

150 years of the discovery of the Cambrian Lagerstätte of Murero (Cadenas Ibéricas, NE Spain)

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Abstract

The classical, lower and middle Cambrian Lagerstätte of Murero (NE Spain) was first reported by the French geologist Edouard de Verneuil in 1862, and now it achieves 150 years of geological works. In this paper the main stratigraphical and palaeontological characteristics of the site are given. Murero is exceptional because the coexistence of both skeletal and soft-bodied groups along a continuous record of ca. 10 million years, which is subdivided into 14 trilobite biozones. The educational and social interest of the site is also highlighted.

Key words: Palaeontological heritage, Stratigraphy, Palaeontology, Biochronology, Palaeoecology, Cadenas Ibéricas, Spain.

Introduction

Murero is a small village placed 8 km West from the medieval town of Daroca (Aragón, Zaragoza Province, NE Spain). It is renowned for its Cambrian Lagerstätte since 1862, when the French geologist Edouard de Verneuil discovered the “primordial fauna”, here composed of paradoxidid and conocoryphid trilobites. Later it was included in the doctoral thesis of Dereims (1898). Since then, several other thesis and over one hundred geological papers dealing with the Cambrian of Murero have appeared, and near eighty trilobite taxa are known. Murero is thus a classic locality with regard to the palaeontology of late lower and middle Cambrian times, including the transition between Cambrian Series 2 and 3 (Gozalo *et al.*, in press). In the present year, the 150th anni-

versary of the discovery of the site is celebrated.

For a thorough overview of the history of geological studies in Murero see Liñán & Gozalo (1986, 1999). The monographs by Sdzuy (1961) and Liñán & Gozalo (1986) are perhaps the most relevant palaeontological contributions to the understanding of the site, since they describe most of the trilobite species used in building the late lower – mid middle Cambrian Mediterranean biochronology (Mediterranean Province) (Liñán *et al.*, 1993).

Geology and stratigraphy

Murero is located in the Cadena Ibérica Occidental (Badules Unit), in the heart of the Iberian Mountains. The fossiliferous successions near Murero are located in the so – called Villafeliche block, cropping out in a normal succession dipping SW, being affected by minor normal faults. The Cambrian strata are exposed to the North of the village along the Rambla de Valdemedes. The two main stratigraphic sections are located on its right (Rambla de Valdemedes 1, or RV1) and left (RV2) banks (Liñán & Gozalo, 1986) (Figs. 1 and 2).

From a stratigraphic point of view, the Murero Lagerstätte embraces from the partially exposed Mesones Group (195 m in thickness; comprising the upper Valdemedes, Mansilla, and Murero formations) to the basal Acón Group, ranging in age from the Upper Bilbilian (Cambrian Series 2, Stage 4) through the Lower Languedocian (Cambrian Series 3, Drumian

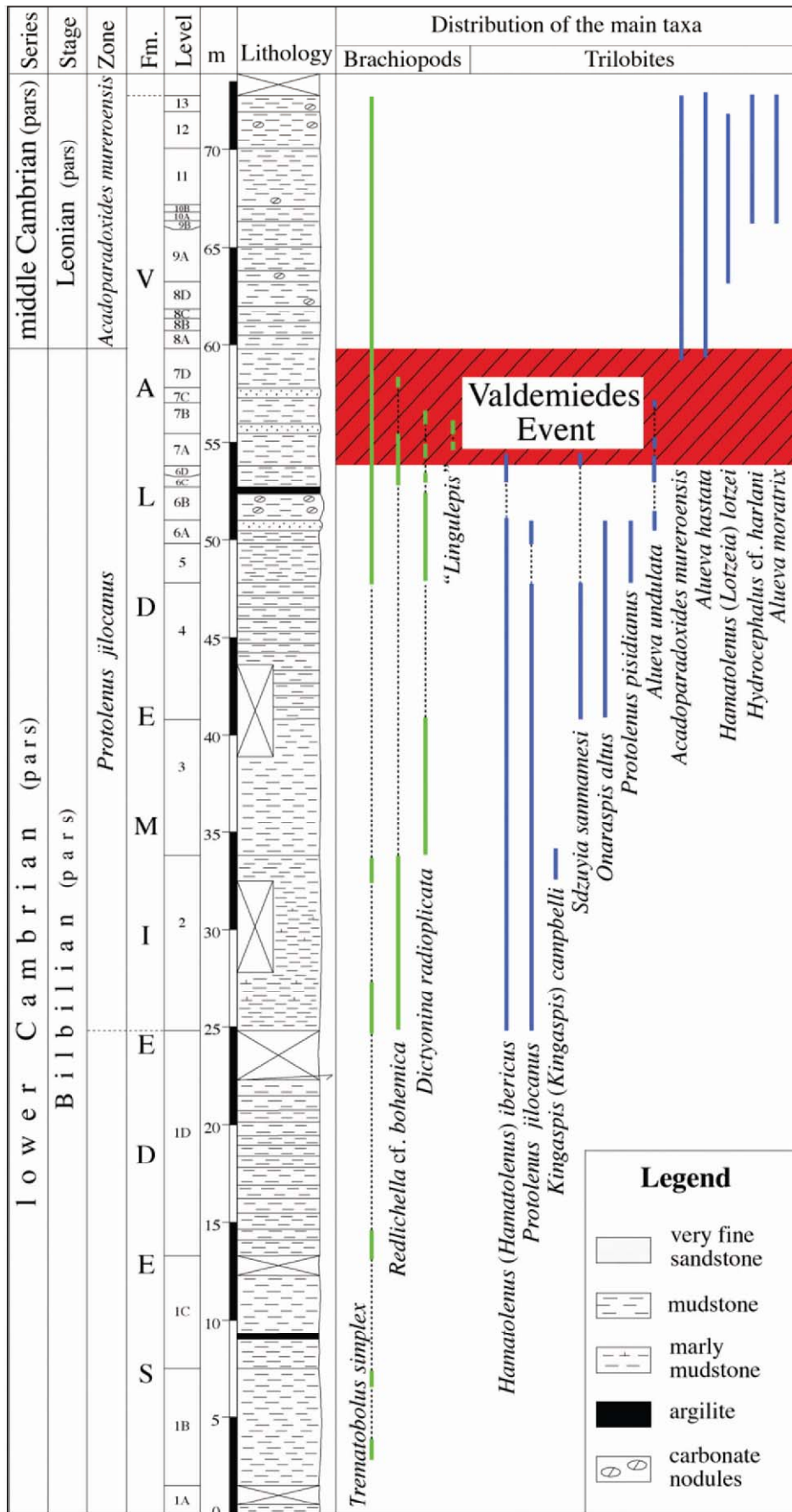


Figure 1. Litho-, bio- and chronostratigraphy of the lower part of the Rambla de Valdemiesdes 2 section, with indication of brachiopod and trilobite taxa, and the Valdemiesdes Event. (Slightly modified from Dies Álvarez, 2004.)

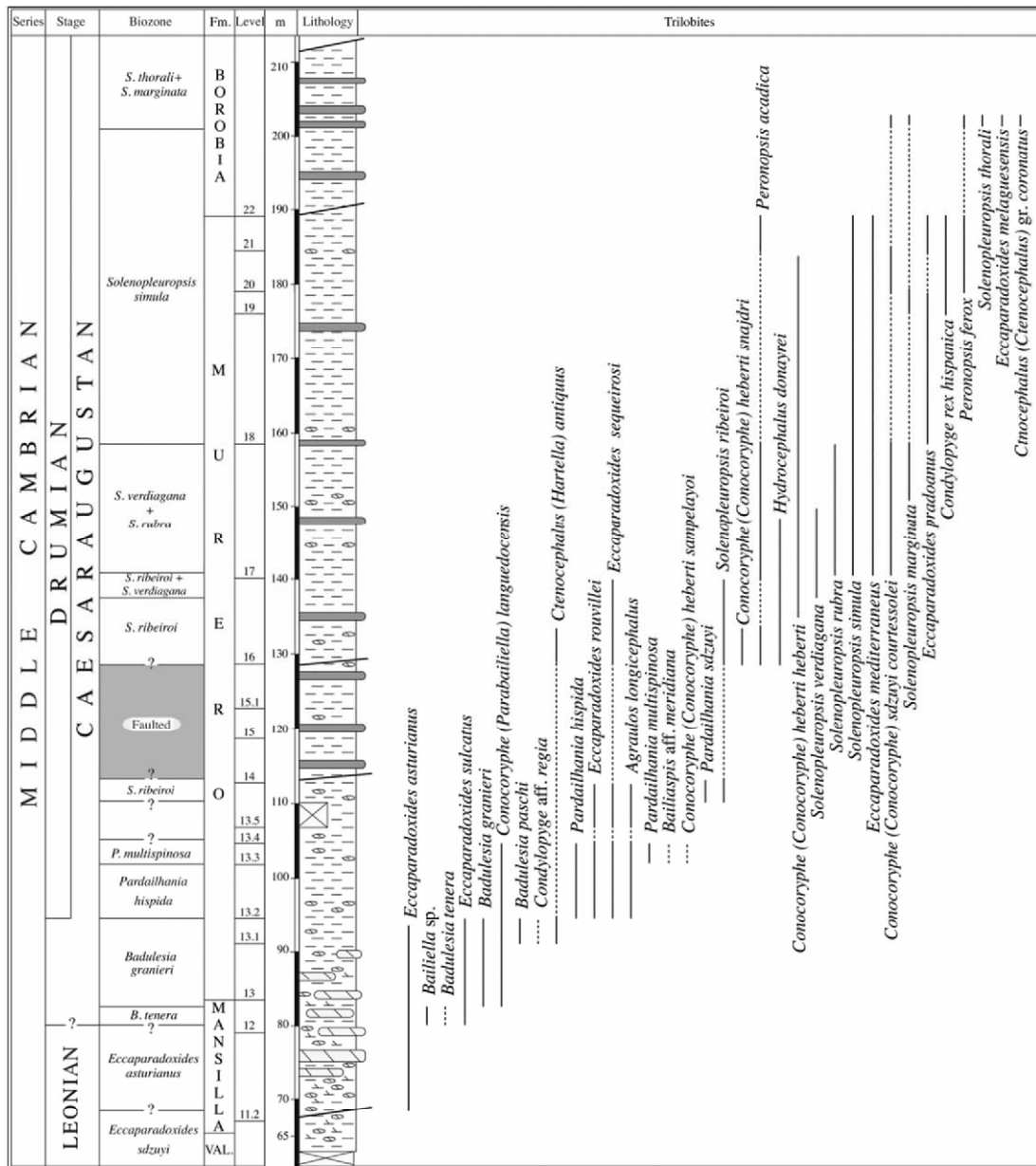


Figure 2. Litho-, bio- and chronostratigraphy of the upper part of the Rambla de Valdemiedes 1 section. Only trilobite taxa are shown. (Slightly modified from Liñán et al., 2008.)

Stage). The whole succession is represented mainly by fine-grained siliciclastic rocks – silty mudstone and shale – with carbonate nodules and occasional thin dolostone interbeds (dolostone is more abundant in the Mansilla Formation). Mineralogical data indicates the mudstones of the Mesones Group experienced an incipient anchimetamorphism (Bauluz et al., 1998). The succession represents a transgressive – highstand – transgressive systems tract succession.

As for the biochronology, the Murero site features a continuous record of ca. 10 million years (from ca. – 515 Ma to ca. – 505 Ma), which is subdivided into 14 trilobite biozones, the finest subdivision in the world for this time interval (Gozalo et

al., 2008; Liñán et al., 2008), which are from the bottom to the top the zones of *Protolenus jillocanus*, *Acadoparadoxides mureoensis*, *Eccaparadoxides sdzuyi*, *Eccaparadoxides asturianus*, *Badulesia tenera*, *Badulesia granieri*, *Pardailhania hispida*, *Pardailhania multispinosa*, *Pardailhania sdzuyi* +, *Solenopleuropsis ribeiroi*, *Solenopleuropsis ribeiroi* + *S. verdiagana*, *Solenopleuropsis verdiagana* + *S. rubra*, *Solenopleuropsis simula*, and *Solenopleuropsis thoralis* + *S. marginata*.

The classical lower – middle Cambrian (i.e., Bilbilian – Leonian) boundary is placed at the FAD of the polymeroid trilobite *Acadoparadoxides mureoensis* Sdzuy, 1958 (Fig. 3b), underlain by strata with

scarce fauna recording the Valdemiedes Event (Fig. 1), which shows a pronounced negative $\delta^{13}\text{C}_{\text{org}}$ excursion at its base; this event coincided in time with the extinction of olenellid trilobites in Laurentia (Gozalo et al., in press).

Palaeontology

Cambrian strata in Murero are amazingly fossiliferous and show exceptionally preserved specimens of both skeletal and soft-bodied groups (Figs. 3 and 4). Trilobites are especially abundant, with near to eighty species described (Fig. 3) (Gozalo et al., 2008). Among them, the wealth of the paradoxidid record has permitted to demonstrate that intraspecific (most probably sexual) dimorphism existed in trilobites by Middle Cambrian times (Gozalo et al., 2003). Other arthropods include arachnomorphs and bradoriids (Gozalo et al., 2004). Brachiopods sum six species (Liñán & Mergl, 2001). Echinoderms include eocrinoids, edrioasteroids, and cinctans, summing up fifteen taxa (Zamora, 2011). Hyoliths are also present.

The first description of Burgess Shale-type fossils from Murero was made by Conway Morris & Robison (1986). Later studies have increased the importance of this Lagerstätte in the understanding of Cambrian life. Several chlorophytic and phaeophytic algae, sponges (García - Bellido et al., 2011), ecdysozoans (palaeoscolecidans and xenusian lobopods; Gámez Vintaned et al., 2011) and twenty ichnotaxa (Gámez Vintaned & Mayoral Alfaro, 1995) have been described from Murero. Other groups are still under study.

In general terms, the depositional environment in Murero is interpreted as a low-to-moderate energy, relatively warm water open sublittoral (infralittoral) shelf (Fig. 5).

Murero as an educational resource

Starting at least in the late 1970's, the Murero site is visited by students of numerous Spanish universities and also by pre-university groups. It has also been used as an example in Geology didactics. In consonance with its scientific and social importance, Murero was the first palaeontological site in Spain to obtain the highest protection figure (*Bien de Interés Cultural BIC*,) from the Spanish Administration in 1997. In the recent years, two tourist/educational field geological routes have been set up in the Rambla de Valdemiedes and also on the way from Daroca to Murero, and a third one is planned (Dies Álvarez et

al., 2009). An all-audience oriented, scientific documentary about the Cambrian Explosion which features the Murero Lagerstätte has also recently been produced (Liñán & Bayón, 2009).

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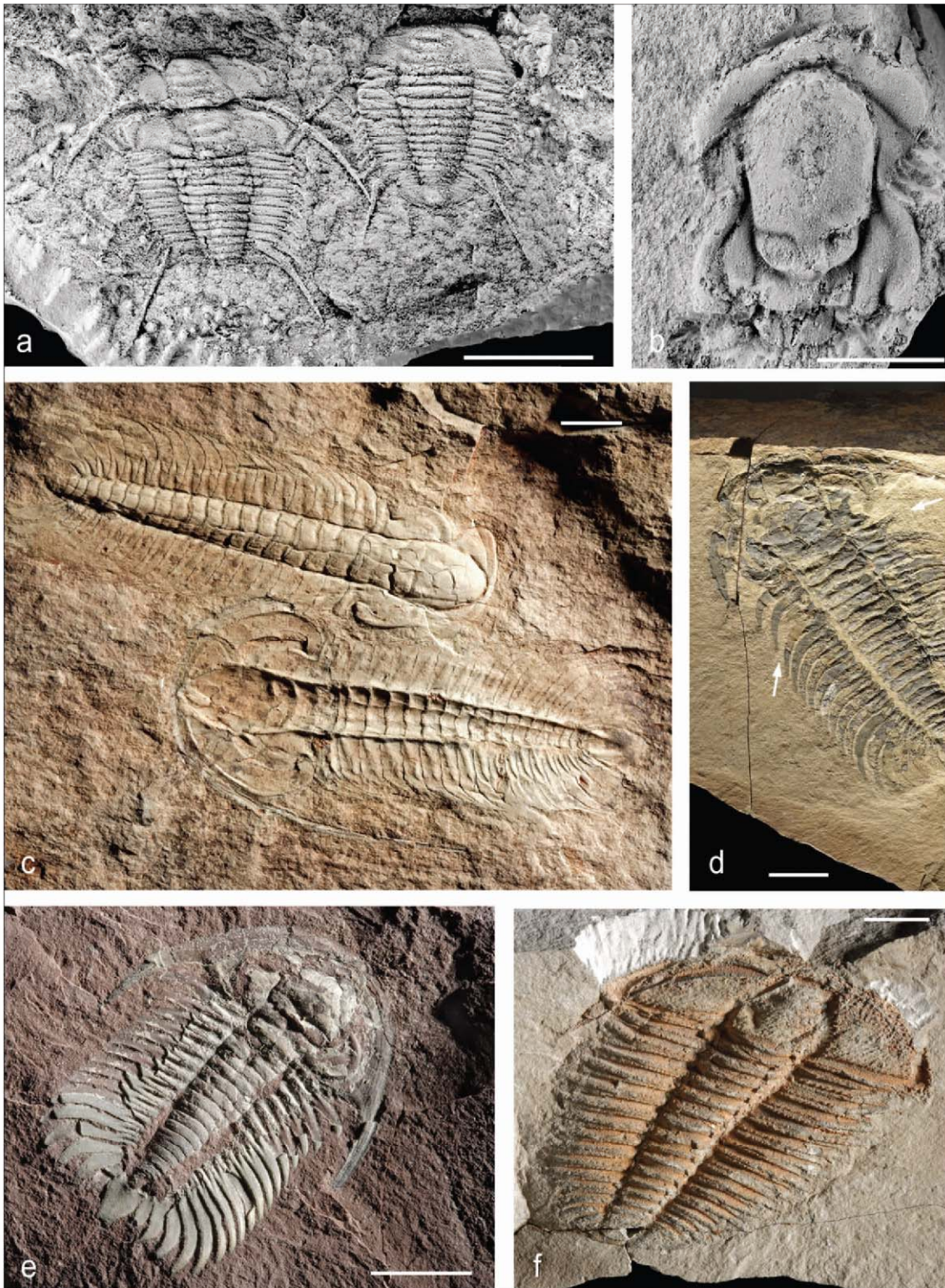


Figure 3. Lower (a, Bilbilian) and middle Cambrian (b, Leonian; c-f, Caesaraugustan) trilobites from the Murero biota. a. *Onaraspis altus* (Liñán & Gozalo, 1986). Specimens MPZ 99/515b (left) and MPZ 99/586b (right) (Museo Paleontológico de la Universidad de Zaragoza, Spain). Latex replica of two complete specimens and one cranium. Upper Valdemiedes Formation. b. *Acadoparadoxides mureoensis* Sdzuy, 1958. MPZ 2003/682. Internal mould of cranium. Upper Valdemiedes Formation. c. *Eccaparadoxides mediterraneus* Pompeckj, 1901. MPZ 3004. Internal and external moulds of two specimens (one complete); morphotypes A and B. Murero Formation. d. *E. sequeirosi* Liñán and Gozalo, 1986. MPZ 2006/375a. Internal mould of complete specimen showing shortened pleural spine on the left and (right) anterior part of the thorax (arrows). Murero Formation. e. *E. pradoanus* De Verneuil and Barrande, 1860. MPZ 2006/374a. Internal mould of complete specimen. Murero Formation. f. *Conocoryphe* (*C.*) *heberti* Munier – Chalmas and Bergeron, 1889. MPZ 2006/21. Internal mould of complete specimen. Murero Formation. (Scale bar = 10 mm in all photographs.)



Figure 4. Selected, uppermost lower (c – e) and middle (a, b, f, and g) Cambrian shelly and soft body fossils from the Murero biota. a. *Schistoscolex* sp. nov. Palaeoscolecoid worm. Specimen MPZ 2006/372 (Museo Paleontológico de la Universidad de Zaragoza, Spain). Murero Formation; Upper Caesaraugustan. b. *Aragonia szuyi* Ferrer, Liñán and Diez, 1995. Phaeophyta. Specimen MPZ 95/176. Murero Formation; Upper Caesaraugustan. c. *Crumillospongia mureroensis* García – Bellido *et al.*, 2011. Incomplete specimen. MPZ 2008/158a. Upper Valdemiedes Formation; Upper Bilbilian. d, e. *Trematobolus simplex* (Vogel, 1962). External mould of ventral (d) and internal mould of dorsal (e) valves. Valdemiedes Formation. f. *Gogia parsleyi* Zamora in Zamora *et al.*, 2009. Lateral view. MPZ 2004/161b (right) and MPZ 2004/162b (left). Murero Formation; Lower Caesaraugustan. g. *Gyrocystis testudiformis* Friedrich, 1993. Ventral side. MPZ 2006/373a. Murero Formation; Caesaraugustan. (Scale bar = 10 mm in a – c, f, g, and 1 mm in d, e.)

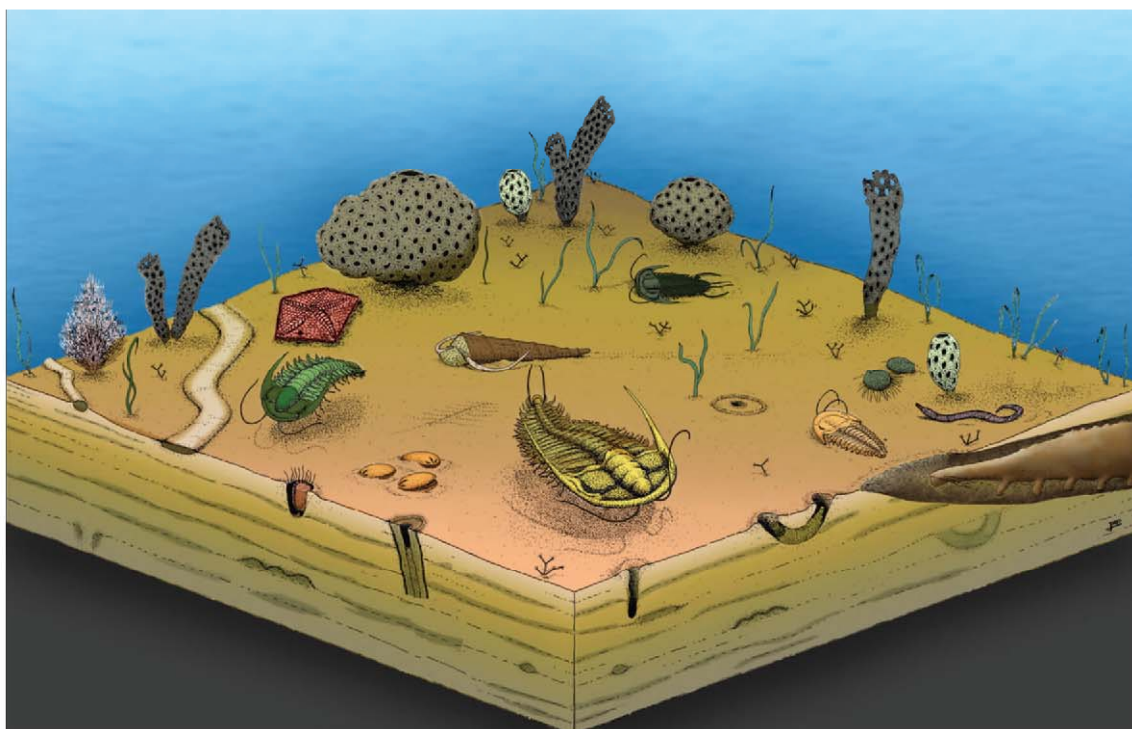


Figure 5. Synthetic palaeoecological reconstruction towards the end of the Bilbilian Age in Murero. (See the reconstruction of the xenusian lobopod *Mureropodia mureroensis* Gámez Vintaned *et al.* , 2011 on the lower right.)

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