

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

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Abstract: The Marianiian (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 Marianiian 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.

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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 *Protaldonaia 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 (n° 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

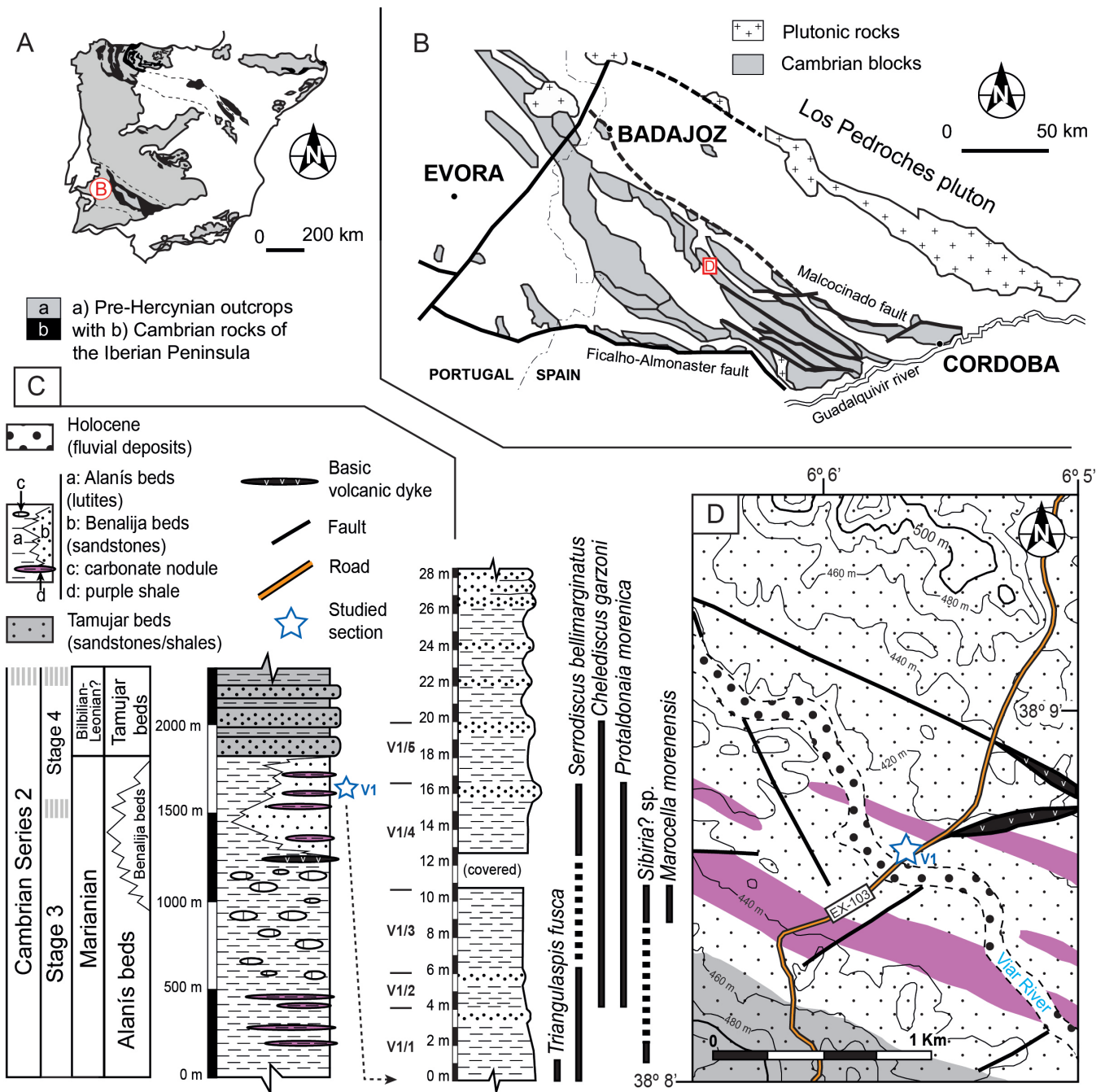


Figure 1. **A**, Pre-Hercynian outcrops of the Iberian Peninsula; **B**, geological setting of fossil site in the Cambrian blocks of the Ossa-Morena Zone, indicating the position of the studied fossil site, modified from Liñán and Quesada (1990); **C**, stratigraphic column of the Viar-Benalija Block, 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, *Triangluaspis 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.**, exsagittal; **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 PALAEOLOGY

Class TRILOBITA Walch, 1771
Order REDLICHIIA Richter, 1932
Suborder REDLICHIIINA 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 acuminate 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 cranium (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-Palares 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 cranium. Anterior border slightly curved backwards, subtly domed, acuminate 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 cranium, 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 acuminate, 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 cranial width (tr.); subtly curved. Domed,

subtrapezoidal palpebral area, about 35% of the total cranial width (tr.). Reduced posterior area, rectangular to trapezoidal outline. Deep, wide (sag.) posterior furrow, widened laterally (exsag.), about 8% of the total cranial

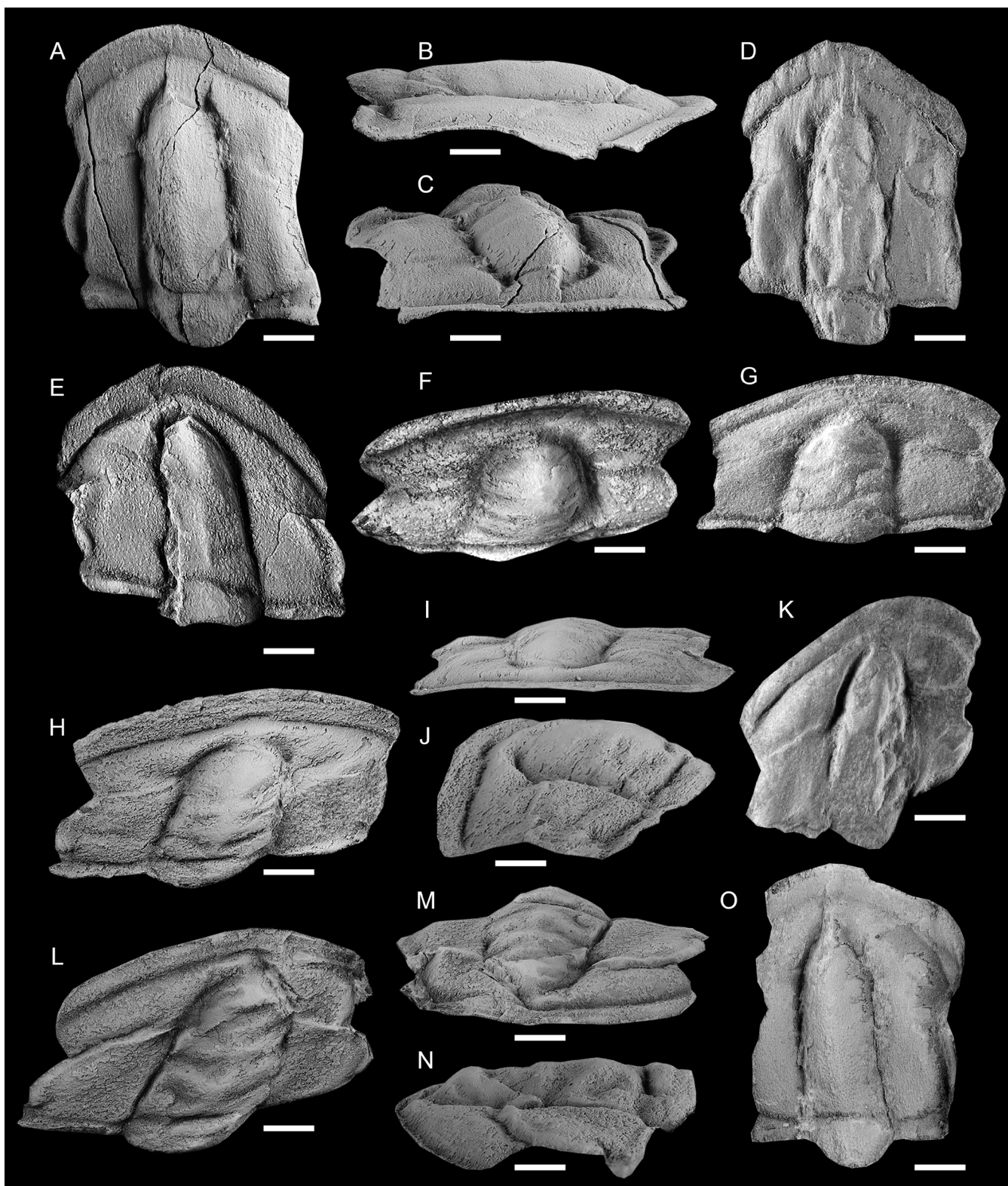


Figure 2. *Protaldonaia morenica* Sdzuy, 1961 (cranidia), upper Marianian, Viar River section, Badajoz, Spain. **A–C**, MPZ–2021/249; **A**, dorsal view; **B**, frontal view; **C**, lateral view; **D**, DPM-A234-824-LL038, dorsal view; **E**, SMF X 16803a, dorsal view; **F**, SMF X 16864, dorsal view; **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).

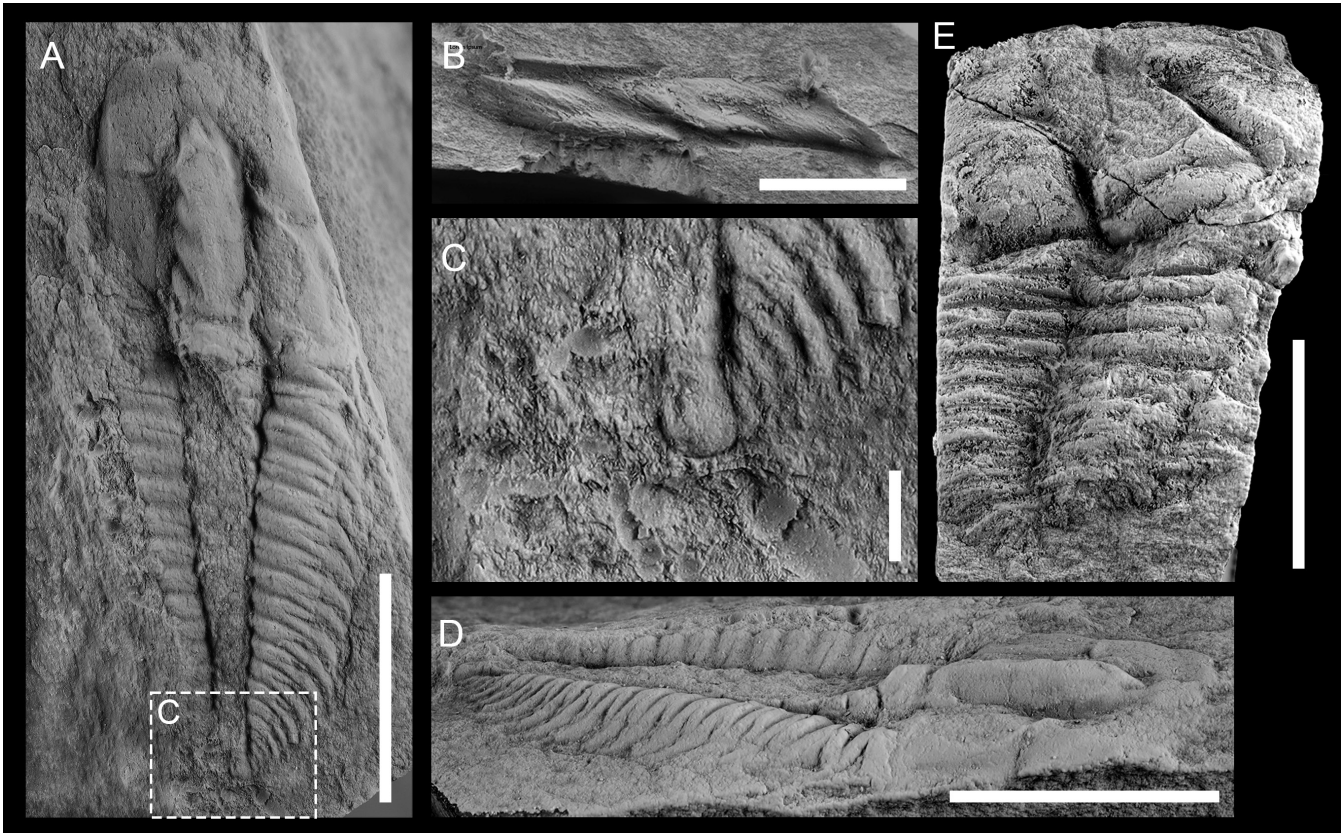


Figure 3. *Protaldonaia morenica* Szduy, 1961, upper Marianian, Viar River section, Badajoz, Spain. **A**, MPZ-2021/224, articulated specimen, dorsal view; **B**, MPZ-2021/225, pleura, dorsal view; **C**, MPZ-2021/224, detail of the pygidium, dorsal view; **D**, MPZ-2021/224, articulated specimen, lateral 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 acuminate; 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 cephalata (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 cephalon. 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 cephalon (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*, *speciosus* 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

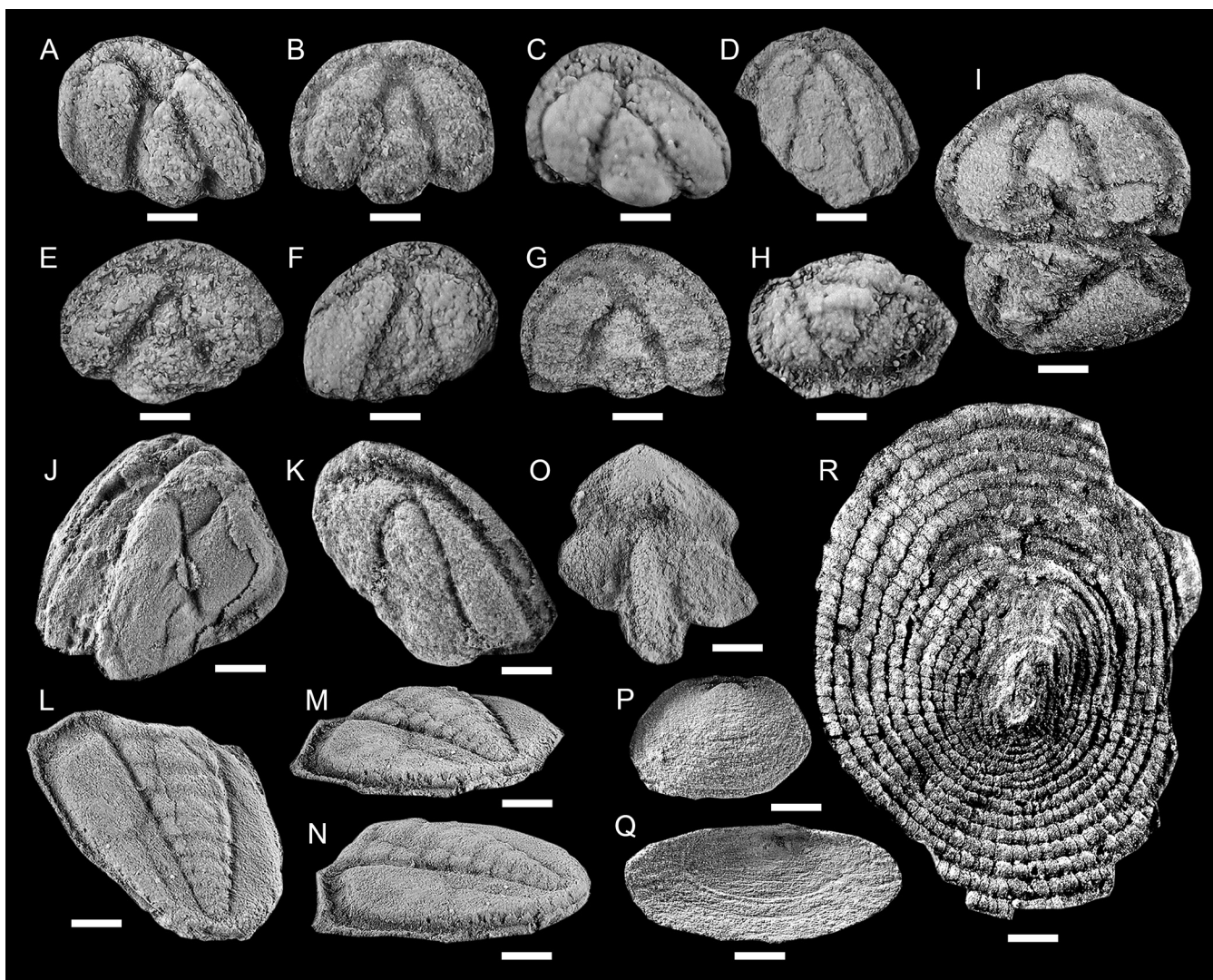


Figure 4. Upper Marianian trilobites and SSF from the Viar River section, Badajoz, Spain. **A–I**, *Chelediscus garzoni* Collantes, Pereira, Mayoral & Gozalo, 2023; **A**, MPZ–2022/779, cephalon, dorsal view; **B**, MPZ–2022/780, cephalon, dorsal view; **C**, MPZ–2022/782, cephalon, dorsal view; **D**, 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,

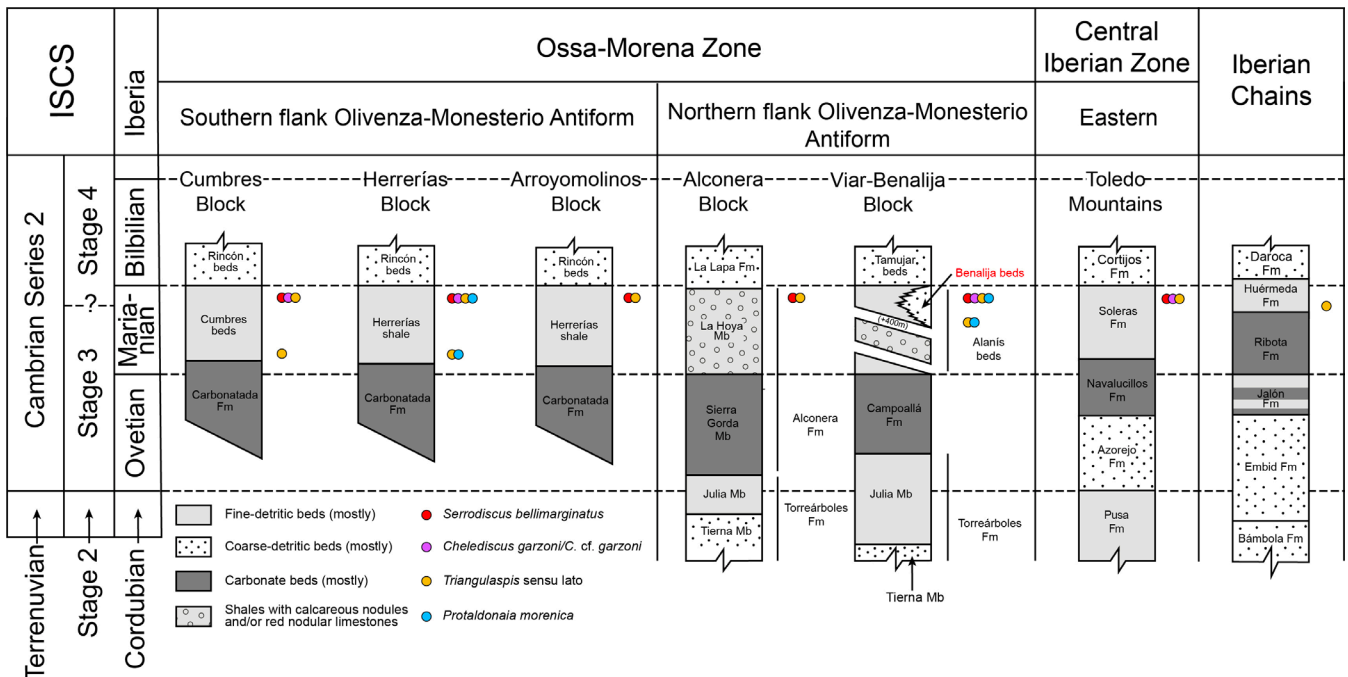


Figure 5. Stratigraphic position and distribution of the studied trilobite species from the Viar river fossil site along the Cambrian outcrops of the Ossa-Morena Zone, the Central Iberian Zone and the Iberian Chains.

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, it 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. Additionally, 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 be 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.

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