SPANISH JOURNAL OF PALAEONTOLOGY

Spanish Journal of Palaeontology 39, 2024
https://doi.org/10.7203/sjp.29736
Sociedad Española de Paleontología ISSN 2255-0550 / eISSN 2660-9568

OPEN ACCESS RESEARCH PAPER

Trilobites and other fossils from the Viar River section (Cambrian Series 2, Stage 4), SW Spain

Trilobites y otros fósiles de la sección del río Viar (Serie 2, Piso 4 del Cámbrico), suroeste de España

Luis COLLANTES

Abstract: The Marianian (Cambrian Series 2) fossil assemblage of the Viar River section is here reviewed and updated, based on previous collections and new collected specimens. This section is located in southern Badajoz, southwestern Spain, and belongs to the northern branch of the Cambrian outcrops of the Ossa-Morena Zone, southwestern Iberian Massif. Specimens studied occur in the 'Benalija beds' of the Viar-Benalija Block. The fossil assemblage from this section is composed of the trilobites *Protaldonaia morenica*, *Triangulaspis fusca, Chelediscus garzoni* and *Serrodiscus bellimarginatus*, the brachiopod *Sibiria*? sp. and the helcionelloid mollusc *Marocella morenensis*. *Protaldonaia* is revised, and its classification as a subgenus of *Protolenus* is rejected. The species *T. fusca* and *C. garzoni* are here described and illustrated for the first time from this section. Also, new data show that *C. garzoni* is more broadly distributed throughout the Cambrian of the Ossa-Morena Zone. This fossil assemblage suggests a late Marianian age according to the Iberian regional biostratigraphic scheme, and it can be tentatively correlated with the early Cambrian Stage 4 at international level.

Resumen: La asociación de fósiles del Marianiense (Serie 2 del Cámbrico) de la sección del río Viar es revisada y actualizada, en base a colecciones previas, así como a nuevos especímenes recogidos. Esta sección se localiza en el sur de Badajoz, suroeste de España, y pertenece a la rama septentrional de los afloramientos cámbricos de la Zona de Ossa-Morena, en el suroeste del Macizo Ibérico. Los ejemplares de estudio se encuentran en las "capas de Benalija" del Bloque de Viar-Benalija. La asociación de fósiles de esta sección está compuesta por los trilobites *Protaldonaia morenica*, *Triangulaspis fusca*, *Chelediscus garzoni* y *Serrodiscus bellimarginatus*; el braquiópodo *Sibiria*? sp. y el molusco helcioneloido *Marocella morenensis*. El género *Protaldonaia* es revisado, y su clasificación como subgénero de *Protolenus* es rechazada. Las especies *T. fusca* y *C. garzoni* se describen e ilustran aquí por primera vez en esta sección. Además, los nuevos datos muestran que *C. garzoni* se encuentra más ampliamente distribuido en la Zona de Ossa-Morena. Esta asociación de fósiles sugiere una edad Marianiense tardío de acuerdo con el esquema bioestratigráfico regional ibérico, y puede correlacionarse tentativamente con el inicio del Piso 4 de Cámbrico a nivel internacional.

Received: 14 June 2024
Accepted: 7 November 2024
Published: 20 November 2024

Corresponding author:
Luis Collantes
luis.collantes.geo@gmail.com

Keywords:
Trilobita
Helcionelloida
Brachiopoda
Systematics
Biostratigraphy
Badajoz
Cambrian

Palabras-clave:
Trilobita
Helcionelloida
Brachiopoda
Sistemática
Bioestratigrafía
Badajoz
Cámbrico

INTRODUCTION

The first fossils from the Viar River section were collected in 1937 by Prof. Franz Lotze between the localities of Llerena and Pallares, southern Badajoz (Spain). Trilobites from this section represent some of the first Cambrian trilobites from southwestern Iberia and were published in a brief report together with the first Cambrian trilobites from the Huelva and Seville provinces (Lotze, 1939). Additional data on the stratigraphy and palaeontology of this section were provided by Lotze (1958, 1961), indicating up to three different fossil levels within the section; and also by Sdzuy (1961, 1962), who carried out the first detailed description of the trilobites and reported a new trilobite genus and species from this section (*Protaldonaia morenica* Sdzuy, 1961). Later on, Yochelson and Gil Cid (1984) described the helcionelloid mollusk *Scenella* (=*Marocella*) *morenensis* from this section, re-evaluating this genus as a possible coelenterate; and Gil Cid (1988) gave a general view of the palaeontological content of this section, with a fossil assemblage composed, up to that moment, of the mollusc *Marocella morenensis* and the trilobites *Protaldoania morenica*, *Serrodiscus speciosus* (=*S. bellimarginatus*), Protolenidae indet. and *Hicksia* sp., the latter never being illustrated. This section was also studied in the context of the MAGNA project of Puebla del Maestre (nº 898), in which the palaeontological studies were carried out by Profs. Eladio Liñán, Teodoro Palacios, Jenaro García-Alcalde and Antonio Perejón (Apalategui *et al.*, 1989). More recent studies on the fossils of the Viar River section include those by Liñán and Mergl (2001) reviewing the Cambrian brachiopods from Sierra Morena, Collantes *et al.* (2020) revisiting the genus *Marocella* Geyer, 1986, Collantes *et al.* (2022) on the trilobite *Serrodiscus* Richter & Richter, 1941, and Liñán *et al.* (in press) presenting a new biostratigraphical framework for the Zafra-Alanís Domain of the Ossa-Morena Zone, including all the trilobite species from the Cambrian outcrops of the northern branch of this territory.

New field campaigns have been carried out in this section in recent years and new specimens have been collected. In the present paper, the fossil assemblage of the Viar River section is reviewed, based on previously studied material and new specimens, and new data is provided. The fossils found in this section are described, including four trilobite species, an helcionellid mollusk and a brachiopod. Of the trilobite species described, two species are reported for the

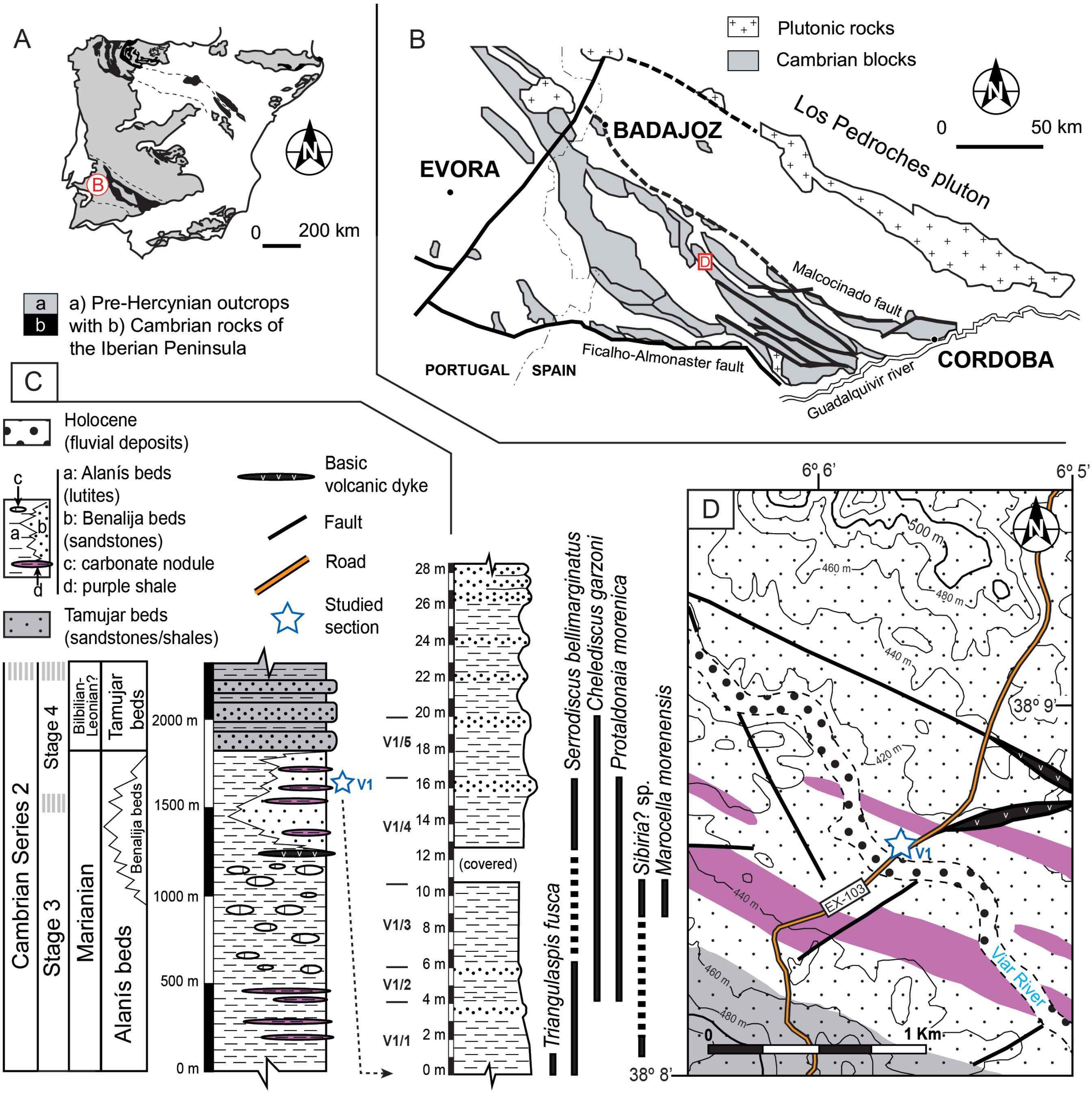

Figure 1. **A,** Pre-Hercynian outcrops of the Iberian Peninsula; **B,** geological setting of fossil site in the Cambrian blocks of the Ossa-Morena Zone, indicating the position of the studied fossil site, modified from Liñán and Quesada (1990); **C,** stratigraphic column of the Viar-Benalija Block, and detail stratigraphic column of the Viar River section with the stratigraphic range of the fossils; **D,** geological map of the surroundings of the Viar River section, modified from Apalategui *et al.* (1989). For explanation of the map colours and symbols, please see key legend of subfigure C.

first time in this section: *Chelediscus garzoni* and *Triangluaspis fusca*. In addition, the ellipsocephalid genus *Protaldonaia* is reviewed, and the regional biostratigraphical implications of these trilobites are here discussed.

GEOLOGICAL FRAMEWORK

The Viar River section is located in the northern branch of the Ossa-Morena Zone (**OMZ**), southwestern Iberia (Fig. 1A–1B) and between the localities of Llerena and Pallares, southern Badajoz, at the intersection of the EX-103 road with the Viar riverbed (Fig. 1D)

The OMZ contains some of the most extensive Cambrian outcrops in southern Europe, which are divided in 'blocks' (Liñán & Quesada, 1990). The studied specimens come from the Viar-Benalija Block, located in the northern limb of the Olivenza-Monesterio Anticlinorium and included in the Zafra-Alanís Domain (see Fig. 1B). This block includes a stratigraphical record which ranges from the upper Neoproterozoic to Miaolingian.

Trilobites and other fossils from this block occur in a mostly detrital formation consisting of yellow-green shales, with some carbonate component in the intermediate levels, and with lenticular levels of sandstones and basic volcanic rocks in its basal part. This formation has been referred to as 'Benalija beds' (*sensu* Fricke, 1941) or, more commonly, the 'Alanís beds' (*sensu* Simon, 1951). However, Collantes *et al.* (2024) considered the former as a sandstone lateral facies change of the latter, mostly present in the upper part of the formation (Fig. 1C). Although both the bottom and the top of the formation have been recognised, it should be noted that the complete formation has not been mapped accurately, mainly due to the abundant presence of faults, which, presumably, may have generated duplications in the succession.

The uppermost part of the series is composed of green shales and greenish to yellowish fine-grained sandstones, depending on the section, with frequent intercalations of purple shales. The top of the formation has yielded a fossil assemblage composed of the trilobites *Serrodiscus bellimarginatus* (Shaler & Foerste, 1888), *Protaldonaia morenica* Sdzuy, 1961, *Triangulaspis fusca* Sdzuy, 1962 and *Chelediscus garzoni* Collantes, Pereira, Mayoral & Gozalo, 2023, as well as the brachiopod *Sibiria*? sp. and the helcionellid mollusk *Marocella morenensis* (Yochelson & Gil Cid, 1984).

MATERIALS AND METHODS

The available specimens are preserved as internal and external moulds and consist mainly of isolated cranidia, in addition to several complete or almost complete exoskeletons. A part of the material of this work was collected by Prof. Eladio Liñán in 1985 during MAGNA project. In addition, some specimens of the type material of Sdzuy (1961, 1962) are illustrated here, as well as some specimens of Gil Cid (1988). The studied material is tectonically distorted.

For trilobite descriptive terminology, we follow that of Whittington in Kaesler (1997). For the systematic classification of trilobites, this work follows Adrain's (2011). Abbreviations in the systematic descriptions are the following: **exsag.,** exsaggittal; **LO,** occipital lobe; **L1, L2,** etc., glabellar lobes; **S1, S2,** etc., glabellar furrows; **sag.,** sagittal; **tr.,** transverse.

All specimens were prepared using a pneumatic hammer, coated with magnesium, and photographed using a Canon EOS 77D coupled with a macro lens Canon 100 mm f/2.8L. Final photographs of the specimens were made by a focus-stacking technique with the Helicon Focus software. Fossil plates were elaborated with Adobe Photoshop.

All studied specimens are housed in the palaeontological collections of the Departamento de Ciencias de la Tierra (Laboratorio de Tectónica y Paleontología) of the Facultad de Ciencias Experimentales, University of Huelva, Spain (**UHU**), the Museo de Ciencias Naturales of the University of Zaragoza, Spain (**MPZ**), the Área de Paleontología of the Complutense University of Madrid (**DPM**), and the Senckenberg Museum, Frankfurt, Germany (**SMF**).

SYSTEMATIC PALAEONTOLOGY

Class TRILOBITA Walch, 1771
Order REDLICHIIDA Richter, 1932
Suborder REDLICHIINA Richter, 1932
Superfamily ELLISOCEPHALOIDEA Matthew, 1887
Family ELLIPSOCEPHALIDAE Matthew, 1887
Genus *Protaldonaia* Sdzuy, 1961

Type-species. *Protaldonaia morenica* Sdzuy, 1961

Emended diagnosis. A genus of the Ellipsocephalidae characterized by a subpentagonal cranidium with broad anterior border, anterior branches of the facial suture divergent outwards, parafrontal band, glabella cylindrical to subconical, an abrupt transition from a narrow (sag.) ocular ridge to a well-developed palpebral lobe, and the palpebral lobe almost reaching the posterior border furrow.

Remarks. *Protaldonaia* was originally erected by Sdzuy (1961) as a subgenus of *Aldonaia* Lermontova, 1940. Shortly afterwards, Sdzuy (1962) emphasized that the differences between *Aldonaia* and *Protaldonaia* were greater than originally though, upgrading *Protaldonaia* to genus level. Sdzuy (1962) also stressed that *Protaldonaia* was closely related to *Myopsolenus* Hupé, 1953, which was considered to be a subgenus of *Hamatolenus* Hupé, 1953 by several authors (*e.g.*, Sdzuy, 1961; Basset *et al.*, 1976; Liñán & Gozalo, 1986; Geyer, 1990; Dies & Gozalo, 2006). However, regardless of its taxonomic position, *Myopsolenus* differs from *Protaldonaia* in having 1) wider ocular ridges, 2) a more rounded margin of the anterior border, and 3) a clearly defined parafrontal band (see *Myopsolenus magnus* Hupé, 1953, pl. 10, figs. 11, 14–15). Later, Geyer (1990, p.189), Geyer and Elicki (1995, p. 106) regarded *Protaldonaia* as a subgenus of *Protolenus* Matthew, 1892. However, Westrop and Landing (2000, p. 869) considered that the diagnosis of *Protolenus* (*Protaldonaia*) provided by Geyer "*lacks unequivocal apomorphies, with all of the character states listed (...) occurring in other taxa*", regarding the status and affinities of *Protaldonaia* as uncertain. Nonetheless, the differences between *Protaldonaia* and *Protolenus* include: 1) a different morphology of the anterior border, with an acuminated border in *Protaldonaia* and an homogeneous curvature in *Protolenus*; 2) a different course of the anterior branches of the facial suture, diverging outwards in *Protaldonaia* and being subparallel to slightly convergent in *Protolenus*; 3) the absence of parafrontal band in *Protolenus*; and 4) a different morphology of the ocular ridges, *i.e.*, *Protaldonaia* shows a narrow (sag.), straight ocular ridge in abrupt contact with a wide (tr.), curved palpebral lobe, while *in Protolenus* the ocular ridges are continuous, considerably wider (sag.) and curved backwards (see *Protolenus jakutensis* Lazarenko, 1962 in Repina *et al.*, 1974, pl. 32, figs. 1–2; *P. elegans* Matthew, 1892 in Westrop & Landing, 2000; figs. 7–8). Based on these differences, the previous framing of '*Protaldonaia*' as a subgenus of *Protolenus* is rejected here.

Protaldonaia morenica Sdzuy, 1961 has also been compared with *Lusatiops lusaticus* Schwarzbach, 1934 by Geyer and Elicki (1995, p. 107), who considered it to represent "a morphological counterpart of *Lusatiops lusaticus* (Schwarzbach, 1934) in Sierra Morena", whatever the taxonomic meaning of the expression 'morphological counterpart' is. Although it is true that '*P. morenica*' is morphologically similar to *L. lusaticus* and both share a subtle parafrontal band (see Geyer & Elicki, 1995, figs. 7–8), they differ in the proportions of the cranidium (length represents 1/2 of the width in *L. lusaticus*), ocular ridges [wider (tr.), continuous and C-shaped in *L. lusaticus*], the anterior branches of the facial suture (strongly diverging outwards in *L. lusaticus*), and the general morphology of the glabella (rounded frontal lobe, deep glabellar furrows, and more convergent axial furrows in *L. lusaticus*).

Protaldonaia morenica Sdzuy, 1961

Figures 2–3

*1961 *Aldonaia* (*Protaldonia*) *morenica* n. subgen. n. sp.; Sdzuy, p. 291, pl. 12, fig. 4.

1962 *Protaldonaia morenica*; Sdzuy, p. 200–201, pl. figs. 1–9, ?10–12, pl. 21, figs. 10–12.

1988 *Protaldonaia morenica*; Gil Cid, p. 110, fig. 1.

1990 *Protolenus* (*Protaldonaia*) *morenicus*; Geyer, p. 189

1995 *Protolenus* (*Protaldonaia*) *morenicus*; Geyer & Elicki, p. 106–107.

2024 *Protaldonaia morenica*; Collantes, fig. 48.12.

Holotype. L3191, Münster, Germany.

Type locality. Viar River section, Llerena-Pallares road, EX-103, Km. 187, Badajoz.

Material. 'Benalija beds', Viar River section:, one articulated cephalothorax with pygidium (MPZ-2021/224); one exuvia with several thoracic segments (MPZ-2021/237); thirty two cranidia (MPZ-2021/226; MPZ-2021/228-229; MPZ-2021/231; MPZ-2021/233-236; MPZ-2021/240-242; MPZ-2021/249, MPZ-2021/251-252; MPZ-2021/255-256, MPZ-2021/300-302, DPM-1234-824-LL038, DPM-1234-824-LL000, DPM-1234-824-LL039, DPM-1234-824-LL035, DPM-1234-824-AV01042, DPM-1234-824-V89a, DPM-1234-824-LLa, DPM-1234-824-LLb, DPM-1234-824-V89b, DPM-1234-824-V89c, DPM-1234-824-LL037, UHU-LLE-01/02), fifteen thoracic segments (MPZ-2021/225; MPZ-2021/227; MPZ-2021/230; MPZ-2021/232; MPZ-2021/238-239; MPZ-2021/243-248; MPZ-2021/250; MPZ-2021/253-254).

Diagnosis. Same as for the genus.

Description. Cranidium with subpentagonal outline, anterior branches of the facial suture divergent outwards, posterior ones short and subtly divergent. Sagittal length about 70–75% of maximum width. Known cranidial range 7–25 mm length and 10–28 mm width. Glabella, occipital lobe (LO) and palpebral lobes with slightly higher relief than the rest of the cranidium. Anterior border slightly curved backwards, subtly domed, acuminated at its sagittal point, occupying about 8–10% of the total sagittal length. Deep, wide (sag.) anterior border furrow. Short (sag.), subtly domed preglabellar field, about 8% of the total cranidial length (sag.). Deep, wide (sag.) preglabellar furrow. Cylindrical to subconical glabella, with greater relief than the rest of the cranidium, about 75% of the total cranidial length (sag.) without LO. Subparallel axial furrows, slightly convergent to the front. Four lateral furrows, non-transglabellar, nearly straight, oblique; S1 parallel to S2 and S3; S4 poorly defined. Three lateral lobes, each of them occupying ~20% of the total sagittal length of the glabella, without LO. L1 subrectangular, moderately inflated dorsally, similar to L2 and L3. LA slightly acuminated, subtly inflated, occupying ~30% of the glabellar length (sag.) without LO. LO crescent-shaped, widened at its sagittal point, extending about 16% of the total cranidial length (sag.), with convexity to the posterior area, progressively narrowed laterally (exsag.). Shallow oblique furrow separating the preglabellar and preocular fields. Subrectangular to subtrapezoidal preocular field, subtly depressed with respect to the preglabellar field, occupying ~15% of the total cranidial length (sag.) and ~36% of the total cranidial width (tr.). Shallow, narrow (tr.) preocular furrow, extending all along the anterior branch of the ocular ridge. Long, narrow (sag.) ocular ridge, subparallel to the anterior border, about 4% of the total cephalic length (sag.), in abrupt contact with the palpebral lobe. The anteriormost part of the ocular ridges are joined by a poorly defined parafrontal band. Palpebral lobe considerably wide (tr.), extending 8% of the total cranidial width (tr.); subtly curved. Domed, subtrapezoidal palpebral area, about 35% of the total cranidial width (tr.). Reduced posterior area, rectangular to trapezoidal outline. Deep, wide (sag.) posterior furrow, widened laterally (exsag.), about 8% of the total cranidial

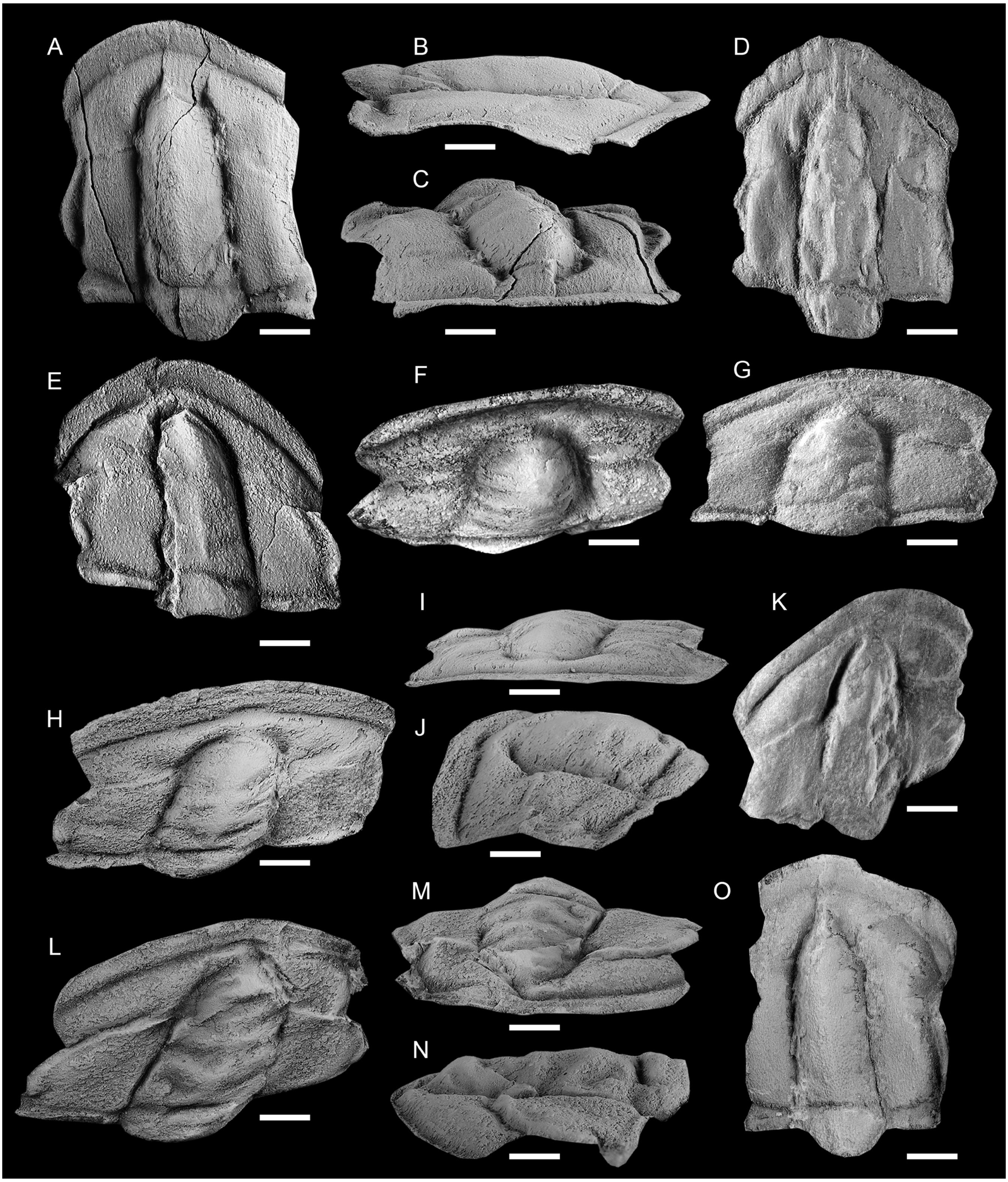

Figure 2. *Protaldonaia morenica* Sdzuy, 1961 (cranidia), upper Marianian, Viar River section, Badajoz, Spain. **A–C,** MPZ–2021/249; **A,** dorsal view; **B,** frontal view; **C,** lateral view; **D,** DPM-A234-824-LL038, dorsal view; **E,** SMF X 16803a, dorsal view; **F,** SMF X 16864, dorsal view; **G,** DPM-A234-824-V89a; **H–J,** MPZ–2021/229; **H,** dorsal view; **I,** frontal view; **J,** lateral view; **K,** DPM-A234-824-LL039; **L–N,** MPZ–2021/231; **L,** dorsal view; **M,** frontal view; **N,** lateral view; **O,** MPZ–2021/252; scale bars = 3 mm (A–C, E–N), 5 mm (D, O).

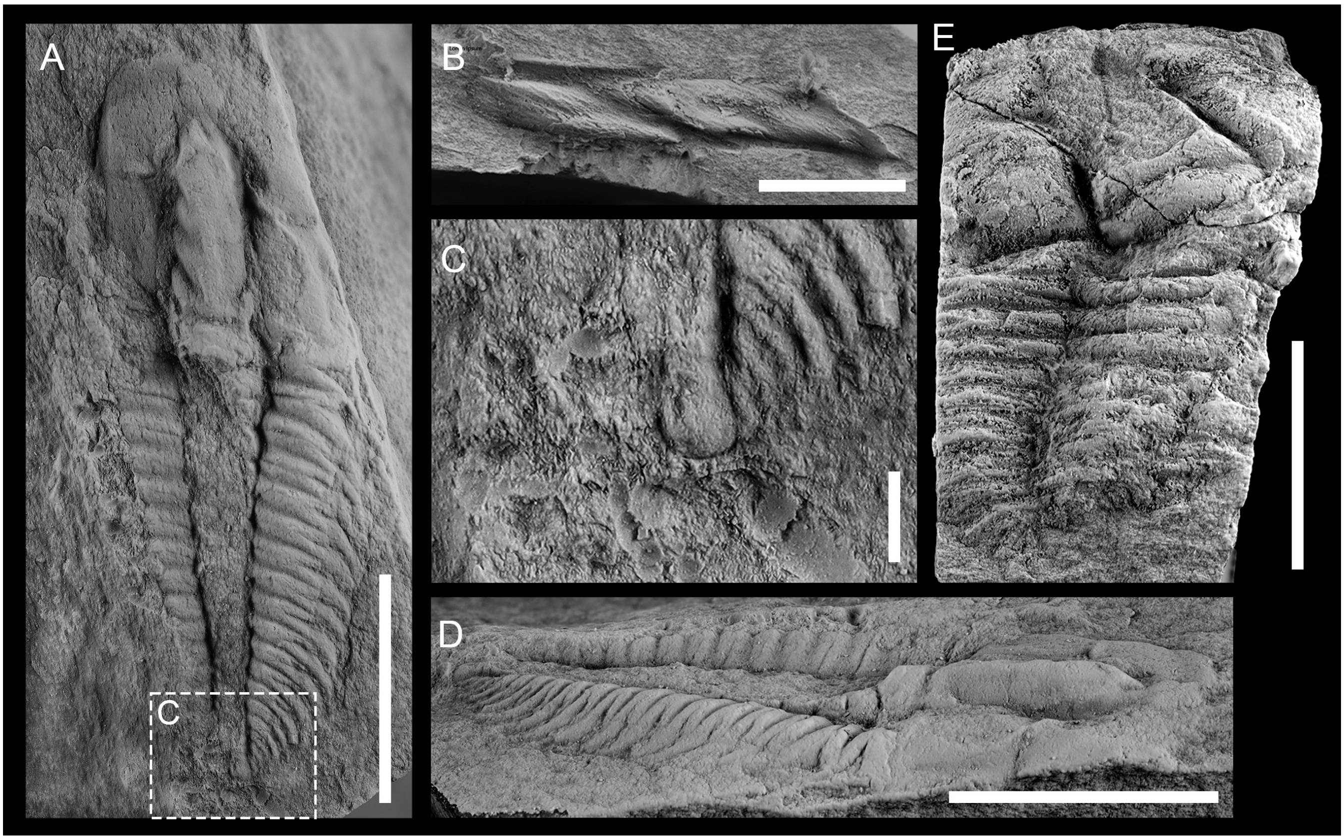

Figure 3. *Protaldonaia morenica* Sdzuy, 1961, upper Marianian, Viar River section, Badajoz, Spain. **A,** MPZ–2021/224, articulated specimen, dorsal view; **B,** MPZ–2021/225, pleura, dorsal view; **C,** MPZ–2021/224, detail of the pygidium, dorsal view; **D,** MPZ–2021/224, articulated specimen, lateral view; **E,** MPZ–2021/228, articulated specimen, dorsal view; scale bars = 10 mm (A, D, E), 5 mm (B), 2 mm (**C**).

length. (sag.) Narrow (sag.), short (tr.), continuous posterior border, about 8% of the total cranidial length (sag.) and 28–30% of the cranidial width (tr.).
Trunk composed of 17 thoracic segments (Fig. 3A). Wide (sag.), convex axial rings, narrowing towards the posterior area. Axial ring length (sag.) occupying 8% of the total length of the thorax anteriorly, and about 2% posteriorly. Shallow axial ring furrows. Lateral extension (tr.) of the pleural region equivalent to the lateral extension (tr.) of the cranidium. First pleura considerably shorter and straight, extending 30% of the thoracic width, and subsequent pleurae progressively widened (tr.) up to the fourth pleura, about 38–40% of the total thoracic width; then progressively narrowing (tr.) towards the posterior end. Pleurae thin (sag.), knife-shaped, and slightly curved backward; with curvature progressively increasing posteriorly. Pleural furrow deep and wide (sag.), about 60% of the first pleura (tr.). Sharped pleural spine occupying 1/4 of the pleural width. Pygidium (Fig. 3C) very reduced with oval outline, about 5% of the total length (sag.) of the specimen. Width (tr.) of pygidium ~80% of its length (sag.). Narrow, subtly domed border surrounding the entire pygidium, with shallow border furrow.

Remarks. The studied specimens show a certain variability in some characters from one specimen to another. Examples of this are 1) the extension of the preglabellar field, punctually almost inappreciable (Fig. 2G, 2L), 2) the morphology of the glabella, which varies from cylindrical (see Fig. 2A, 2O) to conical (see Fig. 2G, 2K), as well as in the deepness of the lateral furrows (compare Fig. 2L with Fig. 2O); 3) the morphology of the ocular ridges, going from a narrow structure (see Fig. 2A, 2H) to a wide, continuous ridge in connection with the palpebral lobes (see Fig. 2L); or 4) the morphology of the occipital lobe, varying in both extension and convexity (compared Fig. 2D with Fig. 2H). Another character to be taken into consideration is the parafrontal band, which is represented very subtly in some specimens (Fig. 2A–2C, 2D, 2E), while in others it is completely obliterated (Fig. 2G, 2O). These differences may be due to either tectonic distortion, possible intraspecific variation, or even represent different species. However, the sample size is too small to draw any conclusions on this issue, thus it is therefore assumed that all specimens belong to the same species with varying levels of deformation.

Geographical and stratigraphical distribution. ‘Benalija beds’, upper Marianian (lower Stage 4), Llerena, Badajoz, Spain. Collantes (2024) reported *P. morenica* from the ‘Herrerías shale’, upper Marianian (lowermost Stage 4), Sierra del Bujo section and El Pozuelo fossil site (Arroyomolinos de León, Huelva), and Minas de Cala (Cala, Huelva), Spain.

Genus *Triangulaspis* Lermontova, 1940

Type-species. *Ptychoparia meglitzkii* Toll, 1899; by original designation Lermontova (1940, p. 120–121).

Triangulaspis fusca Sdzuy, 1962
Fig. 2L

1941 *Strenuaeva* cf. *vigilans*; Richter & Richter, p. 48, pl. 2, figs. 34–35, pl. 4, fig. 71.
1941 *Strenuaeva* cf. *annio*; Richter & Richter, p. 49, pl. 2 fig. 33, pl. 4, fig. 70.
1953 *Strenueva* cf. *vigilans*; Hupé, p. 206, 209, 210.
1953 *Angusteva* cf. *annio*; Hupé, p. 115, 209.
1958 *Strenuaeva* cf. *vigilans*; Lotze, p. 743.
1958 *Strenuaeva* cf. *annio*; Lotze, p. 743.
1961 *Triangulaspis* cf. *vigilans*; Lotze, p. 164.
1961 *Triangulaspis* cf. *annio*; Lotze, p. 164.
1961 *Triangulaspis* sp.; Lotze, p. 171.
1961 *Strenuaeva* cf. *vigilans*; Sdzuy, p. 230.
1961 *Strenuaeva* cf. *annio*; Sdzuy, p. 230.
*1962 *Triangulaspis fusca* n. sp.; Sdzuy, p. 208, pl. 18, fig. 11, pl. 22, figs. 12–132, pl. 23, figs. 1–7.
2001 *Triangulaspis fusca*; Sdzuy, fig. 24.
2024 *Triangulaspis fusca*; Collantes, fig. 48.8.
in press *Triangulaspis fusca*, Liñán *et al*., fig. 10c.

Holotype. SMF 16821_{a1}

Type locality. Arroyo del Tamujar, Guadalcanal, Seville, Spain.

Material. Three cranidia (MPZ 2022/886, UHU-LLE-300/301).

Diagnosis. See Sdzuy (1962, p. 208).

Description. Cranidium subpentagonal, highly convex. Cranidial length (sag.) about 3/4 of cranidial width (tr.) across palpebral lobes. Preglabellar area subtriangular, inflated, occupying 35% of the total cranidial length (sag.). Preglabellar furrow wide (sag.) and deep. Glabella subconical, strongly convex, about 60% of total cranidial length (sag.) and 35% of total cranidial width (tr.), with no glabellar furrows. LA acuminated; posterior area of glabella curved and inflated. Axial furrows deep and well-marked. Occipital furrow almost unnoticeable. Palpebral area is highly convex, inflated, about 50% of the total cranidial length (sag.) and 40% of the total cranidial width (tr.). Anterior branch of facial suture short and diverging outwards. Preocular area wide and deep, progressively widening to the sides. Ocular ridges almost unnoticeable. Posterior branch of the facial suture short and diverging outwards. Posterior border narrow (both sag. and exsag.) and shallow. Posterior border is narrow (exsag.), widening to the sides.

Remarks. According to Sdzuy (1962), the most distinctive character of *T. fusca* compared to other species of the genus is that the occipital furrow is subtly marked or even obliterated. Other differences include a larger glabella [compared to *T. meglitzkii* (Toll, 1899) or *T. annio* (Cobbold, 1910)], the absence of recognizable lateral glabellar furrows [like *T. vigilans* (Matthew, 1899) or *T. zirarii* Hupé, 1953], or the absence of a prominent occipital spine (like in *T. meglitzkii*). A detailed comparison of all species belonging to the genus *Triangulaspis* will be carried out in a future work.

Geographical and stratigraphical distribution. ‘Cumbres beds’, middle to upper Marianian (upper Stage 3 to lowermost Stage 4), Cumbres de San Bartolomé and Cumbres Mayores, Huelva, Spain; ‘Herrerías shale’, middle to upper Marianian (lowermost Stage 4), Sierra del Bujo section (Arroyomolinos de León, Huelva), Minas de Cala, Cala (Huelva), Spain. Upper part of La Hoya Member (upper Marianian), Alconera Formation, Alconera (Badajoz, Spain). ‘Benalija beds’, upper Marianian (lower Stage 4), Llerena, (Badajoz), and Guadalcanal (Seville), Spain. *Triangulaspis* cf. *fusca* has been reported from the Soleras Formation, upper Marianian (lower Stage 4), Totanés-Noez area, Toledo, Spain.

Order EODISCIDA Kobayashi, 1939
Family CALODISCIDAE Kobayashi, 1943
Genus *Chelediscus* Rushton, 1966

Type-species. *Chelediscus acifer* Rushton, 1966, Purley Shales (upper Comley Series, Cambrian Stage 4), Warwickshire, United Kingdom.

Chelediscus garzoni Collantes, Pereira, Mayoral & Gozalo, 2023
Figure 2A–2I

2023 *Chelediscus garzoni* sp. nov; Collantes *et al*., p. 1703, fig. 2.
2024 *Chelediscus garzoni*; Collantes, fig. 48.3.

Holotype. UHU–CSB–514.

Type locality. Cumbres de San Bartolomé, Huelva, Spain.

Material. 21 cephala (MPZ 2022/777 to MPZ 2022/789, MPZ 2022/791 to MPZ2022/793, UHU-LLE-101 to UHU-LLE-106), one pygidium (MPZ 2022/790) and a cephalon fused with pygidium (UHU-LLE-100).

Diagnosis. See Collantes *et al.* (2023, p. 1703).

Description. Cephalon semicircular, low convexity, 0.9–2.0 mm in length and 0.9–2.3 mm in width. Subtly domed anterolateral border, sagittally elongate, occupying about 15% of the total cephalic length (sag.). Deep, continuous anterolateral border furrow. Median preglabellar furrow present. Subconical glabella, about 60% of the total cephalic length (sag.). Anteriormost part of glabella pointed anteriorly. Posteriormost part of the glabella showing a higher relief and is rounded posteriorly, with a maximum width about 40% of the total cephalic width. Deep, narrow axial furrows, frontally convergent and merging with the median preglabellar furrow. Genae subtly domed and smooth, with low convexity and max width occupying about 60% of the total cephalic width. Deep, wide posterior furrow. Posterior border continuous with lateral border, narrowing adaxially and slightly convex backwards.

Semicircular, highly convex pygidium. Maximum length 1.5 mm and width 2.0 mm. Subconical pygidial axis, with greater relief than the adjacent pleurae; length (sag.) about 90–95% of total pygidial length, maximum width (tr.) opposite second axial ring, about 48–52% of the total pygidial width. Five axial rings plus one terminal piece. Pygidial axial furrows narrow and moderately deep. Pleurae moderately convex and smooth. Border furrow broad and deep. Anterior border is continuous with the posterolateral one.

Remarks. Specimens of *C. garzoni* from the Viar river section are similar to those described from the type locality in Cumbres de San Bartolomé, showing a smooth glabella, LO transverse, and a pygidium with five axial rings plus a terminal piece with smooth pleurae, characters that differentiate it from the species *C. acifer* Rushton, 1966 and *C. chathamensis* Rasetti, 1967. On the other hand, specimens from the Viar River section lack the lateral border spines, but considering the fragility of this character, the author considers that they still fit the description of *C. garzoni*.

Sepúlveda et al. (in press) described *Chelediscus* cf. *garzoni* from the Soleras Formation in the Toledo Province, Spain, which were not clearly assigned to *C. garzoni* due to the poor preservation of the posterior area of the cephala. Samples of *C. garzoni* from the Viar River section share the unlobed glabella with the Toledo specimens, but other characters related to the cephalon (*e.g.*, position of the LO, or the cephalic border) cannot be compared.

Geographical and stratigraphical distribution. 'Cumbres beds', upper Marianian (lowermost Stage 4), Cumbres de San Bartolomé, Huelva, Spain; 'Herrerías shale', upper Marianian (lowermost Stage 4), El Pozuelo fossil site (Arroyomolinos de León, Huelva), and Minas de Cala, Cala (Huelva), Spain. 'Benalija beds', upper Marianian (lower Stage 4), Llerena, Badajoz, Spain. *Chelediscus* cf. *garzoni* has been reported from the Soleras Formation, upper Marianian (lower Stage 4), Totanés-Noez area, Toledo, Spain.

Family WEYMOUTHIIDAE Kobayashi, 1943
Genus *Serrodiscus* Richter & Richter, 1941

Type species. *Eodiscus* (*Serrodiscus*) *serratus* Richter & Richter, 1941 (junior subjective synonym of *Microdiscus bellimarginatus* Shaler & Foerste, 1888; see Collantes *et al.*, 2022, p. 298).

Serrodiscus bellimarginatus (Shaler & Foerste, 1888)
Figure 2J–2K

2022 *Serrodiscus bellimarginatus*; Collantes *et al*., p. 300, figs. 5–9 (with previous synonyms).
in press *Serrodiscus bellimarginatus*; Sepúlveda *et al*., p. 6, figs. 3a–3c (with previous synonyms).

Holotype. Currently lost. Paratype: MCZ 4811, designated by Shaw (1950).

Type locality. Hoppin limestone, Hoppin Hill, North Attleboro, Massachusetts, USA.

Material. Thirteen cephala (UHU-LLE-201, UHU-LLE-202, UHU-LLE-204, UHU-LLE-205/212, MPZ2021/334, MPZ2021/336), five pygidia (UHU-LLE-200/200(M), UHU-LLE-2023/2023(M), MPZ2021/335).

Diagnosis. See Collantes *et al.* (2022, p. 304).

Description. A more complete description is provided in Collantes *et al.* (2022, p. 304): Semi-elliptic cephalon, moderately convex in frontal and lateral views. Anterior and lateral border continuous, about 15% of the cephalic sagittal length (including LO), convex, occasionally widened (sag.) frontally. Subtle nodes on the lateral border. Border furrow is wide and moderately deep. The preglabellar area is narrow, shorter (sag.) than the anterior border. Preglabellar furrow is shallow to moderately deep. Glabella is subconical in outline, convex (tr.), sloping forward, showing higher relief than the genae, tapered forward and widened posteriorly. Axial furrows are deep, moderately wide (tr.) and convergent forwards. Glabella has about 80% cephalic sagittal length, including LO, and about 40% cephalic width at the posterior border. Three pairs of poorly defined shallow glabellar furrows, non-transglabellar, directed backwards, shallowing frontally from S1 to S3. Glabellar lobes are poorly inflated, being L1 the longer (exsag.) and more pronounced. LA slightly tapered frontally. SO is subtle, shallowing abaxially. LO is convex, with trapezoidal outline, about 5% cephalic length (sag.). Genae is domed, smooth and homogeneous. Posterior border continuous with lateral border, widening adaxially to posterior cephalic corner.

Subtriangular pygidium, moderately convex in frontal and lateral view. The pygidial axis is conical, prominent, and convex (tr.), higher than the adjacent pleurae; length is about 90–95% total pygidial length, width about 30–35% anterior pygidial width. Small postaxial area. Nine pygidial axial rings plus one terminal piece. Pygidial axial furrow is broad and deep. Pleurae are moderately convex, smooth and homogeneous. Border furrow is wide, deep and continuous. Anterior pleural border sloping posteriorly, narrowing abaxially. The lateral border is continuous with the anterior one, convex and homogeneous posteriorly.

Remarks. Specimens of *Serrodiscus* from the Viar River section were originally assigned to *S.* aff. *speciosus* (see Gil Cid, 1988). Collantes *et al.* (2022) grouped the species of *Serrodiscus* into three distinct groups (*bellimarginatus*, *specious* and *daedalus*), mainly based on morphological, stratigraphical and palaeobiogeographical data. In this grouping, they assigned all the species from Western Gondwana (including the Iberian occurrences) and Avalonia to the

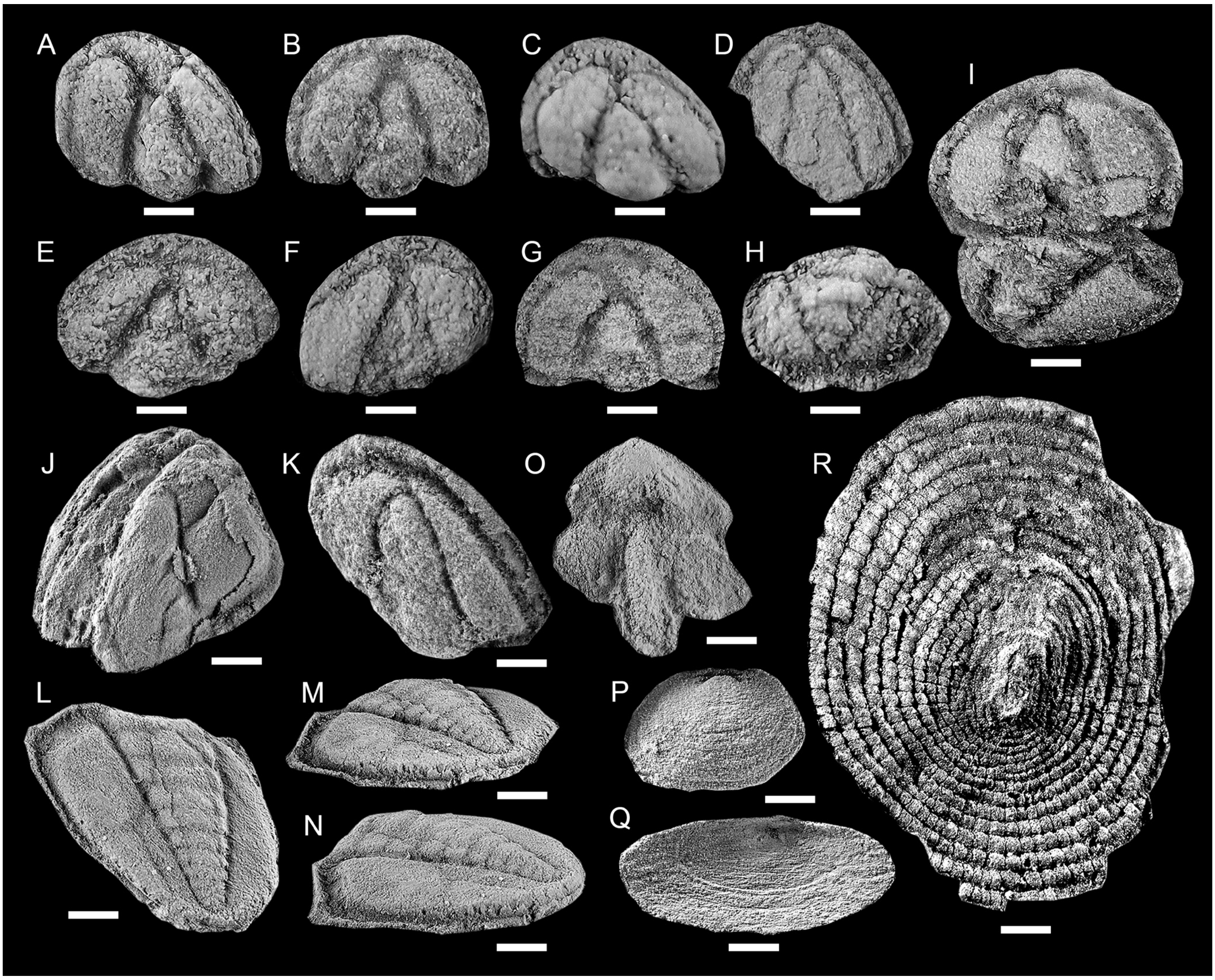

Figure 4. Upper Marianian trilobites and SSF from the Viar River section, Badajoz, Spain. **A**–**I,** *Chelediscus garzoni* Collantes, Pereira, Mayoral & Gozalo, 2023; **A,** MPZ–2022/779, cephalon, dorsal view; **B,** MPZ–2022/780, cephalon, dorsal view; **C,** MPZ–2022/782, cephalon, dorsal view; **D,** MPZ–2022/793, cephalon, dorsal view; **E,** MPZ–2022/780, cephalon, dorsal view; **F,** MPZ–2022/783, cephalon, dorsal view; **G,** MPZ–2022/778, cephalon, dorsal view; **H,** MPZ–2022/790, pygidium, dorsal view; **I,** UHU–LLE–100, cephalon and pygidium, dorsal view; **J**–**N,** *Serrodiscus bellimarginatus* (Shaler & Foerste, 1888); **J,** MPZ–2021/336, cephalon, dorsal view; **K,** MPZ–2021/334, cephalon, dorsal view; **L**–**N,** UHU–LLE–200, pygidium; **L,** dorsal view; **M,** posterolateral view; **N,** lateral view; **O,** *Triangulaspis fusca* Sdzuy, 1962, MPZ–2022/886, cranidium, dorsal view; **P**–**Q,** *Sibiria*? sp.; **P,** MPZ-95/555, dorsal view; **Q,** MPZ-95/556, dorsal view; **R,** *Marocella morenensis* (Yochelson & Gil Cid, 1984), MPZ–2019/223, dorsal view; scale bar = 1 mm.

so-called *bellimarginatus* group. The arguments for the division of these groups as well as the assignment of the Spanish specimens were extensively discussed in that paper so, as previously noted, the specimens of *Serrodiscus* from the Viar River section are here assigned to the *bellimarginatus* group.

Geographical and stratigraphical distribution. *Hebediscus attleborensis* Subzone (uppermost *Callavia broeggeri* Zone) to upper *Strenuella sabulosa* Zone, St. Mary's Member, Brigus Formation (Newfoundland and Massachusetts), Branchian Series (lower Stage 4). Lowermost to middle "*Protolenus*" Zone, Comley Series (lower Stage 4), Warwickshire, United Kingdom. *Sectigena* Zone, Issafen Formation, middle to upper Banian Stage (lower Stage 4), Morocco. *Serrodiscus* Zone, upper Marianian (lower Stage 4), 'Cumbres beds' (Cumbres de San Bartolomé, Cumbres de Enmedio; Huelva province, Spain), 'Herrerías shale' (Sierra del Bujo, El Pozuelo, Minas de Cala, Arroyomolinos de León; Huelva province, Spain), La Hoya Member, Alconera Formation (Alconera, Badajoz province); 'Benalija) beds' (Llerena; Badajoz province; and Guadalcanal and Alanís; Seville province, Spain). Soleras Formation, upper Marianian (lower Stage 4), Totanés, Polán and Noez; Toledo province, Spain. *Lusatiops* Member (lower Stage 4), Charlottenhof Formation, Görlitz Synclinorium (Germany).

Phylum MOLLUSCA Linnaeus, 1758
Class HELCIONELLOIDA Peel, 1991
Order uncertain
Family MAROCELLIDAE Topper, Brock, Skovsted & Paterson, 2009
Genus *Marocella* Geyer, 1986

Type-species. *Marocella mira* Geyer, 1986

Marocella morenensis (Yochelson & Gil Cid, 1984)
Figure 4R

1941 *Scenella reticulata*; Richter & Richter, p. 56, pl. 3, figs. 56, 57.
1961 *Scenella reticulata*; Lotze & Sdzuy, p. 190.
1961 *Scenella* sp.; Lotze, p. 196.
1972 "Forma A"; Gil Cid, p. 222, figs. 1–2, 7.
*1984 *Scenella morenensis*; Yochelson & Gil Cid, p. 333, figs. 2–4.
1988 *Scenella morenensis*; Gil Cid, p. 112, figs. 3, 6, 7.
2020 *Marocella morenensis*; Collantes *et al*., 2020, p. 198, fig. 8.

Holotype. CPL–03.

Type locality. Viar River section, Llerena-Pallares road, EX-103, Km. 187, Badajoz.

Material. Three specimens (MPZ-2019/223, UHU-LLE-400/401).

Diagnosis. See Topper *et al.* (2009, p. 233).

Description. A more complete description is provided by Collantes *et al.* (2020, p. 198): In apical view, cap-shaped conch with elliptical outline, length is approx. 4/3 of the width. Eccentric apex. Apical surface flattened or slightly inclined near the margin, with a more strongly developed slope near the apex. The supra-apical zone is nearly flat or slightly convex. Apex is slightly curved towards the sub-apical margin. Concentric rounded folds around the apical zone. Subequally spaced radial striae. The intersection of the concentric folds with radial striae gives rise to a reticulate pattern of subquadrate compartments, which is finer around the apical zone and wider near the margins, square and smaller on the sub-apical zone, rectangular and larger on the supra-apical zone.

Remarks. The main differences between *M. morenensis* and the type species *M. mira* consist of the presence of a higher angularity in concentric folds and a less recurved apex in *M. morenensis* (Topper *et al.*, 2009). Also, Collantes *et al.* (2020) carried out a biometrical comparison of figured specimens of *M. mira* and *M. morenensis* and noted that both species can be biometrically differentiated (see Collantes *et al.*, 2020, fig. 10) and that *M. morenensis* differs from *M. mira* in the number of folds in adult forms, which indicates that they should be treated as different species.

Geographical and stratigraphical distribution. 'Cumbres beds', upper Marianian (lowermost Stage 4), Cumbres de San Bartolomé, Huelva, Spain; 'Herrerías shale', upper Marianian (lowermost Stage 4), El Pozuelo fossil site (Arroyomolinos de León, Huelva), and Minas de Cala, Cala (Huelva), Spain. 'Benalija beds', upper Marianian (lower Stage 4), Llerena, Badajoz, Spain. 'Alanís beds', middle Marianian (upper Stage 3), Alanís, Seville.

Phylum BRACHIOPODA Duméril, 1806
Class OBOLELLATA Williams, Carlson, Brunton, Holmer & Popov, 1996
Order Obolellida Rowell, 1965
Superfamily Obolelloidea Walcott & Schuchert in Walcott, 1908
Family Trematobolidae Popov & Holmer, 2000
Genus *Sibiria* Gorjansky in Pelman, 1977

Type species. *Sibiria magna* Gorjansky in Pelman, 1977

Sibiria? sp.
Fig. 4P–4Q.

2001 *Sibiria* (?) sp.; Liñán & Mergl, p. 328, figs. 4i–4k.

Material. UHU-LLE-500/501.

Description. See Liñán and Mergl (2001, p. 328). Valves are oval in outline, asymmetrically conical, subtly convex, apex highly raised above the posterior margin. Width is about 60% of the length, with maximum width posterior to midlength. Posterior margin subtly curved. Ornamentation formed by subtle concentric fila.

Remarks. the overall morphology of the illustrated specimens is similar to the species *Sibiria magna* Gorkansky in Pelman, 1977 from the Atdabanian (*i.e.*, Cambrian Stage 3) of Siberia, but given the poor preservation of the specimens (with no pedicle track in the external surface of the valve and no imprints of muscle scars) a clear comparison with the type species was not possible (see Liñán & Mergl, 2001). In addition, the few new specimens found during the recent field campaign are considerably deformed and do not add new information.

DISCUSSION

The Viar River section has yielded a trilobite association consisting on the species *Protaldonaia morenica*, *Triangulaspis fusca*, *Chelediscus garzoni* and *Serrodiscus bellimarginatus*, as well as the helcionelloid *Marocella morenensis* and the brachiopod *Sibiria*? sp. This Marianian fossil assemblage is equivalent to those found in the upper 'Cumbres beds' and the upper 'Herrerías shale' from Huelva province, from the southern branch of the OMZ (Collantes *et al.*, 2020, 2022, 2023), thus having biostratigraphical implications and a great correlation potential at regional level. A regional correlation chart of the studied trilobites is shown in Figure 5.
The potential of the genus *Serrodiscus* for both regional and international correlation has been discussed for a long time (Geyer & Shergold, 2000; Shergold & Geyer,

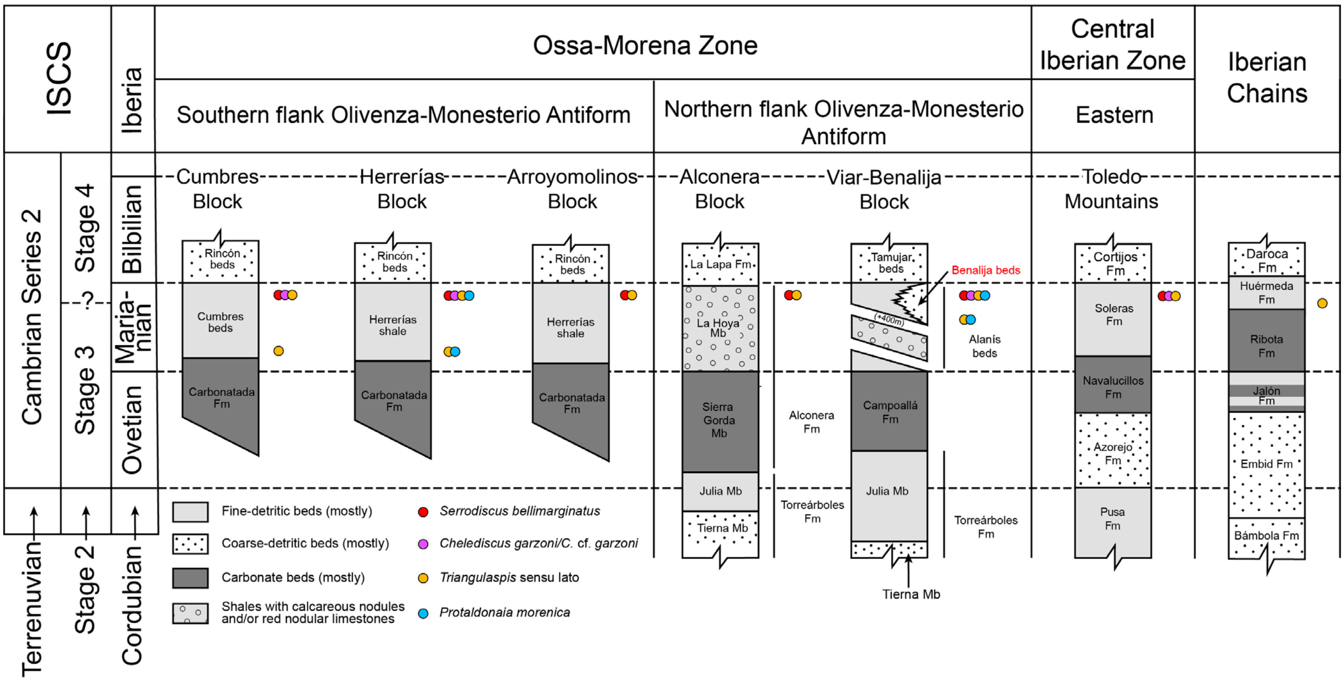

Figure 5. Stratigraphic position and distribution of the studied trilobite species from the Viar river fossil site along the Cambrian outcrops of the Ossa-Morena Zone, the Central Iberian Zone and the Iberian Chains.

2003; Westrop & Landing, 2011; Collantes *et al.*, 2022). Following the different *Serrodiscus* groups established by Collantes *et al.* (2022), species from Western Gondwana (including Morocco, Iberia and Germany) and Avalonia (United Kingdom and Newfoundland) are grouped within the *bellimarginatus* group. Among this group, in Iberia *Serrodiscus* occurs in numerous localities of the OMZ, and also in the Central Iberian Zone (Collantes *et al.*, 2022; Sepúlveda *et al.*, in press). In Western Gondwana, *S. bellimarginatus* occurs in the upper Banian rocks of Morocco (Geyer, 1988, 2005) and in the Cambrian Series 2 rocks of the Görlitz Synclinorium in Germany (Geyer & Elicki, 1995). This group is also present in the United Kingdom and Newfoundland (eastern and western Avalonia, respectively): from the UK, is has been reported from the Comley Series of Warwickshire (Rushton, 1966) and the Llanberis Slate from North Wales (Birch & McCobb, 2023), while in Newfoundland it is well represented in the rocks of the middle Branchian Series (Fletcher, 2006; Fletcher & Theokritoff, 2008; Westrop & Landing, 2011). For a more detailed explanation on international correlation and palaeobiogeographical distribution of the *Serrodiscus* groups, see Collantes *et al.* (2022, figs. 3–4).

The species *Chelediscus garzoni* has been recently reported from different locations of the OMZ. The type material was described from the uppermost part of the 'Cumbres beds' of the Cumbres block in Cumbres de San Bartolomé (Huelva province, Spain) (Collantes *et al.*, 2023). Later Collantes (2024) noticed the presence of this species from several fossil sites in Huelva province, including El Pozuelo fossil site (Arroyomolinos de León) and Minas de Cala. The specimens of *C. garzoni* illustrated here were previously listed by Liñán (1984), Liñán and Quesada (1990) and more recently by Liñán *et al.* (in press). Therefore, it can be concluded that *Chelediscus* was widely distributed along the western margin of Gondwana. Additionaly, Sepúlveda *et al.* (in press) reported *Chelediscus* cf. *garzoni* from the upper Marianian of Totanés, Toledo province. Regarding other species, *Chelediscus* also occurs in the Comley Series of the UK (Rushton, 1966), in the Branchian Series of Newfoundland (Fletcher, 2003), in the upper Dyerian rocks of New York (Rasetti, 1967), in the uppermost "*Ornamentaspis*" *linnarsoni* Zone (*i.e.*, uppermost Vergalian-Rausvian *sensu* Geyer, 2019) of Sweden (Axheimer *et al.*, 2007) and in the lower Botoman of Russia (Repina, 1972). For detailed biostratigraphical and palaeobiogeographical distribution of *Chelediscus*, see Collantes *et al.* (2023, figs. 4–5).

The trilobite genus *Triangulaspis* has been recognised in several parts of the Iberian Peninsula, including the OMZ (Huelva, Seville and Badajoz provinces; see Sdzuy, 1962; Liñán & Perejón, 1981; Collantes, 2024), the Central Iberian Zone (Toledo province, Sepúlveda *et al.*, in press) and the Iberian Chains (Sdzuy, 1972). It has been also reported from several sections in Morocco, all assigned to the *Sectigena* Zone of the Banian Stage (Cambrian Stage 4) (Hupé, 1953; Geyer, 1988, 1990, 2005; Geyer *et al.*, 1995). In Newfoundland, *Triangulaspis* occurs in rocks belonging to the *Callavia* Zone of the Branchian Series (Fletcher, 1972, 2003; Hutchinson, 1962; Westrop & Landing, 2011). In Russia, *Triangulaspis* ranges from the late Atdabanian to the middle Botoman of the Siberian Platform (Lermontova, 1940; Lazarenko, 1957; Repina, 1972; Repina *et al.*, 1964; Astashkin *et al.*, 1991, 1995; Geyer, 2005; Korovnikov & Novozhilova, 2012).

Based on the presence of the trilobite genera *Serrodiscus*, *Chelediscus* and *Triangulaspis*, this fossil assemblage indicates a late Marianian age according to the regional Iberian scheme (Collantes *et al.*, 2022, 2023). In addition, and according to previous authors, this trilobite assemblage can been tentatively correlated with the lower part of Cambrian Stage 4 internationally (see Geyer & Shergold, 2000; Shergold & Geyer, 2003; Sundberg *et al.*, 2016; Geyer, 2019).

Protaldonaia shows a more restricted geographical distribution, being limited to the Marianian outcrops of the OMZ. Apart from its type locality in the Viar River section, *P. morenica* has been reported from the Sierra del Bujo section, El Pozuelo fossil site and Minas de Cala fossil site, from northern Huelva province (see Collantes, 2024, p. 43), and also from the Arroyo Tamujar (T1-T2) section, in northern Seville (Liñán *et al.*, in press).

Regarding other fossils from the section, the helcionelloid *Marocella* has a wide geographical distribution: this genus occurs in the Cambrian of Antarctica (Evans, 1992; Claybourn *et al.*, 2019), Australia (Topper *et al.*, 2009; Jacquet & Brock, 2016; Parkhaev, 2019), North and South China (Lin, 1999; Li *et al.*, 2019), Germany (Geyer & Malinky, 2019), Iberia (Yochelson & Gil Cid, 1984; Collantes *et al.*, 2020), Morocco (Geyer, 1986; Geyer *et al.*, 1995; Geyer & Landing, 2006; Mghazli *et al.*, 2023) and Siberia (Vostokova, 1962). However, Betts *et al.* (2017) pointed out that, despite its great geographical distribution, this genus is unsuitable for precise correlation, with a biostratigraphical range spanning from upper Stage 3 to the middle Drumian (see Collantes *et al.*, 2020, fig. 6).

CONCLUSIONS

The present study on the Cambrian Series 2 fossils from the Viar River section has shown a trilobite assemblage composed of four trilobite species (*Protaldonaia morenica*, *Triangulaspis fusca*, *Chelediscus garzoni* and *Serrodiscus bellimarginatus*), one helcionelloid mollusc (*Marocella morenensis*) and one undetermined brachiopod species (*Sibiria*? sp.). The taxonomic position of the genus *Protaldonaia* is reviewed and updated here, and its previous assignments to the genus *Protolenus* are dismissed. Also, the species *Triangulaspis fusca* and *Chelediscus garzoni* are described and illustrated in this section for the first time, subtly expanding the distribution of these species along the OMZ.

The presence of trilobite genera *Serrodiscus*, *Chelediscus* and *Triangulaspis* indicates a late Marianian age in the regional stratigraphic chart of the Iberian Peninsula. This fossil assemblage facilitates the correlation of the 'Benalija beds' with other Marianian formations of the OMZ, *i.e.*, the 'Cumbres beds' or the 'Herrerías shale' in the Huelva province, and other Marianian successions from the Iberian Peninsula (*e.g.*, Soleras Formation from the Central Iberian Zone). In addition, new data indicates that *C. garzoni* is more widely distributed throughout the Cambrian of the OMZ. Finally, from an international correlation perspective, these fossils are also present in other Cambrian Stage 4 rocks from Western Gondwana (*e.g.*, Morocco, Germany) as well as in equivalent rocks from other domains, *i.e.,* western and eastern Avalonia (*i.e.*, Newfoundland, United Kingdom), Baltica (Scandinavian Peninsula) or Siberia.

Author's contributions. LC wrote the manuscript and elaborated the figures.

Supplementary information. The article has no additional data.

Competing interests. The author declares none.

Funding. The author was awarded with a SYNTHESYS + grant (application number: DE-TAF-TA4-043) for visiting the palaeontological collections of Senckenberg Museum, permitting the completion of this study. This research was partially funded by the Comisión de Ayudas a la Investigación de la Sociedad Española de Paleontología (AJISEP-2020). This work was supported by Portuguese funds by Fundação para a Ciência e a Tecnologia (Portugal) in the frame of UI/DB/151298/2020 project.

Author details. **Luis Collantes.** Centro de Geociências, Departamento de Ciências da Terra, Universidade de Coimbra, Rua Sílvio Lima, 3030-790 Coimbra, Portugal; luis.collantes.geo@gmail.com.

Acknowledgement. Two anonymous reviewers are thanked for their comments and suggestions. Thanks to Dr Sofia Pereira (University of Coimbra), Prof. Rodolfo Gozalo (University of Valencia) and Prof. Eladio Liñán (University of Zaragoza) for their comments and suggestions on the early version of the manuscript. Thanks to Dr Ignacio Canudo and Dr Ester Díaz-Berenguer (University of Zaragoza) for providing permission to study the material housed at the Museo de Ciencias Naturales of the University of Zaragoza, and Isabel Pérez Urresti for the photographs of some of the specimens housed in this institution. Thanks to Dr Mónica M. Solórzano (Senckenberg Museum, Frankfurt) for the facilities and assistance during the study of the material at Senckenberg Museum. We thank Dr Mª de la Concepción Herrero and Isabel Díaz Megías (Complutense University of Madrid) for their assistance with the collections housed at the UCM, and Gema García Martín for the photographs of some of the specimens housed in the UCM. This work is a contribution to IGCP project 652.

REFERENCES

Adrain, J. M. (2011). Class Trilobita Walch, 1771. In Zhang Z-Q. (Ed.), *Animal Biodiversity: An Outline of Higher Level Classification and Survey of Taxonomic Richness. Zootaxa*, *3148*, 104–109.

Apalategui, O., Contreras, F., Matas, J., & Carvajal, A. (1989). Mapa geológico de la Hoja nº 898 (Puebla del Maestre). *Mapa Geológico de España, segunda serie, primera edición.* Instituto Geológico y Minero de España.

Astashkin, V. A., Pegel, T. V., Shabanov, Y. Y., Sukhov, S. S., Sundukov, V. M., Repina, L. N., Rozanov, AYu., &

Zhuravlev, A. Yu. (1991). The Cambrian System on the Siberian Platform. Correlation chart and explanatory notes. *International Union of Geological Sciences Publication*, *27*, 1–133.

Astashkin, V. A., Belyaeva, G. V., Esakova, N. V., Osadchaya, D. V., Pakhomov, M. N., Pegel, T. V., Repina, L. N., Rozanov, A. Yu., & Zhuravlev, A. Yu. (1995). The Cambrian System of the foldbelts of Russia and Mongolia. Correlation chart and explanatory notes. *International Union of Geological Sciences*, *32*, 1–132.

Axheimer, N., Ahlberg, P., & Cederström, P. (2007). A new lower Cambrian eodiscoid trilobite fauna from Swedish Lapland and its implications for intercontinental correlation. *Geological Magazine*, *144*, 953–961. doi: 10.1017/S0016756807003597

Basset, M. G., Owens, R. M., & Rushton, A. W. A. (1976). Lower Cambrian fossils from the Hell's Mouth Grits, St. Tudwal's Peninsula, North Wales. *Journal of the Geological Society of London*, *132*, 623–644.

Betts, M., Paterson, J. R., Jago, J. B., Jacquet, S., Skovsted, C. B., Topper, T. P., & Brock, G. A. (2017). Global correlation of the early Cambrian of South Australia: shelly fauna of the *Dailyatia odyssey* Zone. *Gondwana Research*, *46*, 240–279. doi: 10.1016/j.gr.2017.02.007

Birch, R., & McCobb, L. M. E. (2023). The oldest trilobites in Cambria: Early Cambrian trilobite faunas from the Llanberis Slates Formation, Gwynedd, North Wales. *Proceedings of the Geologists' Association*, *134*, 197–215. doi: 10.1016/j.pgeola.2023.02.003

Claybourn, T. M., Jacquet, S. M., Skovsted, C. B., Topper, T. P., Holmer, L. E., & Brock, G.A. (2019). Mollusks from the upper Shackleton Limestone (Cambrian Series 2), Central Transantarctic Mountains, East Antarctica. *Journal of Paleontology*, *93*, 437–459. doi: 10.1017/jpa.2018.84

Cobbold, E. S. (1910). On some small trilobites from the Cambrian rocks of Comley (Shropshire*). Quarterly Journal of the Geological Society of London*, *66*, 19–51.

Collantes, L. (2024). *Trilobites and stratigraphy of the Marianian Stage (Cambrian Series 2) of the Ossa-Morena Zone, SW Iberia*. (PhD Thesis, Universidade de Coimbra). Available in [https://hdl.handle.net/10316/114928]

Collantes, L., Mayoral, E., Chirivella-Martorell, J. B., & Gozalo, R. (2020). New data on *Marocella* (Mollusca, Helcionelloida) from the Cambrian (Series 2–Miaolingian) of the Iberian Peninsula. *GFF*, *142*(3), 190–205. doi: 10.1080/11035897.2020.1762722

Collantes, L., Mayoral, E., Liñan, E., Gozalo, R., & Pereira, S. (2022). The trilobite *Serrodiscus* Richter & Richter from Iberia, with systematic review of the genus and its international correlation through the Cambrian Series 2. *Bulletin of Geosciences*, *97*(3), 289–317. doi: 10.3140/bull.geosci.1852

Collantes, L., Pereira, S., Mayoral, E., & Gozalo, R. (2023). First report of *Chelediscus* Rushton, 1966 (Trilobita) from Western Gondwana, with description of a new species from the Cambrian Series 2 of Spain. *Historical Biology*, *35*(9), 1701–1708. doi: 10.1080/08912963.2022.2109966

Dies, M. E., & Gozalo, R. (2006). El género *Hamatolenus* Hupé, 1953 (Cámbrico inferior-medio) en Murero y áreas adyacentes de las Cadenas Ibéricas (NE de España). *Spanish Journal of Palaeontology*, *21*, 61–78. doi: 10.7203/sjp.21.1.20481

Duméril, A. M. C. (1806). *Zoologie analytique ou méthode naturelle de classifications des animaux*. Allais.

Evans, K. R. (1992). *Marocella*: Antarctic specimens of an enigmatic Cambrian animal. *Journal of Paleontology*, *66*, 558–562. doi: 10.1017/S0022336000024422

Fricke, W. (1941). *Die Geologie des Grenzgebietes zwischen nordöstlicher Sierra Morena und Extremadura*. (PhD Thesis, Mathematisch-Naturwissenschaftliche Fakultät Berlin).

Fletcher, T. P. (1972). *Geology and lower to middle Cambrian faunas of the southwest Avalon, Newfoundland.* (PhD Thesis, Christ's College, Cambridge).

Fletcher, T. P. (2003). *Ovatoryctocara granulata*: The key to a global Cambrian Stage Boundary and the correlation of the olenellid, redlichiid and paradoxidid realms. *Special Papers in Palaeontology*, *70*, 73–102.

Fletcher, T. P. (2006). Bedrock geology of the Cape St. Mary's Peninsula, Southwest Avalon Peninsula, Newfoundland. *Government of Newfoundland and Labrador, Geological Survey, Department of Natural Resources, St. John's Report*, *06–02*, 1–117.

Fletcher, T. P., & Theokritoff, G. (2008). The Early Cambrian of eastern Massachusetts. *Northeastern Geology and Environmental Sciences*, *30*, 304–329.

Geyer, G. (1986). Mittelkambrische Mollusken aus Marokko und Spanien. *Senckenbergiana Lethaea*, *67*, 55–118.

Geyer, G. (1988). Agnostida aus dem höheren Unterkambrium und der Mittelkambrium von Marokko. Teil 2: Eodiscina. *Neues Jahrbuch Geologie und Paläontologie Abhandlungen*, *177*, 93–133.

Geyer, G. (1990). Die marokkanischen Ellipsocephalidae (Trilobita: Redlichiida). *Beringeria*, *3*, 1–363.

Geyer, G. (2005). The base of a revised Middle Cambrian: are suitable concepts for a series boundary in reach? *Geosciences Journal*, *9*, 81–99.

Geyer, G. (2019). A comprehensive Cambrian correlation chart. *Episodes*, *42*(4), 321–332. doi: 10.18814/epiiugs/2019/019026

Geyer, G., & Elicki, O. (1995). The Lower Cambrian trilobites from the Görlitz Synclinorium (Germany) – review and new results. *Paläontologische Zeitschrift*, *69*(9), 87–119. doi: 10.1007/BF02985976

Geyer, G., & Landing, E. (2006). Morocco 2006. Ediacaran–Cambrian depositional environments and stratigraphy of the western Atlas regions. Explanatory description and field excursión guide. *Beringeria*, *Special Issue*, *6*, 1–120.

Geyer, G., & Malinky, J. M. (2019). Helcionelloid molluscs and hyoliths from the Miaolingian (middle Cambrian) of the subsurface of the Delitzsch–Torgau–Doberlug Syncline, northern Saxony, Germany. *Paläontologische Zeitschrift*, *93*, 23. doi: 10.1007/s12542-019-00472-z

Geyer, G., & Shergold, J. (2000). The quest for internationally recognized divisions of Cambrian time. *Episodes*, *23*(3), 188–195.

Geyer, G., Landing, E., & Heldmaier, W. (1995). Faunas and depositional environments of the Cambrian of the Moroccan Atlas regions. *Beringeria*, *Special Issue 2*, 47–119.

Gil Cid, M. D. (1972). Aportación al conocimiento del Cámbrico inferior de Sierra Morena. *Boletín de la Real Sociedad Española de Historia Natural*, *70*(4), 215–222.

Gil Cid, M. D. (1988). Nuevos datos sobre la fauna del Cámbrico inferior (Marianiense) de Llerena (Badajoz). *Boletín Geológico y Minero*, *99*(4), 578–583.

Hutchinson, R. D. (1962). Cambrian stratigraphy and trilobite faunas of southeastern Newfoundland. *Bulletin of the Geological Survey of Canada*, *88*, 1–165.

Hupé, P. (1953). Contribution a l'étude du Cambrien inférieur et du Précambrien III de l'Anti-Atlas marocain. *Notes et Mémoires, Service des Mines et de la Carte géologique du Maroc*, *103*, 1–402.

Jacquet, S. M., & Brock, G. A. (2016). Lower Cambrian helcionelloid macromolluscs from South Australia. *Gondwana Research*, *36*, 333–358. doi: 10.1016/j.gr.2015.06.012

Kaesler, R. L. (1997). *Treatise on invertebrate paleontology. Part O. Arthropoda 1. Trilobita, Revised. Volume 1: Introduction, Order Agnostida, Order Redlichiida*. Geological Society of America and University of Kansas, Boulder, Colorado and Lawrence.

Kobayashi, T. (1939). On the agnostids (Part 1). *Journal of the Faculty of Science*, *Imperial University of Tokyo*, *5*(5), 70–198.

Kobayashi, T. (1943). Brief notes on the eodiscids 1, their classification with a description of a new species and a new variety. *Proceedings of the Imperial Academy of Japan*, *19*, 37–42.

Korovnikov, I. V., & Novozhilova, N. V. (2012). New biostratigraphical constraints on the Lower and lower Middle Cambrian of the Kharaulakh Mountains (northeastern Siberian Platform, Chekurovka anticline). *Russian Geology and Geophysics*, *53*, 776–786.

Lazarenko, N. P. (1957). New data on the trilobite genus Triangulaspis. *Sbornik Statei Po Paleontologii i Biostratigrafii*, *3*, 3–16. [in Russian]

Lazarenko, N. P. (1962). New Lower Cambrian trilobites from the Soviet Arctic. *Sbornik Statei po Paleontologii i Biostratigrafii (NIIGA)*, *29*, 29–78. [in Russian]

Lermontova, E. V. (1940). Class Trilobita. In A. G. Vologdin (Ed.), *Atlas of the Index Forms of Fossil Faunas of the USSR*, Moscow, 112–162. [in Russian]

Li, L., Zhang, X., Skovsted, C. B., Yun, H., Pan, B., & Li, G. (2019). Revisiting the molluscan fauna from the Cambrian (Series 2, Stages 3–4) Xinji Formation of North China. *Papers in Palaeontology*, *7*(1), 521–564. doi: 10.1002/spp2.1289

Lin, T. R. (1999). Discovery of Middle Cambrian *Marocella* from Yaxian County, Hainan Province, China. *Acta Palaeontologica Sinica*, *38*, 102–105.

Linnaeus, C. (1758). *Systema naturæ: per regna tria naturaæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Impensis Direct Laurentii Salvii, Holmiæ.

Liñán, E. (1984). Introducción a la paleogeografía del Cámbrico de Ossa Morena. *Cuadernos do Laboratorio Xeolóxico de Laxe*, *8*, 283–314.

Liñán, E., & Gozalo, R. (1986). Trilobites del Cámbrico Inferior y Medio de Murero (Cordillera Ibérica). *Memorias del Museo Paleontológico de la Universidad de Zaragoza, 2*, 1–104.

Liñán, E., & Mergl, M. (2001). Lower and Middle Cambrian brachiopods from the Iberian Chains and Sierra Morena (Spain). *Spanish Journal of Palaeontology*, *16*(2), 317–337. doi: 10.7203/sjp.16.2.21607

Liñán, E., & Perejón, A. (1981). El Cámbrico inferior de la Unidad de Alconera, Badajoz (SW de España). *Boletín de la Real Sociedad Española de Historia Natural (Geología)*, *79*, 125–148.

Liñán, E., & Quesada, C. (1990). Ossa-Morena Zone stratigraphy: rift phase (Cambrian). In R. D. Dallmeyer, & E. Martínez García, (Eds.), *Pre-Mesozoic Geology of Iberia* (pp. 259–271). Springer-Verlag.

Liñán, E., Collantes, L., Mayoral, E., & Gozalo, R. (in press). Trilobite biostratigraphy of the Marianian (Cambrian Series 2) from Seville and Badajoz provinces (Zafra-Alanís Domain, Ossa-Morena Zone, Spain): A review. *Journal of Iberian Geology*. doi: 10.1007/s41513-024-00247-9

Lotze, F. (1939). Hallazgo de trilobites cambrianos en las provincias de Huelva, Badajoz y Sevilla. *Anales de la Sociedad Española para el Progreso de las Ciencias*, *4*, 622.

Lotze, F. (1958). Zur Stratigraphie des spanischen Kambriums. *Geologie*, *7*, 727–750.

Lotze, F. (1961). Das Kambrium Spaniens. Teil 1: Stratigraphie. *Akademie der Wissenschaften und der Literatur, Abhandlungen der mathematisch naturwissenschaftlichen Klasse*, *6*, 1–216.

Matthew, G. F. (1887). Illustrations of the fauna of the St. John Group. No. 4. - On the smaller-eyed trilobites of Division I., with a few remarks on the species of the higher divisions of the group. *Canadian Record of Science*, *2*, 357–363.

Matthew, G. F. (1892). *Protolenus*: A new genus of Cambrian trilobites. *Bulletin of the Natural History Society of New Brunswick*, *10*, 34–37.

Matthew, G. F. (1899). Studies on the Cambrian faunas. No. 4 – Fragments of the Cambrian faunas of Newfoundland. *Proceedings and Transactions of the Royal Society of Canada*, *5*, 67–95.

Mghazli, K., Lazreq, N., Geyer, G., Landing, E., Boumehdi, M. A., & Youbi, N. (2023). Cambrian microfossils from the High Atlas, Morocco: Taxonomic, biostratigraphic, palaeobiogeographic, and depositional significance of the Brèche à *Micmacca* limestone beds. *Journal of African Earth Sciences*, *197*, 104751.

Peel, J. S. (1991). Functional Morphology of the Class Helcionelloida nov., and the Early Evolution of the Mollusca. In A. M. Simonetta, & S. Conway Morris (Eds.), *The Early Evolution of Metazoa and the Significance of Problematic Taxa* (pp. 157–177). Cambridge University Press.

Pelman, Y. L. (1977). Ranne i srednekembrijskie bezzamkovije brachiopody Sibirskoj platformy. *Trudy Instituta Geologii i Geofiziki*, *319*, 1–167. [in Russian]

Parkhaev, P. Y. (2019). Cambrian Mollusks of Australia: taxonomy, biostratigraphy and paleobiogeography. *Stratigraphy and Geological Correlation*, *27*, 181–206. doi: 10.31857/S0869-592X27252-79

Popov, L. E., & Holmer, L. E. (2000). Class Obolellata. In R. L. Kaesler (Ed.), *Treatise on Invertebrate Paleontology*, *Part H*, *Brachiopoda*, *Vol. 2*. (pp. 200–208). The Geological Society of America and the University of Kansas Press.

Rasetti, F. (1967). Lower and middle Cambrian trilobite faunas from the Taconic sequence of New York. *Smithsonian Miscellaneous Collections*, *152*, 1–111.

Repina, L. N. (1972). Trilobites from the Taryn Horizon of the Lower Cambrian sections in the Sukharikha River (Igarka area). In I. T. Zhuravleva (Ed.), *Problems of Lower Cambrian stratigraphy and palaeontology in Siberia* (pp. 184–216). Nauka. [in Russian]

Repina, L. N., Khomentovskij, V. V., Zhuravleva, I. T., & Rozanov, A. J. (1964). *Lower Cambrian Biostratigraphy* *of the Sayan-Altai Folded Region. Akademiya Nauk SSSR*, Sibirskoe Otdelenie, Institut Geologii i Geofiziki, Izdatel′stvo Nauka. [in Russian]

Repina, L. N., Lazarenko, N. P., Meshkova, N. P., Korshunov, V. I., Nikiphorov, N. I., & Aksarina, N. A. (1974). *Biostratigraphy and fauna of the lower Cambrian of Charaulach (ridge Toura-Sis)*. Nauka.

Richter, R. (1932). Crustacea (Paläontologie). In R. Dittler, G. Joos, E. Korschelt, G. Linek, F. Oltmanns, & K. Schaum (Eds.), *Handwörterbuch der Naturwissenschaften* (second edition) (pp. 840– 864). Gustav Fisher.

Richter, R., & Richter, E. (1941). Die Faune des Unter-Kambriums von Cala in Andalusien. *Abhandlugen Der Senckenbergische Naturforschenden Gessellschaft*, *455*, 1–90.

Rowell, A. J. (1965). Inarticulata. In R. C. Moore (Ed,), *Treatise on Invertebrate Paleontology, part H, Brachiopoda* (pp. H260–H297), Geological society of America and University of Kansas Press.

Rushton, A. W. A. (1966). The Cambrian trilobites from the Purley Shales of Warwickshire. *Palaeontographical Society Monographs*, *120*(511), 1–55.

Schwarzbach, M. (1934). Neue Trilobiten aus dem Cambrium der Oberlausitz. *Sonder-Abdruck aus dem Centralblatt fur Mineralogie, Geologie und Paläontologie*, *Abteilung B*, *11*, 586–593.

Sdzuy, K. (1958). Neue Trilobiten aus dem Mittelkambrium von Spanien. *Seckenbergiana lethaea*, *39*, 235–253.

Sdzuy, K. (1961). Das Kambrium Spaniens. Teil II Trilobiten. *Abhandlungen der mathematisch-naturwissenschaftlichen Klasse*, *1961*, *Akademie der Wissenschaften und der Literatur*, 502–694.

Sdzuy, K. (1962). Trilobiten aus dem Unter-Kambrium der Sierra Morena (S-Spanien). *Seckenbergiana lethaea*, *43*, 181–229.

Sdzuy, K. (1972). Das Kambrium der acadobaltischen Faunenprovinz. *Zentralblatt Für Geologie Und Paläontologie, Teil II*, *1972*(1–2), 1–91.

Sdzuy, K. (2001). La reformación de fósiles deformados demostrado en trilobites del piso Marianiense (Cámbrico inferior) del Sur de la Península Ibérica. *Boletín de la Real Sociedad Española de Historia Natural*, *96*(3–4), 85–100.

Sepúlveda, A., Chirivella-Martorell, J. B., Collantes, L., Mayoral, E., Liñán & Gozalo, R. (in press). Upper Marianian (Cambrian Series 2) trilobites from the Totanés–Noez area (Central Iberian Zone, Toledo province, Spain): systematics and intercontinental correlation. *Journal of Iberian Geology*. doi: 10.1007/s41513-024-00231-3

Shaler, N. S., & Foerste, A. F. (1888). Preliminary description of North Attleborough fossils. *Bulletin of the Museum of Comparative Zoology*, *2*(16), 27–41.

Shaw, A. B. (1950). A revision of several early Cambrian trilobites from eastern Massachusetts. *Journal of Paleontology*, *24*(5), 577–590.

Shergold, J., & Geyer, G. (2003). The Subcomission on Cambrian Stratigraphy: the status quo. *Geologica Acta*, *1*(1), 5–9.

Simon, W. (1951). Untersudrungen im Paläozoikum von Sevilla (Sierra Morena, Spanien). *Abhandlugen der senckenbergische naturforschenden Gessellschaft*, *485*, 31–52.

Sundberg, F. A., Geyer, G., Kruse, P. D., McCollum, L. B., Pegel, T. V., Żylińska, A., & Zhuravlev, A. (2016). International correlation of the Cambrian Series 2-3, Stages 4-5 boundary interval. *Australasian Palaeontological Memoirs*, *49*, 83–124.

Toll, E. (1899). Beiträge zur Kenntniss des Sibirischen Cambrium. *Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg*, *8*(10), 1–57.

Topper, T., Brock, G. A., Skovsted, C. B., & Paterson, J. R. (2009). Shelly fossils from the lower Cambrian *Pararaia bunyerooensis* Zone, Flinders Ranges, South Australia. *Memoirs of the Association of Australasian Palaeontologists*, 37, 199–246.

Vostokova, V. A. (1962). Kembriyskie gastropody Sibirskoy platformy i Taymyra. *Sbornik Statey po Paleontologii i Biostratigrafii*, *28*, 51–74. [in Russian]

Walch, J. E. I. (1771). *Die Naturgeschichte der Versteinerungen zur Erläuterung der Knorrischen Sammlungen von Merkwürdigkeiten der Natur*. Felsecker Offizin.

Walcott, C. D. (1908). Cambrian Geology and Paleontology, pt. 3 – Cambrian Brachiopoda, descriptions of new genera and species. *Smithsonian Miscellaneous Collections*, *53*, 53–137.

Westrop, S. R., & Landing, E. (2000). Lower Cambrian (Branchian) trilobites and biostratigraphy of the Hanford Brook Formation, southern New Brunswick. *Journal of Paleontology*, *74*(5), 858–878. doi: 10.1017/S0022336000033060

Westrop, S., & Landing, E. (2011). Lower Cambrian (Branchian) eodiscoid trilobites from the lower Brigus Formation, Avalon Peninsula, Newfoundland, Canada. *Memoirs of the Association of Australasian Palaeontologists*, *42*, 209–262.

Williams, A., Carlson, S. J., Brunton, C. H. C., Holmer, L. E., & Popov, L. (1996). A supra-ordinal classification of the Brachiopoda. *Philosophical Transactions of the Royal Society of London*, *Series B*, *351*, 1171–1193. doi: 10.1098/rstb.1996.0101

Yochelson, E. L., & Gil Cid, M. D. (1984). Reevaluation of the systematic position of *Scenella*. *Lethaia*, *17*(3), 331–340. doi: 10.1111/j.1502-3931.1984.tb02024.x