

New biostratigraphical data from the Ordovician of Bulgaria

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Introduction

Ordovician sedimentary rocks from Bulgaria are mainly integrated in the Balkan and Moesian terranes, which are part of the complex tectonic collage of the pre–Alpine basement and Alpine terranes of the Balkan Peninsula.

Ordovician fossils were first identified in Bulgaria by Haberfelner and Bonchev (1934), who described a locality bearing some identifiable graptolites, as well as few trilobite fragments and nautiloids, considered to be of "upper Skiddaw" age. Zaharieva–Kovacheva (1957), Spasov (1958) and Belev (1963) added five other localities with Ordovician fossils, leading to the characterization of diverse "Llanvirn" to "Caradoc" graptolites (*Didymograptus perneri*, *D. murchisoni*, *Glyptograptus dentatus*), brachiopods (*Chonetoides aquila*) and trilobites (*Pricyclopyge prisca*, *P. prisca longicephala*, *Cyclopyge rediviva*, *Ectillaenus perovalis hughesi* and *Pseudobasilicus* sp.). These taxa, represented by less than fifty fossil samples (including only 11 trilobite specimens), were repeatedly listed in more than twenty papers on Bulgarian regional topics and geological syntheses, published between 1955 and 2000.

In the meantime, Ordovician acritarchs derived from few localities of "Arenig" to "Caradoc" age were mentioned, but rarely described in detail, during the period 1969 to 1992 in twenty papers lead by Dr. R. Kalvacheva. Most of these papers need a deep revision according with the modern criteria for systematics and biostratigraphy of acritarchs: see for instance Kalvacheva (1979, 1986) or Kalvacheva and Chobanova (1974).

Some important paleoichnological data from the Ordovician of Bulgaria were also recently provided by Yanev (1992), Yanev *et al.* (2000) and Aceñolaza and Yanev (2001). Eighteen ichnogenera were identified or described, ranging in age from Arenigian to Kosovian.

The agreement on cooperation between the Bulgarian Academy of Sciences and the Spanish Council for Scientific Research (CSIC) made it possible for the present team to collaborate in a joint project dealing with the improvement of Ordovician paleontology in Bulgaria, as well as with the reappraisal of stratigraphic correlation of the Bulgarian Ordovician with other peri–Gondwanan sequences of SW Europe. Some of our

first results, including the discovery of new fossiliferous localities, were anticipated by Sachanski and Gutiérrez–Marco (1999), Rábano *et al.*, (2001) and Gutiérrez–Marco *et al.*, (in press). The peri–Gondwanan character of the Bulgarian Ordovician was demonstrated, among others, by Yanev (1990, 1997, 2000) and Haydoutov and Yanev (1997). Paleontological data agrees with this interpretation and, in our opinion, would justify the adoption of the regional chronostratigraphical scheme for the Mediterranean area, which provides a more precise event–stratigraphy and more accurate biochronological correlation (see Gutiérrez–Marco *et al.*, 2002, and complete references therein).

In this paper we report the main paleontological results obtained from a reassessment of a key area for standard correlation of the Bulgarian Ordovician. Our work also included the review of most of the original material obtained in some previous studies. Original specimens of early authors are stored in the Geological Museum of the University of Sofia and the Geological Institute of the Bulgarian Academy of Sciences, including a part of the Bonchev, Spasov and Belev collections. Detailed description of fossils and localities will follow in a longer paper currently under preparation.

Geological setting and studied localities

Figure 1 shows the main area with Ordovician sediments in Bulgaria, corresponding to the Paleozoic core of the Svogve and Berkovika Alpine anticlinoria, which form part of the Sofia Balkan (Balkan Terrane). The Ordovician succession starts with more than 2000 m of metamorphic siliciclastic rocks that include metavolcanic and ophiolitic rocks, interpreted as olistoliths (Dalgi Dyal Group). A few records of middle to upper Arenigian acritarchs were located towards the upper part of the unit (see Kalvacheva, 1986).

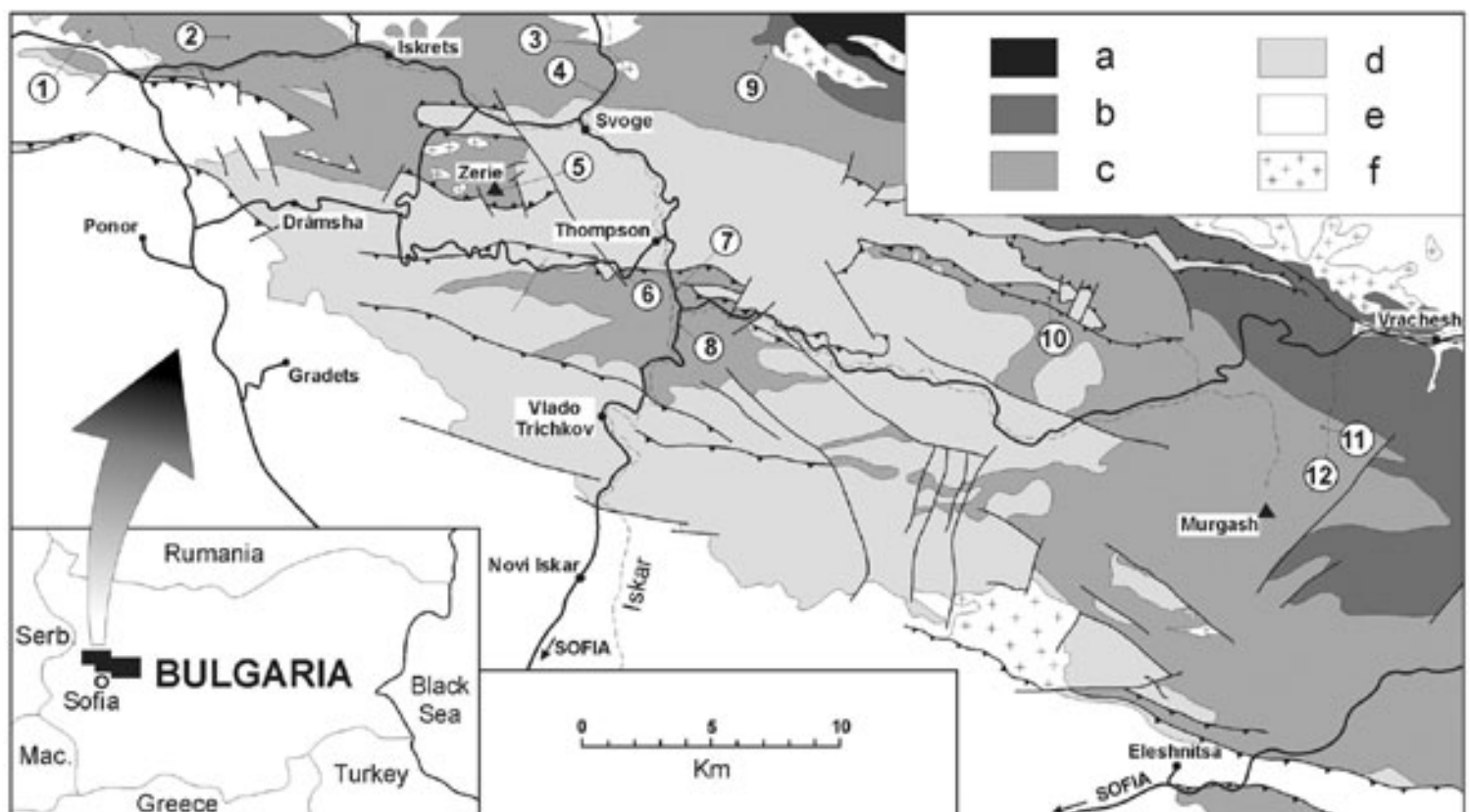


Figure 1. Geological sketch map of the Paleozoic basement in the Stara Planina area (Sofia Balkan), showing some key Ordovician localities mentioned in the text. a) Precambrian basement; b) Lower Ordovician Dalgi Dyal Group; c) Middle to Upper Ordovician formations; d) Silurian to Carboniferous rocks; e) Post–

Paleozoic rocks; f) Igneous rocks. Ordovician paleontological localities and ironstone beds: 1, El Jako near Shuma (middle Berounian); 2, Zavidovci (Oretanian); 3, N Svoge (lower oolitic ironstone); 4, NE Svoge (Oretanian); 5, Zerie mountain (lower and upper Oretanian); 6, SW of Thompson (Ordovician fossils previously described as Carboniferous); 7, Bryastovo (lower Oretanian); 8, Rebrovo (lower Dobrotivian); 9, Leskov Dol (basal middle Berounian oolitic ironstone); 10, "Ogoya" (Oretanian); 11, Cheshkovitsa section, lower part (lower Oretanian); 12, *ibidem*, upper part (upper Oretanian).

The Middle and Upper Ordovician sedimentary sequence is mainly represented by the Grohoten, Cerecel and Sirman formations. The Grohoten Formation ("Rebrovo complex" of some authors) is a thick succession (up to 2000 m) of siltstones and shales with abundant quartzitic interbeds. Some major lenticular quartzitic bodies, reaching 250 m in thickness and with individual strata up to 3 m thick, are represented in the basal and lower part of the formation in the northeastern flank of the Berkovika anticline and in the Svoge anticlinorium, respectively. At least two oolitic ironstone beds are also identified in the Grohoten Formation (Figure 2). From a paleontological point of view, the oldest fossils come from the basal part of this unit and consist of upper Arenigian acritarchs (see Kalvacheva, 1986). The remaining paleontological data are shown in Figure 2 and involve the localities numbered 2 to 8 and 10 to 12 in Figure 1. Yanev *et al.*, (2000) and Aceñolaza and Yanev (2001) add many ichnological records from the Grohoten Formation which are not represented in our figures, and the same procedure is adopted for the palynological data summarized by Kalvacheva (1986). According to the paleontological record and stratigraphic correlation, the formation essentially ranges from Oretanian to middle and upper Berounian ages (see below).

The Cerecel Formation rests unconformably over the Grohoten Formation and is composed by approximately 350 m of massive argillites. Towards the upper part they contain heterometric grains and pebbles of sandstone, quartzite and weathered limestone, of probable glaciomarine origin. The overlying Saltar Formation is a sandstone unit of variable thickness (2 to 20 m) with a slightly unconformable basal contact. This type of contact has also been observed on some African and SW European peri-Gonwanan sequences at the base of late Kosovian sandstones (see for instance Ghienne, 2003, and references therein).

The Bulgarian Ordovician succession ends in the basal meter of lydites and silicified shales that characterize the beginning of the Saltar Formation. This unit includes over 30 m of graptolitic strata ranging in age from lowermost Rhuddanian to early Telychian, except for its first basal meter, which bears the last Ordovician graptolites.

Biostratigraphical results

Middle Ordovician fossils from Bulgaria can be grouped in three stratigraphical successive assemblages included within the Grohoten Formation.

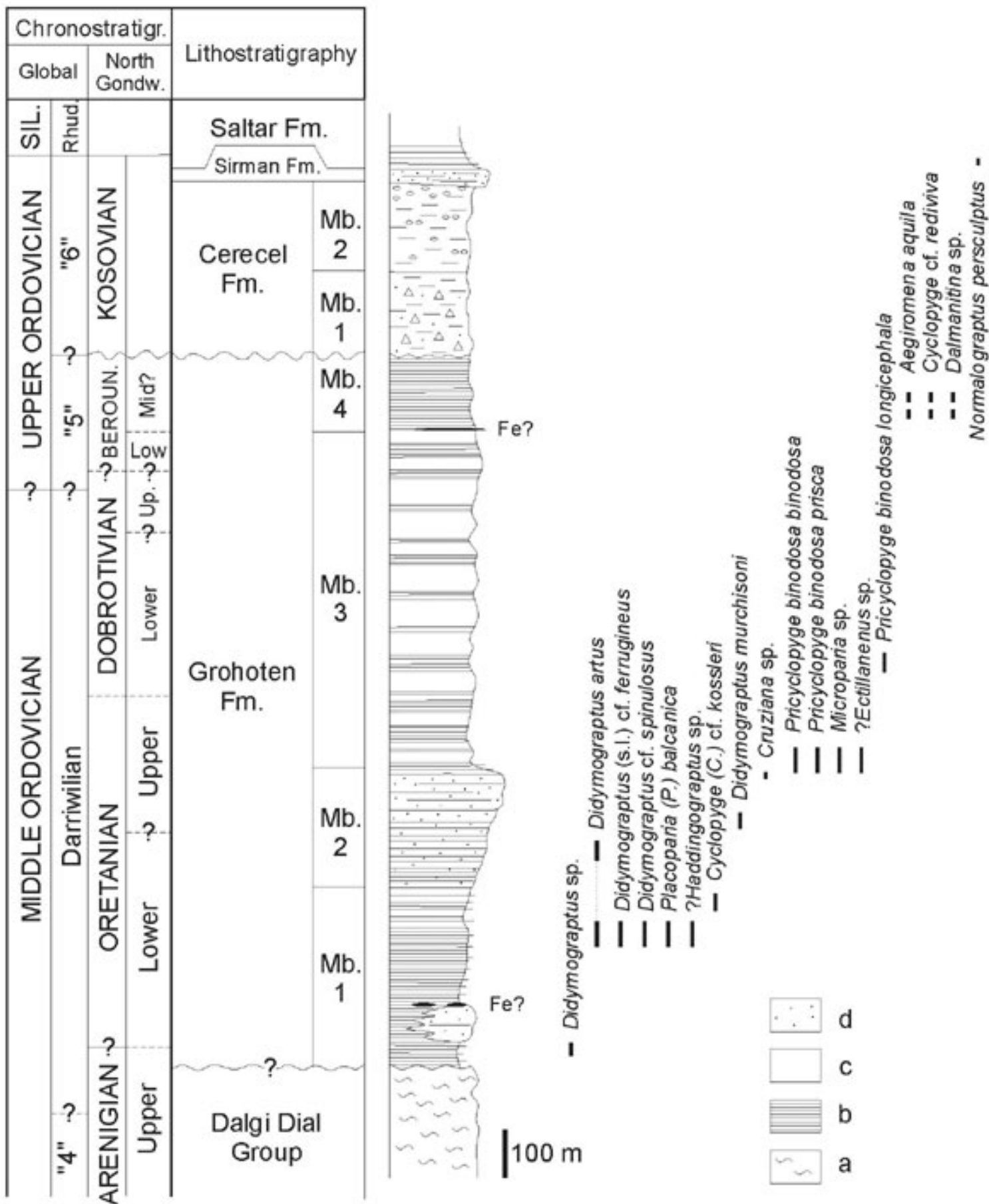


Figure 2. Simplified lithostratigraphy of the Ordovician rocks in the Svoge anticlinorium, with reference to the global and north-Gondwanan chronostratigraphic schemes, showing the vertical range of the identified fossils. Lithologies: a, interbedded shales and lidites with greenschists facies; b, argilites; c, siltstones; d,

sandstones and quartzites. In the Cerecel Formation, circles represent nodules and triangles represent clasts.

The first and oldest paleontological assemblage derives from lower Oretanian shales with nodules bearing pendent and extensiform didymograptids [*Didymograptus* cf. *artus* Elles and Wood, *D.* cf. *spinulosus* (Perner), *Didymograptus* s.l. cf. *ferrugineus* (Suess)], some biserials (?*Haddingograptus* sp.), a single benthic atheloptic trilobite (*Placoparia balcanica* n.n.) and probably also a rare pelagic form [*Cyclopyge* cf. *kossleri* (Kloucek)]. They were recorded at locality numbers 4, 5, 7 and 11 (see Figure 1), all of them lying below the thick quartzite body recognized in the lower half of the Grohoten Formation (Figure 2).

The second and middle paleontological assemblage is dominated by pelagic trilobites such as *Pricyclopyge binodosa binodosa* (Salter), *P. binodosa prisca* (Barrande) and *Microparia* sp., with some sparse benthic elements (*Ectillaenus* sp). Its concurrence with the graptolite *Didymograptus murchisoni* (Beck) and a rare indeterminable biserial form, characterize an upper Oretanian age for the assemblage. This assemblage occurs within siltstones and silty shales that directly overlie the heterogeneous quartzitic member, in fossil localities number 2, 5, 10 and 12 (see Figure 1). A single specimen of the trace fossil *Cruziana* isp., so far unknown in the Bulgarian Ordovician, was also recorded in the middle quartzite of the Zerie Mountain fossil site (Figure 1, loc. 5).

The third and youngest Middle Ordovician paleontological horizon is characterized by the occurrence of the cyclopygid trilobite *Pricyclopyge binodosa longicephala* (Kloucek), indicative of a lower Dobrotivian age. The same one was recorded at locality number 8 (Figure 1), belonging to the basal upper half of the Grohoten Formation (Figure 2).

To an unknown stratigraphical horizon within the Grohoten Formation, we could also add the benthic dendroid graptolites described as two new species (*Callograptus belmustakovi* and *C. boncevi*) by Spasov and Nikolov (1959), at that time alleged to be of early Carboniferous age. However, the absence of marine Carboniferous rocks in the locality (6 in Figure 1) and the fact that the fossils were recovered from a block of shale in the river, suggest that it could come from the nearby outcrops of the Grohoten Formation, lying on the left margin of the same valley. Moreover, the type material of the Bulgarian dendroids shows strong morphological differences when compared with the global record of Carboniferous benthic graptolites.

Upper Ordovician fossils have only been recovered from a single locality in the upper part of the Grohoten Formation (Nº. 1 in Figure 1), with an additional palynological record of uncertain stratigraphic position (see Kalvacheva, 1987) that needs taxonomical revision. Paleontological data from the better known locality includes trilobites like *Dalmanitina* sp. and *Cyclopyge* (*C.*) cf. *rediviva* (Barrande), as well as the brachiopod *Aegiromena aquila* (Barrande). This assemblage most probably corresponds to a middle or late Berounian age. The discovery of weathered oolitic ironstone in the upper half of the Grohoten Formation (locality Nº. 9 in Figure 1) would indicate the existence of a stratigraphic gap of unknown extent, perhaps involving part of the lower Berounian and/or even part of the lower Dobrotivian. This may be possible according to our suggested tentative correlation of this horizon with the most extended Upper Ordovician ironstone bed occurring in southern and central Europe and North Africa (the Zdice–Nucice bed in Bohemia, the Favaçal bed in Portugal, the Fombuena bed in NE Spain, etc.), and which postdates the "Sardic movements" (see references in Gutiérrez–Marco *et al.*, 2002).

Younger Ordovician rocks of the Cerecel Formation have been correlated with the Kosovian glaciomarine diamictite facies highly characteristic of northern Gondwana. The sedimentation of such deposits occurred after a period of eustatic emersion caused by the latest Ordovician glaciation, almost in every case associated

to short erosive periods of variable intensity. For that reason, we consider that most probably such regional stratigraphic gaps could also be present in the basal and topmost contact of the Cerecel Formation. This unit bears poorly diversified ichnofossils (Yanev, 1992; Aceñolaza and Yanev, 2001), none of which display biostratigraphical significance. Scarce palynological data so far attributed to the Cerecel Formation are being revised by us and seem to come from an unnamed unit (the "pseudo-Cerecel" beds) of Devonian age.

The youngest Bulgarian Ordovician fossils were identified by Sachanski (1993) in the basal part of the Saltar Formation, where *Normalograptus persculptus* (Salter) has been recorded just below the oldest Silurian graptolites.

Paleobiogeographical remarks

The closest comparison of the Bulgarian trilobites is with the cyclopygid biofacies from the deep outer shelf settings of the peri-Gondwanan platform, supported by the record of some typical Bohemian taxa as *Pricyclopyge binodosa prisca* and *P. binodosa longicephala*. The new species of the benthic genus *Placoparia* most probably represents an Oretanian ancestor of the typical Dobrotivian form *Placoparia (P.) zippei* (Boeck). The trilobite genus *Dalmanitina* and the brachiopod *Aegiromena aquila* are also widely distributed in the European and north African Berounian sequences.

Modern proposals on a peri-Gondwanan character of the Bulgarian Ordovician are being developed and start from Yanev (1990). According to the Bulgarian fossils, an alternative terrane explanation with the Sofia Balkan lying as the eastern end of Avalonia is not probable. Many paleontological records in the Alpine collage system of the Balkans are also of peri-Gondwanan character. In this sense, the East-Serbian South Carpatians (Balkan terrane) and the Serbo-Macedonian Massif (Tracian terrane) provide diverse records of most inshore Ordovician sequences of clear peri-Gondwanan type, including Lower Ordovician sandstones with giant obolid brachiopods (Gutiérrez-Marco *et al.*, 1999, and references therein), Middle Ordovician shales with *Neseuretus cf. tristani* (see Petkowski and Temkova, 1981), as well as diverse Upper Ordovician localities with middle Berounian assemblages (*Dalmanitina*, *Aegiromena*, and brachiopod coquinas with the rombiferan cystoid genus *Heliocrinites*, etc.) (Veselinovic, 1973; other data summarized by Krstic *et al.*, 1999).

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