



## Evidence for the presence of the global Late Devonian Kellwasser Event in the Berende section (Parchar Formation, Western Bulgaria)

### Доказателства за присъствие на глобалното къснодевонско събитие Kellwasser в разрез Беренде (Пърчарска свита, Западна България)

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### Introduction

The Frasnian–Famennian mass extinction is stratigraphically associated with the famous Kellwasser Event (cf., Buggisch, 1991; McGhee, 1996). It is one of the largest Phanerozoic mass extinction events that affects most of the global tropical marine ecosystems (e.g., Sandberg et al., 1988; Morrow, 2000). In many sections, the Frasnian–Famennian interval is characterized by a pair of organic-rich dark limestones (the Lower and Upper “Kellwasserkalk” beds) embedded between various lithologies (shales, cephalopod limestones, siliciclastic sediments) (cf., Buggisch, 1991). The global Late Kellwasser Event (Frasnian/Famennian boundary interval) was recognized for the first time in Western Bulgaria in the Tsarichina section by Boncheva et al. (2015), within the deep-water marine deposits of the Katina Formation in the Svoge Unit (Srednogorie Tectonic Zone after Dabovski, Zagorchev, 2009). In this study are presented new conodont data concerning the Late Kellwasser Event in the Parchar Formation, in section Berende, from the Lyubash-Golo Bardo Unit (Srednogorie Tectonic Zone).

### Geological setting and stratigraphy

The Late Kellwasser Event is documented in the Upper Devonian sedimentary successions from the western part of the Srednogorie Tectonic Zone. They are mostly composed of siliciclastic sediments interbedded with rare limestone lenses and are interpreted as flysch deposits (Yanev, 1985; Yanev,

Spassov, 1985; Boncheva, Yanev, 1993; Boncheva et al., 2015).

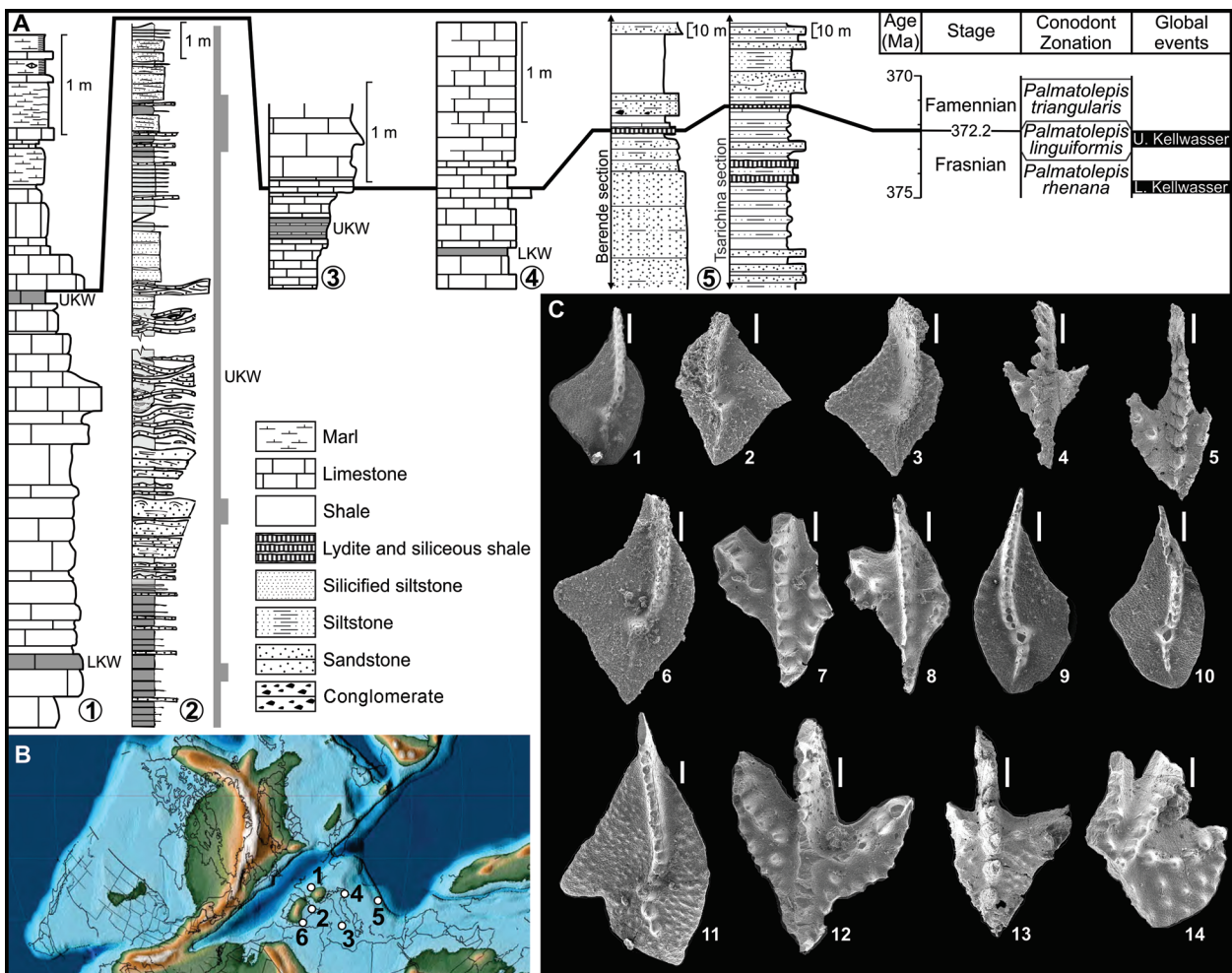
**Tsarichina section (Svoge Unit).** According to previous studies, the turbiditic accumulation in the Svoge Unit starts in Givetian, when siliciclastic and cherty rocks were deposited (Katina Formation). Later, during the Late Devonian, a deposition of thick flysch succession of conglomerates, sandstones and shales occurred. The Frasnian/Famennian boundary interval in the Katina Formation Tsarichina section consists of black shales intercalated between two dark gray to black limestone layers. The latter were dated by conodonts (Boncheva et al., 2015) as topmost Frasnian (*Palmatolepis linguiformis* Zone) and basal Famennian (lower *Palmatolepis triangularis* Zone).

**Berende section (Lyubash-Golo Bardo Unit).** In the Lyubash-Golo Bardo Unit, turbiditic sedimentation dominated from the Emsian–Eifelian to the Early Carboniferous time. In this unit, the Devonian consists of black graptolitic shales (Gradishte Formation, Lochkovian), a lydite series (base of the Parchar Formation), and a rhythmic sequence of shales, siltstones and sandstones (cf., Boncheva et al., 2015). The Upper Devonian flysch sediments (1400 m in thickness) are subdivided into three formal lithostratigraphic units: Parchar, Tumba and Propalnitza Formations (Yanev, Spassov, 1985). The Frasnian/Famennian boundary interval in the Berende section occurred in the Parchar Formation. The last one consists of alternating sandstones, siltstones and shales, thin-bedded black lydites and a few thin limestone beds (cf., Boncheva, Yanev, 1993).

## Conodont data

In Berende section, the Frasnian/Famennian (F/F) interval is characterized by the replacement of the polygnathid biofacies, with the abundantly presented taxa of the genus *Palmatolepis*, as well as the extremely poor and monotaxic icriodid biofacies. At the end of the Frasnian, the big group of conodont species of the genus *Ancyrodella* disappeared. Most probably, this change of the conodont biofacies is related to the global Late Kellwasser mass extinction event. The zonal boundaries are not clearly observed and placed in section due to the complicated tectonic setting in the area and the lack

of carbonates in the sedimentological sequence. The obtained conodont fauna indicates the presence of upper *Palmatolepis rhenana* Zone – *P. linguiformis* Zone (Fig. 1). The taxa *Palmatolepis delicatula* Branson & Mehl, *Ancyrodella ioides* Ziegler, *Ancyrodella nodosa* Ulrich & Bassler, *Palmatolepis* cf. *eureka* Ziegler & Sandberg, *Palmatolepis subrecta* Muller & Youngquist, *Ancyrodella lobata* Branson & Mehl, *Ancyrodella gigas* Ziegler, *Ancyrodella rotundiloba* (Briant) belong to the upper part of the Frasnian and to its last conodont zone – *P. linguiformis* Zone (Ziegler, Sandberg, 1990). The presence of many species of *Ancyrodella* and their absence in the overlying *P. triangularis* Zone, as well



**Fig. 1.** A, B. Palaeogeographic reconstruction for the early Famennian age (after Scotese, 2014), with inferred location and simplified logs of the peri-Gondwanan European sections (sensu Štorch, 1996), where the Kellwasser event was established (see also Carmichael et al., 2019): 1, The basal-Famennian GSSP in the Upper Quarry at Coumiac Section, Montagne Noire, Southern France (House et al., 2000; Becker et al., 2012); 2, FF Les Vilelles section, Catalan Coastal Ranges, Spain (Moreno et al., 2018); 3, Calabria, Southern Italy (Navas-Parejo et al., 2009); 4, Wolayer Glacie section, Carnic Alps, Austria (Joachimski et al., 1994); 5, Tsarichina and Berende sections, Srednogorie Tectonic Zone, Bulgaria (Boncheva et al., 2015); 6, Malaguide Complex, Betic Cordillera, Spain (Navas-Parejo et al., 2009); C, Paleontological plate: 1, *Palmatolepis delicatula* Branson & Mehl; 2, 3, 6, *Palmatolepis triangularis* Sannemann; 4, *Ancyrodella ioides* Ziegler; 5, 7, 8, *Ancyrodella nodosa* Ulrich & Bassler; 9, *Palmatolepis* cf. *eureka* Ziegler & Sandberg; 10, *Palmatolepis delicatula* Branson & Mehl; 11, *Palmatolepis subrecta* Muller & Youngquist; 12, *Ancyrodella lobata* Branson & Mehl; 13, *Ancyrodella gigas* Ziegler; 14, *Ancyrodella rotundiloba* (Briant).

as the appearance of the zonal taxon *Palmatolepis triangularis* Sannemann give evidence for determination of both the end of the Frasnian stage and the mass extinction in the studied section.

The obtained conodont data from the Berende and Tsarichina sections (Srednogorie Tectonic Zone, Western Bulgaria) are very similar to other Peri-Gondwanan sections, indicating the global Late Kellwasser Event (Fig. 1), e.g., the basal-Famennian GSSP in the Upper Quarry at Coumiac Section, Montagne Noire, Southern France and the Wolayer Glacie Section, Carnic Alps, Austria (cf., Carmichael et al, 2019).

## Conclusions

The global Kellwasser Event is documented in the Western Srednogorie Zone in two tectonic units: the Svoje Unit (Tsarichina section) and the Lyubash-Golo Bardo Unit (Berende section), based on conodont faunas. In both sections, the topmost Frasnian (*linguiformis* Zone) and the base of the Famennian (Lower *triangularis* Zone) were recognized. This important bio-event is marked in the Berende section by the replacement of the ancyrodella-polygnathid biofacies with the abundantly presented taxa of the genus *Palmatolepis*, as well as the extremely poor and monotaxic icriodid biofacies. Disappearance of all species of *Ancyrodella* and the abrupt reducing of the species of *Icriodus* both indicate a dramatic environmental change at the F/F boundary (Fig. 1). The genera *Icriodus* and *Ancyrodella* present in biofacies related to shallow water conditions and their replacement with taxa relevant to deep water probably is due to changes in the global sea level and the (Late Kellwasser Event) mass extinction of species on the F/F border. The F/F boundary interval in the Katina and the Parchar formations consists of deep-water flysch deposits commonly containing black shales, suggesting possible anoxic basinal setting.

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