tenue, subelliptical in outline in dorsal view, slightly wider than long; axis long, trilobed, slightly constricted at M2, occupying about 85% of the total pygidial length (excluding articulating half-ring), clearly delimited by narrow, deep axial furrows; M1 and M2 divided into a pair of subquadrate lateral lobes and a central, elongate tubercle; F1 and F2 of similar width and depth, continuous across axis; M3 long, semiovate to ogival in outline, occupying 62–64% of the total length of the axis (excluding articulating half-ring), smooth or with faint indications of an intranotular axis and a delicate terminal node. Acrolobe gently constricted; pleural fields smooth, confluent, narrower (sag.) behind the axis. Border narrow (sag.) and slightly convex, separated from the pleural fields by a shallow border furrow of variable width; sagittally, the border and border furrow combined occupy about 6–7% of the total length of the pygidium (excluding articulating half-ring); posterolateral spine vestigial, with base opposite posterior third of axis.

Remarks. The specimens studied are preserved in siliciclastic rocks and are partially compacted, so that they do not exhibit their original convexity. Nevertheless, the state of preservation of the material is quite good. Specimens are characterized by the presence of a proportionately long glabella, a broad V-shaped F3 glabellar furrow, conspicuous basal lobes, a smooth to weakly scrobiculate gena, a pygidial F1 that is connected across the axis, a long posteroaxis occupying more than 60% of the total length of the axis, and a slightly constricted pygidial acrolobe. This combination of characters indicates direct morphological affinities with *Lotagnostus hedini* (Troedsson, 1937), from the uppermost Cambrian of Xinjiang, Northwest China (Troedsson, 1937, pl. 1, figs. 6–8), western Zhejiang, China (Lu & Lin 1980, pl. 1, figs. 8, 9; 1983a, pl. 1, figs. 5-6; 1983b, pl. 2, figs. 4, 5; 1984, pl. 3, figs. 12, 13; 1989, pl. 7, figs. 4–8), Kazakhstan (Apollonov *et al*., 1984, pl. 14, figs. 1–8) and, possibly, western Newfoundland (Ludvigsen *et al*. 1989, pl. 1, figs. 9–11-only-). Westrop *et al*. (2011, p. 584, 586) provided a diagnosis of *L. hedini* and updated information about its synonymy, distribution and affinities with allied species (see also Peng *et al*., 2015, p. 299–300). *Lotagnostus hedini* usually possesses smooth genae, but some specimens from W. Zhejiang (Lu & Lin, 1983, pl. 2, fig. 4), Kazakhstan (Apollonov *et al*., 1984, pl. 14, fig. 6) and Argentina (Fig. 3.E) show faint signs of genal scrobiculation. Similarly, the posteroaxis is generally smooth, with the exception of certain cases from China (see Lu & Lin, 1989, p. 216; Peng *et al*., 2015) and the Argentinian Cordillera Oriental (Fig. 3.B), which exhibit indications of notular furrows. Intraspecific variability also involves proportions of axial characters. The pygidial axis of small holaspides seems to be a little shorter (sag.) than that of larger specimens (compare Fig. 3.A with Fig. 3.E).

As stated above, Manca (1992) described scarce material of *Lotagnostus* sp. from Quebrada de La Huerta, consisting of one cephalon and one incomplete pygidium. The latter apparently differs from *L. hedini* in having a discontinuous F1 and a much shorter (sag.) posteroaxis; however, the deficient state of preservation of this specimen prevents a proper comparison. *Lotagnostus shergoldi* Tortello in Esteban & Tortello (2007, fig. 8A–I, L) and *L. llamaensis* Tortello in Esteban & Tortello (2007, fig. 8J–K, M–Q), from the western Cordillera Oriental, are clearly distinguished from *L. hedini* because the former have a partially effaced exoskeleton, a more anteriorly positioned glabellar node, a discontinuous F1 pygidial furrow, an unconstricted pygidial acrolobe, and a border lacking posterolateral spines. *Lotagnostus shergoldi* has, in addition, a less constricted pygidial M2, and *L. llamaensis* exhibits a semicircular cephalon and a more delicate pygidial axial node.

Lotagnostus hedini is similar to *L. peladensis* (Rusconi, 1951), from the upper Furongian of the Argentine Precordillera (e.g., Shergold *et al*., 1995, pl. 1, figs. 1–9; Tortello, 2014, figs. 2.1–2.28, 3.1–3.7), but the exoskeleton of the latter differs by having variably effaced dorsal furrows, a proportionately shorter (sag.) pygidial axis, and a pygidial F1 that is not continuous across the axis. Another species from the Precordillera, *L. atenuatus* (Rusconi, 1955), is also distinguished by its discontinuous pygidial F1 and, also, by its relatively shorter glabella, pygidial axis and posteroaxis (Westrop *et al*., 2011; Tortello, 2018). As indicated by Westrop *et al*. (2011) and Peng *et al*. (2015, p. 299–300), the transaxial F1 furrow and the large size of the pygidial axis are two of the most diagnostic characters of *L. hedini*.

Order Ptychopariida Swinnerton, 1915
Suborder Olenina Burmeister, 1843
Family Olenidae Burmeister, 1843
Subfamily Oleninae Burmeister, 1843

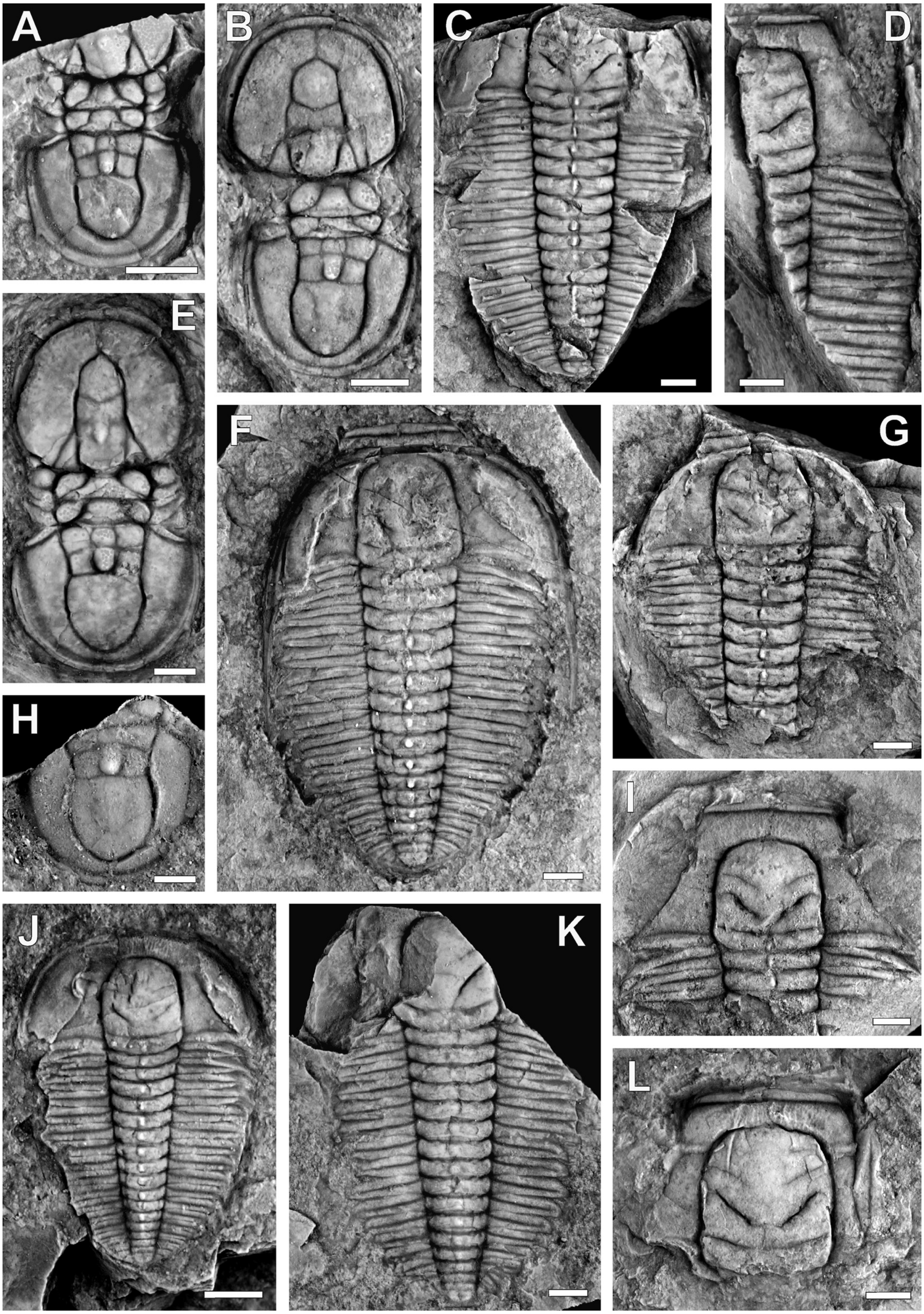
Genus *Parabolinella* Brøgger, 1882

Type species. *Parabolinella limitis* Brøgger, 1882.

Parabolinella coelatifrons Harrington & Leanza, 1957
Fig. 3.C, D, F, G, I–L

1957 *Parabolinella coelatifrons* sp. nov. Harrington & Leanza, p. 109, fig. 39.3a, b, d–f, h (non fig. 39.3c, g).
2007 *Parabolinella coelatifrons* Harrington & Leanza. Esteban & Tortello, p. 49, fig. 11B–D, L (top) (see for further synonymy).
2009 *Parabolinella* cf. *coelatifrons* Harrington & Leanza. Esteban & Tortello, p. 148, fig. 11.C, D, H, J.

Fig. 3. (Next page) Trilobites from the *Parabolina frequens argentina* Zone of Quebrada de Abra Blanca, Huacalera area, Jujuy. **A**, **B**, **E**, **H**, *Lotagnostus hedini* (Troedsson, 1937); **A**, fragmentary exoskeleton, MLP 35825; **B**, complete specimen, CORD-PZ 32189; **E**, complete specimen, MLP 35824; **H**, pygidium and fragmentary thorax, latex mould, MLP 35826. **C**, **D**, **F**, **G**, **I–L**, *Parabolinella coelatifrons* Harrington & Leanza, 1957; **C**, complete specimen, CORD-PZ 32182; **D**, fragmentary cranidium and thorax, MLP 35827; **F**, complete specimen, CORD-PZ 32190a; **G**, cephalon and fragmentary thorax, CORD-PZ 32153; **I**, cranidium and fragmentary thorax, CORD-PZ 32173; **J**, complete specimen, MLP 35828; **K**, axial shield, MLP 35831; **L**, cranidium, MLP 35829.


A
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Material. Five complete specimens, four cephala and thoraces, one cranidium, one cranidium and fragmentary thorax, two axial shields and one thoracopygon (CORD-PZ 32153, 32156, 32171, 32173, 32182, 32187, 32190, 32440a; MLP 35827–35832).

Remarks. *Parabolinella coelatifrons* Harrington & Leanza is well represented in the *Parabolina frequens argentina* Biozone (Harrington & Leanza, 1957; Tortello & Esteban, 2003; Esteban & Tortello, 2007). This species is characterized by the presence of a well-developed, faintly striated preglabellar field; a sub-squared glabella having three pairs of lateral glabellar furrows; a facial suture with sub-parallel anterior branches and straight posterior branches, defining sub-triangular fixigenae; and a pygidium with two axial rings. Specimens from Quebrada de Abra Blanca combine all of these characters, but also display some intraspecific variability which broadens the scope of *P. coelatifrons*. Variations involve the degree of development of the preglabellar field (Fig. 3.I, L), the shape of the anterior glabellar margin (Fig. 3.D, G, J), and the width of the posterior margin of the fixigenae (Fig. 3.D, F, I).

Esteban & Tortello (2009, fig. 11.C, D, H, J) assigned to *Parabolinella* cf. *coelatifrons* several cranidia from the Iruya area, pointing out that their preglabellar furrows are more curved than those of the typical representatives of *P. coelatifrons*. However, according to the variability reported above, these cranidia are now regarded confidently as belonging to this species.

Some specimens from Quebrada de Abra Blanca show the librigenae displaced backwards below the axial shield (Fig. 3.C, F, G). This configuration is common among olenids (e.g. Henningmoen, 1957; Clarkson *et al*., 2003; Tortello & Clarkson, 2003) and is interpreted as the result of the molting process (Harrington, 1959; Henningsmoen, 1975).

Genus *Parabolina* Salter, 1849

Type species. *Entomostracites spinulosus* Wahlenberg, 1818.

Parabolina (*Neoparabolina*) Nikolaisen & Henningsmoen, 1985

Type species. *Parabolina frequens* (Barrande, 1868).

Parabolina (*Neoparabolina*) *frequens* (Barrande, 1868)

Parabolina (*Neoparabolina*) *frequens argentina* (Kayser, 1876)
Fig. 4.A–K

Synonymy. See Tortello & Clarkson (2008) and references therein.

Material figured. One complete specimen, one cephalon, three cephala and thoraces, two axial shields, and five thoraces and pygidia (CORD-PZ 32152, 32163b, 32176, 32177a, 32192a,b; MLP 35833–35837).

Remarks. *Parabolina frequens argentina* is an emblematic late Cambrian trilobite of northwestern Argentina and southern Bolivia (Harrington & Leanza, 1957; Waisfeld & Vaccari, 2003). As stated by Harrington & Leanza (1957) and Tortello & Clarkson (2008), this olenid exhibits a relatively high morphologic variability. In the material from Quebrada de Abra Blanca, variations are especially evident in the width (sag.) of the cephalic anterior border (Fig. 4.A, G), and the degree of expression of the thoracic axial nodes, which are better developed in small adults (e.g., compare Fig. 4.F with Fig. 4.K). It is interesting to note that some late holaspid specimens studied herein reach large sizes (largest observed exoskeleton –excluding 12th thoracic axial spine-: 43mm in length).

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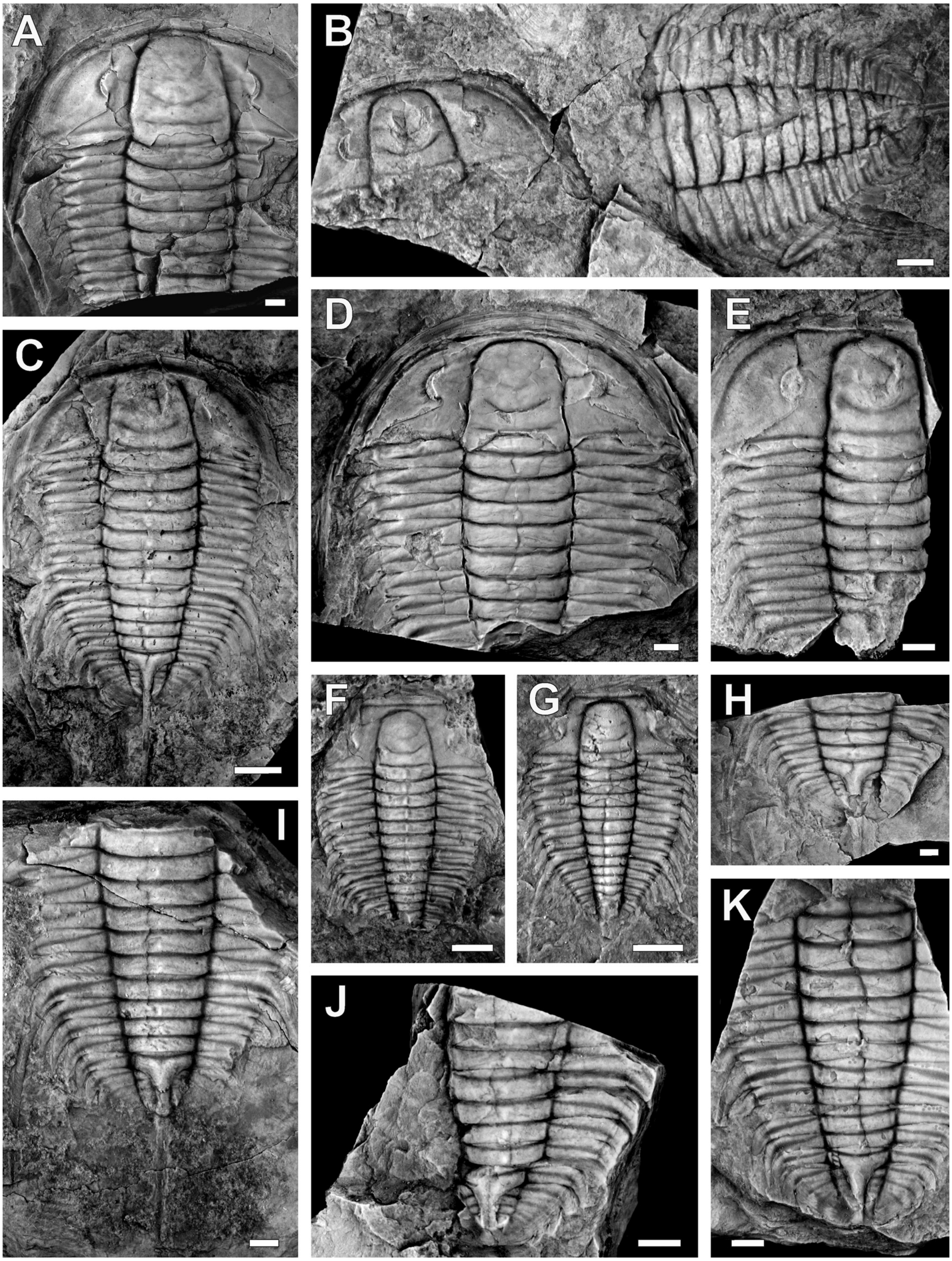

Fig. 4. Trilobites from the *Parabolina frequens argentina* Zone of Quebrada de Abra Blanca, Huacalera area, Jujuy. **A–K**, *Parabolina* (*Neoparabolina*) *frequens argentina* (Kayser, 1876); **A**, cephalon and fragmentary thorax, CORD-PZ 32192a; **B**, cephalon (left) and thoracopygon (right), CORD-PZ 32176; **C**, complete specimen, CORD-PZ 32177a; **D**, cephalon and fragmentary thorax, CORD-PZ 32152; **E**, fragmentary cephalon and thorax, MLP 35834; **F**, small axial shield, MLP 35837; **G**, small axial shield, MLP 35836; **H**, fragmentary thoracopygon, CORD-PZ 32192b; **I**, thoracopygon, MLP 35833; **J**, fragmentary thoracopygon, CORD-PZ 32163b; **K**, thoracopygon, MLP 35835.

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