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## Sedimentary and faunal evidence for the Late Devonian Kellwasser and *Annulata* events in the Balkan Terrane (Bulgaria)

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Late Devonian global events include a sequence of sudden biotic changes and various kinds of drastic environmental perturbations. There were fast transgressions and regressions (eustatic sea-level pulses) as well as catastrophic sedimentary events, well documented by intervals of anoxic marine sediments with elevated organic content, and changes in the geological record of stable isotopes and rare elements. The recognition of some of the well-known specific events in the Balkan region adds to the knowledge of their spatial distribution and, possibly, of their nature and origin.

Devonian marine sedimentary rocks of Bulgaria are related to three tectonic units – the Lyubash-Golo Bardo Unit, Morava Unit, and the Svoge Unit. The most complete Upper Devonian sections of the Lyubash-Golo Bardo and Svoge units were studied in detail, which enabled the recognition of the Kellwasser and *Annulata* events.

The Lyubasha-Golo Bardo Unit is a fault-bounded structure belonging to the Srednogorie Zone. The Devonian consists regionally of black graptolitic shales, a lydite series, and a rhythmic succession of shales, siltstones and sandstones. The upper Emsian – lower Viséan flysch sedimentation in western Bulgaria documents the final stage of the Paleozoic marine basin, which development is related to compression and the Variscan orogeny. Upper Devonian turbiditic sediments are unconformably overlain by Permian continental clastic rocks.

The 1400 m thick Upper Devonian flysch sediments are subdivided into three formations: Parchar, Tumba, and Propalnitza (YANEV & SPASSOV 1985). The Parchar Formation is up to 770 m thick and consists of a rhythmic alternation of sandstones, siltstones, and shales. At the base, there are packages of lydites and silicified shales. Carbonate rocks are characteristic only of the Parchar Formation and are represented by rare, dark, micritic limestone interbeds, which yielded Emsian to lower Famennian conodonts. Established Middle Givetian to lower Famennian conodont zones of the Parchar Formation are the *varcus*, *hassi*, *rhenana* and *triangularis* (SACHANSKI & BONCHEVA 2002) zones. Recent studies (BONCHEVA *et al.* 2010) based on conodonts from two new localities documented the following zones and/or stages: upper Emsian – lower Eifelian (*serotinus* to *partitus* Zones), top Eifelian/Givetian (*ensensis* and *varcus* Zones), Frasnian (*hassi* ? and *rhenana* Zones), Famennian (*triangularis* Zone). A miospore association from the terrigenous matrix at the base of the rhythmic alternation suggests an upper Emsian - lower Eifelian age for the onset of turbiditic deposition. In the upper part of the Parchar Formation, ca. 615 m above the base, there is a distinctive black shale, which yielded frequent bivalves (*Guerichia venusta*) in association with clymeniids (involute and evolute morphotypes of *Platyclymenia subnautilina*, ?*Pl. annulata*, and *Protactoclymenia* sp.). It clearly represents the *Annulata* Black Shales, first recognized in the Rhenish Massif of Germany, and indicates sudden eutrophication of the basin, with increased organic productivity and oxygen deficiency in the lower part of Famennian IV. The *Annulata* Event falls in the top part of the Upper *trachytera* Zone low in the upper Famennian in all regions with conodonts (HARTENFELS & BECKER 2010).

The Tumba Formation is 130 m thick. It is characterised by alternating lydites and shales, with minor sandstones and siltstones. It contains fragments of undeterminable radiolarians and land plant fragments. An upper Famennian age is tentatively assumed based on its position between the Parchar and Propalnitza Formations.

The Propalnitza Formation, over 540 m thick, consists of sandstones with intercalations of thin siltstones and shales. It is assigned to the upper Famennian – Lower Carboniferous mainly based on

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land plants, such as *Cyclostigma hercynium*, *C. ursinum*, *C. kiltorkense*, *Sphenophyllum subtenerrimum*, *S. kiltorkense*, *Bowmanites tumbana*, *Archeopteris cf. halliana* (REMY & SPASSOV 1959, YANEV & SPASSOV 1985), and *Sphenophyllostachys tumbana* (TENCHOV & YANEV 1987).

The lithologic studies in the Svoge Unit allow to distinguish three formations in the Devonian (TENCHOV 1965): the Ogradishte Formation, Romcha Formation and Katina Formation.

The Ogradishte Formation consists of predominant black, thick-bedded (15-30 cm) silty argillites and subordinate grey to dark grey, laminated argillites and silty argillites. The total thickness of the formation is about 300 m. The rocks contain only sporadic fossil remains. Rare graptolites have been found in the lowermost part of the section. They indicate an interval from the Upper Silurian (Pridoli) to the Lower Devonian (Pragian). The boundary between the Silurian and Devonian systems is set at about 20 m above the contact with the underlying Yabukovdol Formation.

The lower boundary of the Romcha Formation is gradational from the Ogradishte Formation. The upper boundary shows a short transition to the Katina Formation. The Romcha Formation consists of predominant greenish and grey-greenish, crudely bedded argillites plus subordinate silty argillites in the lower part of the section. A characteristic lithologic feature is the presence of lenticular nodules and dark spots. Its thickness is 300-350 m. On the basis of chitinozoa and the stratigraphic position below the biostratigraphically dated Katina Formation, it has been assumed that the Romcha Formation covers parts of the Emsian (Lower Devonian) and parts of the Middle Devonian.

The Katina Formation starts with a pre-flysch series of lydites, shales and siliceous shales, 380 m thick. This succession does not contain fossils and is tentatively assigned to the Middle (?) Devonian. Conformably, a flysch succession follows, up to 1000 m thick, consisting of sandstones and shales. It belongs to the Upper Devonian – Visean (?) based on macroflora and on conodonts in single carbonate layers. The continental cover consists of Upper Carboniferous and Permian sediments and pyroclastics. The conodont zones established (BONCHEVA & YANEV 1993) in the Katina Formation include the topmost Frasnian *linguiformis* Zone and the Lower Famennian *triangularis* Zone. Both carbonate layers are separated by black shales. These organic-rich sediments indicate anoxic (oxygen-deprived) bottom waters and are thought to correlate with the Upper Kellwasser level right below the stage boundary.

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