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BIOSTRATIGRAPHY

A FAMENNIAN (LATE DEVONIAN) CONODONT ASSEMBLAGE FROM BRACHIOPOD–RICH LIMESTONES OF THE DJRAVANK SECTION (SOUTHERN ARMENIA)

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Numerous conodont elements were yielded from a sandy brachiopod–rich limestone after processing with formic acid. The sample comes from a ca. 25 m–thick sequence of well–bedded nodular limestones, cropping out along a newly explored section (Djravank), situated on the south bank of the river Arpa, of the river Arpa, near the village of Arpi in Vayots Dzor region. SEM observations allow the identification of species *Icriodus cornutus*, *I. iowaensis iowaensis* and *Polygnathus* sp.cf. *P.bischoffi* suggesting an early Famennian age. The 60–40% relative abundance of *Icriodus* and *Polygnathus* elements represents an icriodontid–polygnathid conodont biofacies typical of shallow water environments.

Keywords: Biostratigraphy; Palaeozoic; Upper Devonian; Armenia: Taxonomy; Conodont; Brachiopod; Limestone; Djravank.

Introduction

Conodonts are tiny phosphatic remains of the feeding apparatus of a primitive eel–like marine chordate, which is known from the late Cambrian to the end Triassic (Armstrong & Brasier, 2005; Blieck *et al*., 2010). These microfossils were known since the mid–19th century and used extensively in biostratigraphic correlations; however, it is only 35 years ago, after the discovery of the conodont animal in the Carboniferous sequences of Scotland (Briggs *et al*., 1983) that we understood their palaeobiological significance.

Conodonts are very important microfossils for the global biostratigraphic framework of Palaeozoic shallow marine sequences, as they are often used in the international definition of many Palaeozoic stage and period boundaries.

In the Lesser Caucasus (Transcaucasia), Palaeozoic sedimentary sequences are encountered mainly in the southern part of Central Armenia (fig.1A), as

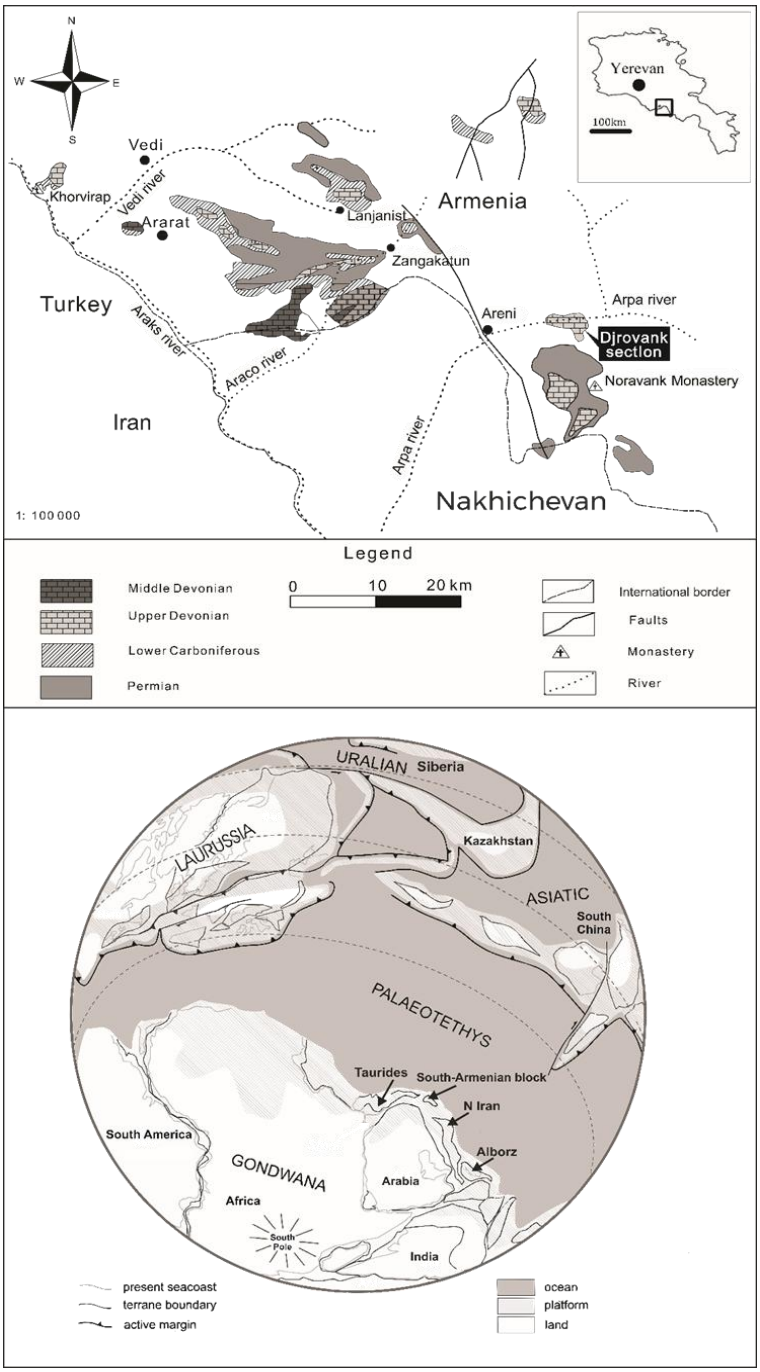

Fig.1. A) Schematic geological map of the Upper Paleozoic sequences in Armenia, including the location of the studied Djravank section (compiled by A.Grigoryan, V.Serobyan, R.Mayilyan, T.Danelian). B) Devonian/Carboniferous paleogeogographic reconstruction of the Palaeotethys ocean and its margins, including the position of the South Armenian Block along the northern margin of the Gondwana megacontiennt (redrawn and modified after Denayer & Hoçgör 2014, based on the maps of Stampfli *et al.* 2002).

well as in the neighboring Nakhichevan AR. The international significance of these Palaeozoic sequences is best expressed recently by Grechishnikova *in* Alekseeva *et al.* (2018, p.832): "the Middle Palaeozoic sections of Transcaucasia are unique in their completeness, exposure, and richness in remains of many fossil invertebrates and vertebrates (fishes, conodonts) and suitable for international standards".

The Palaeozoic sequences of Armenia are known since the mid–19th century as they attracted the interest of pioneers in the geology of the Lesser Caucasus (Abich, 1858; Frech & Arthaber, 1900; Lisitsyn, 1913; Bonnet, 1947). However, it is following the outstanding efforts of Arakelian (1964a, b) and Abrahamian (1957) that major progress was achieved in their stratigraphic knowledge. As Brachiopods are relatively rich in the Devonian sequences of Armenia, they were systematically studied by Abrahamian (1954, 1957, 1959, 1974a, 1974b), although their fossil record requires reassessment since the seventies (see Serobyan *et al*., 2019).

Regarding the conodonts, a significant contribution was made by Aristov (1994), although he worked mainly in Nakhichevan, also studied some material from Armenia, especially in the outcrops situated north of the village of Lanjanist (previously Kadrlu).

The Mid Palaeozoic sequences have the potential to contribute to the understanding of mass extinction events that took place between the Frasnian/Famennian and Devonian/Carboniferous boundaries. In the framework of a French–Armenian collaborative project of revisiting the Upper Palaeozoic sequences of Armenia and having as final objective the understanding of the biotic response of brachiopods and conodonts to the two extinctions events mentioned above, we here report the preliminary results from a new section (Djravank), focusing on the discovered conodont assemblage and its biostratigraphic and palaeoenvironmental significance.

Palaeogeographic and Stratigraphic framework

The Middle and Upper Palaeozoic sequences of Armenia belong to a microcontinent, known as South–Armenian Block (Sosson *et al*., 2010), which was part at the time of the northern margin of the Gondwana megacontinent, facing the Palaeotethys ocean (fig.1B); this part was later individualized as an independent microcontinent, as it migrated northward following the opening of Neotethys further in the south (Sosson *et al*., 2010).

Over 1500 metres of shallow water sediments of mixed carbonate–terrigenous nature (alternations of marly–sandy limestones, shales and quartzites) accumulated on this Gondwanan passive margin. The Middle Devonian (Eifelian to Givetian) part of the Palaeozoic sedimentary pile has a restricted distribution in Armenia; it is only detected along the boundary with Nakhichevan. It is mainly the Upper Devonian part of the pile that crops out in Armenia; it has been subdivided by Arakelian (1964a, b) into nine 'formations';

however, these successive units, although described based on a type locality, they were mainly characterized by their fossil record, rather than distinct lithological differences. In practice, most of the formations have very similar lithological characteristics and they cannot be recognized on the field without knowledge of their brachiopod assemblages. That is why they appear to correspond to horizons with different brachiopod assemblages; thus, they bear a biostratigraphic rather than lithostratigraphic significance (see Murphy & Salvador, 1999). The Frasnian stage is composed mainly of limestones and shales with some intercalations of quartzites. The Famennian has a wider distribution than the Frasnian in Armenia. It is characterized by the absence of corals and the abundance of brachiopods; it is made of limestones, sandy limestones, shales, sandstones and quartzites.

Material and methods

The studied material comes from a ca. 25 m–thick continuous carbonate sequence composed of brachiopod rich well–bedded limestones displaying a more or less clear nodular aspect. It is part of a much thicker section that crops out along a mountain path originated from the ruins of Ertych village and leading to a tiny church hidden in the mountains at the locality known as Djravank (N39° 43’22″, E45° 16’07″). The outcrop is named after the Djrovank abandoned church; it is exposed 500 meters to south–southwest from the Ertych section, on the left slope of a valley upon which the church was built. The section is composed essentially of quartzites, black shales and massive limestones, but the top is distinguished by its interbedding of different types carbonate rocks.

The conodont assemblage discussed in this paper comes from a nodular limestone (sample Dj17–12), full of brachiopods, which was processed with formic acid at the Geological Institute (Yerevan). Several tens of conodont elements were recovered and picked up in Yerevan. Some of them were mounted on SEM stubs and gold coated for ca. 2 minutes. They were photographed with the help of a ZEISS EVO 10 Scanning Electron Microscope hosted with the Palaeontology team of Lille University (UMR 8198 Evo-Eco-Paleo). Complementary observations were made in Paris.

Results

The conodont assemblage discussed in this paper comes from a 2.5 m–thick interval of grey nodular limestones, full of brachiopods (fig.2a–b). Thin section observations of the studied sample Dj17–12 reveal a sandy wakestone/packstone in which may be observed elements derived from echinoderms (fig.2c–d).

Several tens of conodont elements were recovered from the processed sample Dj17–12. Some of them belong clearly to the genus *Icriodus*, characterized by a drop–like outline of the platform and by the absence of a basal platform, by the presence of 3 rows of denticles on their oral view and a basal

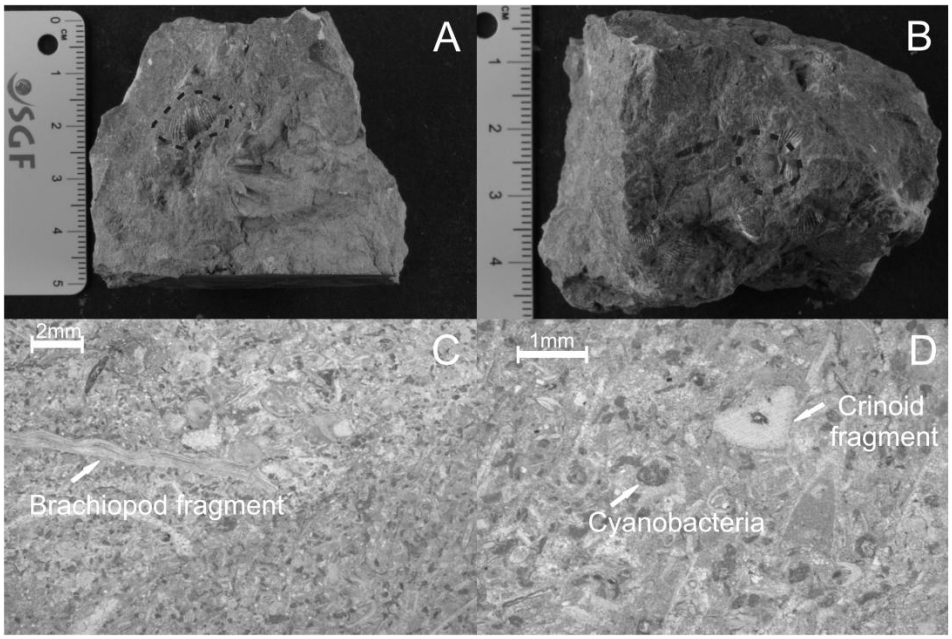

Fig.2. Illustration of the macrofacies (A–B) and microfacies (C–D) of the studied limestone sample Dj17–12.

cavity on aboral view. *Icriodus* conodont elements represent ca. 60 % of assemblage may be assigned to the genus *Icriodus* and 40% to the genus *Polygnathus*, more particularly, species *Icriodus cornutus* Sannemann (Pl. 1A–C) and subspecies *Icriodus iowaensis iowaensis* Youngquist & Peterson and (Pl. 1D) were able to be identified. Another genus that is abundant in our material is *Polygnathus* (Pl. 1E–G), representing ca. 40% of the studied conodont assemblage; it is represented by at least two species in our assemblage. One of the studied conodont elements resembles *Polygnathus bischoffi* Rhodes, Austin & Druce (Pl. 1H), although for the moment it cannot be identified with certainty.

Discussion

Fig.3 illustrates biostratigraphic correlations based on conodonts and their possible relation to the formations established by Arakelian in 1964. The latter is based on the work of Aristov, which was based essentially in studies conducted on sequences cropping out in Nakhichevan. Rzhonsnitskaya & Mamedov (2000) illustrated a correlation of the local biozonation of Aristov with the global conodont biozonation of the time, which was based on the study of Ziegler & Sandberg (1990). Spaletta *et al*. (2017) have recently discussed the age range of a large number of conodont species with reference to the most up–to–date global conodont biozonal scheme, with their supposed duration in the Devonian chapter of The Geologic Time Scale published in 2012 (Gradstein *et al*., 2012).

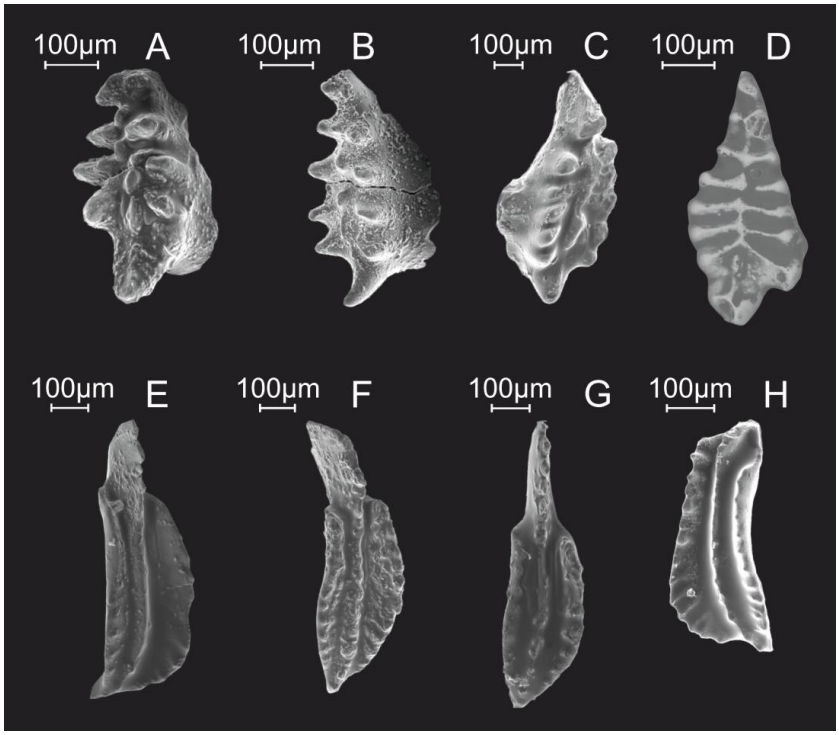

Plate 1. Scanning electron micrographs of conodont elements retrieved from sample Dj17/12 of the Djrovank section. A–C) *Icriodus cornutus*; D) *Icriodus iowaensis iowaensis*; E–G) *Polygnathus* sp.; H) *Polygnathus* sp.cf. *P.bischoffi.*

In the right part of fig.3 we have drawn the age range of the 2 *Icriodus* species/subspecies identified with certainty in this study. Species *Icriodus iowaensis iowaensis* is known since the Frasnian and ranges till the middle part of the *Palmatolepis rhomboidea* conodont zone of the new global zonation, while species *Icriodus cornutus* first occurs in the middle part of the lower Famennian *Palmatolepis delicatula platys* conodont zone and extends up to the Middle Famennian. The co–occurrence of these 2 species in sample Dj17–12 allows correlating it mainly with the Early Famennian.

Conodonts are influenced by several ecological factors, including depth, and can therefore be considered as palaeoenvironmental indicators (Seddon & Sweet, 1971). The 60% *Icriodus*–40% *Polygnathus* assemblage of sample Dj17–12 represents a typical polygnathid–icriodontid biofacies. A similar biofacies was described by Seddon (1970) in the Canning Basin of Australia, where in addition to a deep water *Palmatolepis* biofacies he recognized an *Icriodus* biofacies confined to shallower areas, in which *Icriodus* and *Polygnathus* were dominant. Sandberg (1976) has distinguished five biofacies in the Devonian of western North America, including the polygnathid–icriodontid biofacies, which he regarded as shallow water deposits. Sandberg &

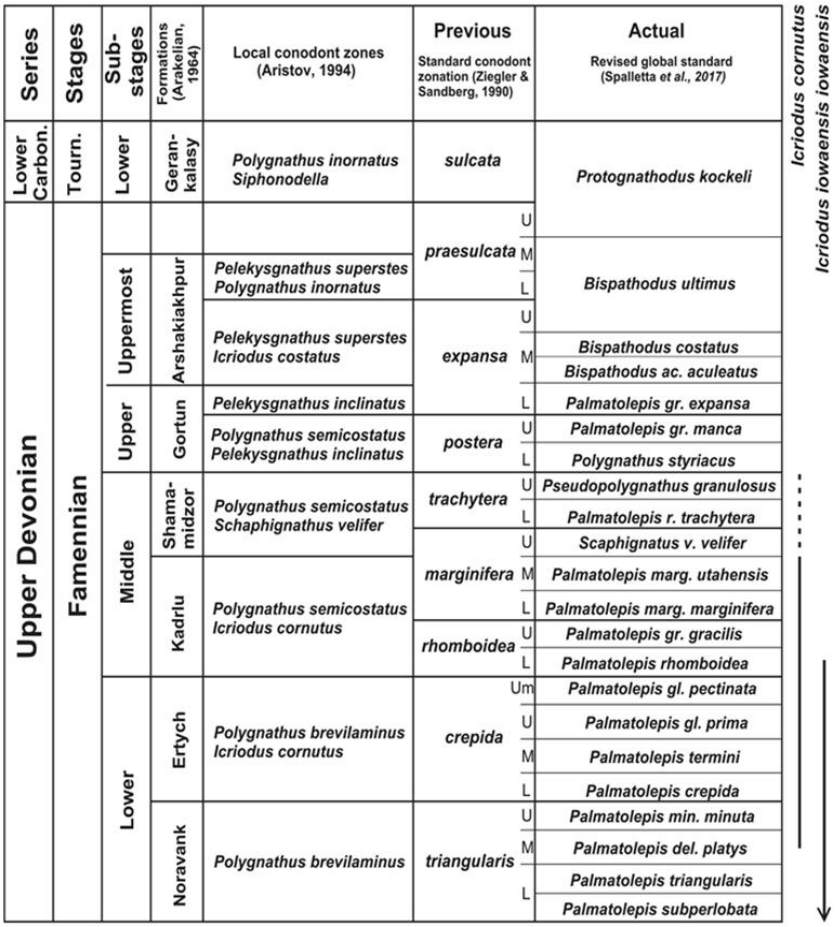

Fig.3. Stratigraphic correlation scheme of the Famennian formations recognized by Arakelian (1964) with the local conodont zones of Aristov (1994) and the international standard conodont zonation as it was published by Ziegler & Sandberg (1990; modified after Rzhosnitskaya and Mamedov 2000). To that we have added the new global zonation scheme and age range of the 2 identified *Icriodus* species/subspecies, based on Spaletta *et al*. (2017).

Dreesen (1984) presented an icriodontid biofacies model in Belgium in which the polygnathid–'icriodontid' biofacies is present in shoal setting environments. Therefore, the conodont assemblage extracted from sample Dj17–12 from Armenia may be regarded as a shallow water biofacies.

Conclusions

The study of conodonts is fundamental for the biostratigraphic study of the Mid Palaeozoic sequences of Armenia, as it will allow to correlate them confidently with the global geological time scale. Our preliminary study highlights the need of modern micropalaeontological and biostratigraphic studies on conodonts from Armenia, as despite the outstanding work that was

conducted by Arakelian and Abrahamyan after the World War II, the Devonian sequences of Armenia and their fauna need re–evaluation with modern standards.

Acknowledgments

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ՋՐԱՎԱՆՔԻ ԿՏՐՎԱԾՔԻ ՖԱՄԵՆԻ ՀԱՍԱԿԻ (ՈՒՇ ԴԵՎՈՆ) ԲՐԱԽԻՈՊՈԴԱՅԻՆ ԿՐԱՔԱՐԵՐԻ ԿՈՆՈԴՈՆՏԱՅԻՆ ՀԱՄԱԼԻՐԸ (ՀԱՐԱՎԱՅԻՆ ՀԱՅԱՍՏԱՆ)

Գրիգորյան Ա., Սերոբյան Վ., Ռանդոն Կ., Ավագյան Ն., Մայիլյան Ռ., Դանիելիան Տ.

Ամփոփում

Կոնոդոնտային բազմաթիվ էլեմենտներ են կորզվել բրախիոպոդներով հարուստ ավազային կրաքարից, թթվով հինգ նմուշ մշակելուց հետո: Նմուշը վերցվել է լավ շերտավորվածությամբ արտահայտված նոդուլային կրաքարերից կազմված մոտ 25մ հզորությամբ նստված-

քային հաջորդականությունից, որոնք մերկանում են վերջերս ուսումնասիրվածված Ջրավանքի կտրծվածքի երկայնքով: Կտրվածքը տեղակայված է Արփի գյուղից հարավ, Արփա գետի աչափնյա մասում: Սկանային էլեկտրոնային մանրադիտակի միջոցով կոնոդոնտների հետազոտությունները թույլ են տալիս ճանաչել *Icriodus cornutus, I. iowaensis iowaensis* և *Polygnathus* sp.cf. *P.bischoffi* տեսակները, որոնց տարիքը որոշվում է որպես վաղ ֆամեն: *Icriodus* և *Polygnathus* տարրերի 60-40% հարաբերական առատությունը ներկայացնում է icriodontid–polygnathid կենսապայմանները, որոնք բնորոշ են տիպիկ ծանծաղ ծովային միջավայրին:

ФАМЕНСКИЙ (ПОЗДНЕДЕВОНСКИЙ) КОМПЛЕКС КОНОДОНТОВ ИЗ БРАХИОПОДОВЫХ ИЗВЕСТНЯКОВ РАЗРЕЗА ДЖРАВАНК (ЮЖНАЯ АРМЕНИЯ)

Григорян А., Серобян В., Рандон К., Авагян Н., Маилян Р., Данелиан Т.

Резюме

Многочисленные элементы конодонтов были извлечены из песчаного известняка, богатого брахиоподами. Образец был взят из приблизительно 25 метровой толщи с хорошо выраженной слоистостью желвакообразных известняков, обнажающиеся вдоль недавно изученного разреза (Джраванк), расположенного южнее села Арпи на правом берегу реки Арпа. Изучение конодонтов с помощью сканирующего электронного микроскопа позволяют идентифицировать виды *Icriodus cornutus, I. iowaensis iowaensis* и *Polygnathus* sp.cf. *P.bischoffi*, что указывает на их раннефаменский возраст. Значительное присутствие конодонтовых элементов *Icriodus* и *Polygnathus* (60–40%) представляют конодонтные биофации икриодонтид и полигнатид, типичные для мелководных бассейнов.