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PALYNOLOGICAL CHARACTERISTICS OF GIVETIAN-FRASNIAN STRATIGRAPHIC INTERVAL ON THE SOUTHERN AND MIDDLE TIMAN

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The relevance of detailed studying Givetian-Frasnian sedimentation is defined by a proceeding discussion about a level of the lower Frasnian Stage bound (according to border of Middle and Upper Devonian) in the Eastern European platform. New results of investigation in a boundary between Middle and Late Devonian within the Southern and Middle Timan presented. There are a correlation between even-aged palynocomplexes in adjacent territories; determination of the new palynozone, which details Lower Frasnian sedimentation; establishment of higher plants spores associations features formed in continental, coastal and sea facies.

Keywords: biostratigraphy, higher plants spores, the Southern and Middle Timan, boundary sediments of Upper and Middle Devonian.

ПАЛИНОЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА ЖИВЕТСКО-ФРАНСКОГО СТРАТИГРАФИЧЕСКОГО ИНТЕРВАЛА НА ЮЖНОМ И СРЕДНЕМ ТИМАНЕ

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Актуальность детального изучения живетско-франского осадконакопления определяется продолжением дискуссии об уровне нижней границы франского яруса (соответственно границы среднего и верхнего девона) на территории Восточно-Европейской платформы. Представлены новые результаты изучения пограничного среднепозднедевонского временного интервала в пределах Южного и Среднего Тимана: скоррелированы одновозрастные палинокомплексы смежных территорий, установлена новая палинозона, детализирующая раннефранский этап осадконакопления; установлены особенности ассоциаций спор высших растений, формировавшихся в континентальных и прибрежно-морских фациях.

Ключевые слова: биостратиграфия, высшие растительные споры, Южный и Средний Тиман, пограничные отложения верхнего и среднего девона.

Introduction

According to the recommendation of the International Commission on stratigraphy (Subcommission on Devonian stratigraphy) the boundary of Middle and Upper Devonian is drawn in the Lower subzone of the Mesotaxis falsiovalis conodont zone [11, 12]. This level is significantly above a traditional border on the Russian Platform. The Givetian Stage corresponds to the Starooskol substage (Vorobiev, Ardatov and Mullin horizons) on the unified stratigraphic scheme of the Russian Platform. Following the modern trends, the Pashiy Horizon was included in Givetian Stage in the interregional stratigraphy scheme of the Devonian deposits of Russia [11]. However, boundary positions of regional divisions are not defined precisely.

The higher plants spores regional scheme developed [6] within a uniform standard for micro- and macrofossils (by the first appearance of a taxon in a geological section) in the Timan — Northern Urals region. Previously [1] palynozones were allocated on different signs, generally on the maximum quantity of a taxon in palynocomplex (acme zone).

The presence of the same species-indices characterizing different age palynozones (*Acanthotriletes bucerus* Tchib., *Archaeoperisaccus ovalis* Naumova, *Tholisporites variabilis* (Naumova) Oshurk. var. *insignis* Sennova, *Calypptosporites bellus* (Naumova) Oshurk.) in both schemes is explained by the difference in the methodical approach of palynozone isolation. The allocation of palynozones by the maximum development of a taxon or its disappearance in the palynocomplex (PC) does not reflect evolutionary trends in the plant biocomplex development. It only fixes adaptation of plants to the certain facies-climatic conditions.

The analysis of even-aged palynocomplexes structure of different facies in the Southern and Middle Timan sediments illustrates facial confinedness of some spore taxons sets (tab. 1). However, implementation of the different methodological techniques (correlations between the palynological zones of coastal and sea facies and paleontological ones, the analysis of the complete taxonomical palynospectrum (PS), percentage of taxons, etc.) allowed to detail the stratigraphical partition of geological sections,

Table 1. Stratigraphic ranking of the most important spores taxa studied in the Givetian-Frasnian sediments of the Middle and Southern Timan

Таблица 1. Стратиграфическое ранжирование наиболее важных таксонов спор, изученных в живетско-франских отложениях на Среднем и Южном Тимане

Formations		Spore taxa																																	
Middle Timan	Southern Timan	Geminospora micromanifesta	G. micromanifesta var. collatus	Geminospora rugosa	Geminospora notata	Contagisporites optivus	Ancyrospora incisa	Acanthoriletes uncata	Archaeozonotriletes variabilis	A. variabilis var. insignis	Acanthotriletes dentatus	Acanthotriletes bucerus	Acanthotriletes similis	Ancyrospora furcula	Ancyrospora involucri	Calyptosporites krestovnikovii	Archaeozonotriletes accretus	Calyptosporites bellus	Archaeoperisaccus verrucosus	Calyptosporites domanicus	Samarisporites costatus	Densosporites meyeriae	Geminospora plicata	Densosporites sorokinii	Ancyrospora laciniosa	Cristatisporites timanica	Ancyrospora melvillensis	Ancyrospora ampulla	Cristatisporites pseudodeliquescens	Archaeoperisaccus ovalis	Hymenozonotriletes argutus	Cristatisporites deliquescens	Cristatisporites dentata	Diducites radianus	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
Kraipol'e	Domanik																																		
Ust-Yarega	Ust-Yarega																																		
Ust-Chirka	Timan	Upper																																	
Tsil'ma			Lower																																
Valsa	South-Timan																																		

— Middle Timan
— Southern Timan

to allocate a new palynozone and to carry out regional and inter-regional correlations. It established that the bottom of Ust-Yarega Formation is characterized by a palynozone of *Cristatisporites pseudodeliquescens*-*Archaeoperisaccus ovalis*, and the top — by *Cristatisporites deliquescens* (tab. 2).

Taking into account the new data about the higher plant spores in the Northern Timan Urals region, authors explore variants of phytostратigraphic boundary level that would be the closest to the modern level of the discussed border.

The history of studies of the regional stratigraphic boundary is not covered in this article as it already has been repeatedly described in other publications [2, 3, 6, 8].

Palynostratigraphy and paleoreconstructions

Russian palynologists traditionally correlated Pashiy-Sargaevo stratigraphic interval with *optivuskrestovnikovii* palynozone (tab. 2) [1]. Its lower bound approximately corresponds to the base of the *hermanni-cristatus* conodont zone.

In the Timan — Northern Urals region the *optivus-krestovnikovii* zone expands on the Yaransk, Dzher, Timan, Sargaevo horizons [2]. O. P. Telnova [6] allocated regional palynozones in the stratigraphic volume of this zone on the Southern Timan and called with names of the first time encountered spores (tab. 2). This scheme has been corrected and expanded

with analysis results of the PS from the Middle Timan geological sections [7].

The Middle Timan PC correlate well with ones in stratotype sections in the Southern Timan (stratotypes of Timan and Ust-Yarega Formations), in the Pechora Sineclise (the Dzher Horizon), in more remote sections on the Chernyshev's Ridge and in the Main Devonian Field.

The general trend in a change of taxonomical structure of PS is observed in the Givetian-Frasnian stratigraphic interval in the compared territories. Spores of a genus *Geminospora* dominate in all PS (producers — *Archeopteris* plants, *Archeopteridales* order). In the Devonian time only *Archeopteris* got a wooden habitus. Well-developed root system allowed them to grow on high landscape sites, all other plants tied to water basins. Thus, *Archeopteris* avoided fierce competition and quickly created a dominating group of plants in the Middle and Upper Devonian floristic communities. Cosmopolitan distribution and wide age range make spores of these plants inert for the stratigraphic constructions. Therefore, the emphasis is placed on spores of subdominant groups in the analysis of PS.

Five PC were established in Valsa, Tsilma, Ust-Chirka, Ust-Yarega and Kraypole Formations on the Middle Timan (tab. 2). On the Southern Timan in Valsa PSs as well as in the Upper

Table 2. The chart of comparison palinozone *optivus-krestovnikovii* of the East-European PlatformТаблица 2. Схема сопоставления палинозоны *optivus-krestovnikovii* на Восточно-Европейской платформе

East European Platform (after Avkhimovitch et al., 1993)		Southern Timan		Middle Timan
Subzone	Zone	Palynozone	Formation	Formation
S. bellus	A. ovalis – V. grumosus	Dominant phytoplankton	Domanik	Kraipol’e
G. semilucensis – P. donensis		G. semilucensis – P. donensis		
A. bucerus – A. variabilis insignis	C. optivus – S. krestovnikovii	C. deliqucsens	Ust’-Yarega	Ust’-Yarega
		C. pseudodeliqucsens – A. ovalis		
		D. sorokinii	Timan	Ust’-Chirka
		P. vermiculatus – C. domanicus		Tsil’ma
A. incise – G. micromanifesta		C. bellus – D. meyeriae	Southern Timan	Valsa
		A. bucerus – A. variabilis insignis		
		A. accretes		

Chibj Formation small (20–40 μ) spores with small-spicular sculpture of exine (*Acanthotriletes bucerus*, *A. eximius* Naumova, *A. similis* Naumova et al.) formed the subdominant group. The spores and pollen size reduction and the small-spicular sculpture of the recent spores connected with deterioration in facies-climatic conditions of their producers growth [4]. It is possible to assume by analogy that increase in quantity and variety of spores of the *Acanthotriletes* group could indicate some aridization and, perhaps, a small cold snap in this period. In this time tectonic and volcanic activity increased in the all Timan territory.

The increase in numbers (up to 25 %) and diversity of spores in PCs of Tsilma, Ust-Yarega, Krypole Formations on the Middle Timan and Timan, Ust-Yarega Formations on the South Timan with a wide thin zone (*Calyptosporites*, *Densosporites*, *Hymenozonotriletes*, etc.) may indicate a climatic trend towards humidity. Producers of the spores were ferric and placid plants [6]. It correlates with the regional manifestation of the Frasnian event (global transgression) recorded in many regions of the world.

Taxonomic composition of PC from sections of the Middle Timan differs from such on the Southern Timan by percentage content, absence of some taxa, including index species (*Perotriletes vermiculatus* Med.) and by different stratigraphic range in rare cases. For example, spores *Archaeozonotriletes variabilis*, *A. variabilis* var. *insignis* were listed as dominant and guiding species for the Sargaev Horizon for the long time [1, 2]. Later, different compositions of PC were established in different areas of the Timan in deposits of Sargaev age [2, 6]. These forms are rare and sometimes absent in the Ust-Yarega Formation of the Sargaev Horizon in the Tsilma River basin.

Minor differences in taxonomic composition of PCs from single-age deposits of the Middle and the Southern Timan are explained by landscape-facial conditions of their producers growth. The constant lowering of the Southern Timan territory was the cause of constant watercourses and various water areas facies of warm humid climate. The Middle Timan slow dive and some elevation of this territory led to the spread of

periodically changing facies from drier to wetter and vice versa. The lithological analysis results show a high sedimental variability of most formations on the Middle Timan both in section and in extension, which is typical of alluvial coastal plains.

For the first time the appearance of taxa spores *Cristatisporites pseudodeliquescens* Telnova et Marshall, *Archaeoperisaccus ovalis* Naumova was traced in the sections of the Ust-Yarega Formation of the Southern Timan. The palynozone *Cristatisporites pseudodeliquescens* [6] was established here. Later, the simultaneous appearance of these taxa was traced at the single-age stratigraphic level in outcrops of the Darshor Creek on the Chernyshev Ridge on the Middle Timan [5, 7]. This allows adding the binary name of palynozone *C. pseudodeliquescens* – *A. ovalis* to the regional spore scheme (tab. 2).

Stratigraphic sequence of appearance of taxa *Cristatisporites pseudodeliquescens* and *Cristatisporites deliquescens* (Naumova) Arkh. is traced in the sections of Ust-Yarega Formation on the Middle Timan. The *C. deliquescens* spores in stratigraphically complete and more shallow-water sections on the Middle Timan are highlighted as index species of miosporous sub-complex B of the *Cristatisporites pseudodeliquescens* zone [7].

In addition, a simultaneous appearance of spores *Cristatisporites deliquescens* and conodonts *Ancyrodella rotundiloba soluta* Sandb. Ziegl. et Bult recorded in section of shallow water-shelf facies in outcrops of the Shera Creek on the Jimparka Plato of the Southern Timan (Telnova, Soboleva, Sobolev, in print). The same association of miospores and conodonts was explored in the upper part of the Kedzydshor Formation in outcrops of the Derashor Creek (Chernyshev Ridge) [5, 10].

Conclusion

Thus, the stratigraphic sequence of appearance of taxa *Cristatisporites pseudodeliquescens* and *Cristatisporites deliquescens* and an association of conodonts *Ancyrodella rotundiloba soluta* and the spore *Cristatisporites deliquescens* found in different areas of the Timan-North Ural region. It allows to identify a new regional spore zone *Cristatisporites deliquescens* (tab. 2). In the

regional Devonian palynostratigraphic zonation scheme [6] the new zone occupies a level between the palynozones *C. pseudodeliquescentis* and *G. semilucensis* — *P. donensis*.

By the present moment, only one stratigraphic level has been correlated on spores and conodonts (orthostratigraphic group of fauna) and it is much higher than the modern boundary of the Middle — Late Devonian. Because of this only phytostratigraphic boundaries can be characterized with spores.

Analysis of taxonomic composition of PCs from border deposits shows that the most significant changes occur in the third PC (palynozone *Densosporites sorokinii*) of the Timan Formation on the Southern Timan and in the Ust-Chirka Formation on Middle Timan [7]. In these PCs the taxonomic composition updates on the species and generic levels. Spores of *Archeopteris* plants (*Contagisporites optivus*, *Geminospora rugosa*, *G. notata*, *G. micromanifesta*, etc.) are the main

(up to 50 %) dominant group still. Spores with film perispores (*Calyptosporites*, *Cristatisporites*, *Hymenozonotriletes*, *Densosporites*, etc.) becomes a subdominant group (up to 16 %), which are among the dominant genera higher in section. This level can be considered as a phytostratigraphic frontier. It is a bit lower than Givetian — Frasnian boundary marked by conodonts. Apparently, the trigger for significant changes in both plant and marine communities was the eustatic Frasnian event. This event is characterized by the beginning of global transgression and is timed to the foundation of the *Early falsiovalis* conodont zone [13]. Regional responses of continental and marine biota components to environmental changes may occur at different rates. Plant biota proved to be more sensitive and responded to climate change almost immediately. In this case, the biotic event almost coincides with the abiotic event.

The most important taxa of spores studied in the Givetian-Frasnian sediments of the Middle and Southern Timan

Наиболее важные таксоны спор из живецко-франских отложений на Среднем и Южном Тимане

1 — *Contagisporites optivus* (Tchib.) Owens, sample 305-1; 2 — *Geminospora micromanifesta* (Naumova) Owens, sample 317-1; 3 — *Geminospora notata* (Naumova) Obukh., sample 150-1; 4 — *Tholisporites variabilis* (Naumova) Oshurk., sample 193-2; 5 — *Tholisporites variabilis* (Naumova) Oshurk. var. *insignis* Sen., sample 150-2; 6 — *Archaeozonotriletes accretus* Tchib., sample P2-3; 7 — *Calyptosporites bellus* (Naumova) Oshurk., sample 417-2; 8 — *Calyptosporites domanicus* (Naumova) Oshurk., sample p2-1; 9 — *Calyptosporites krestovnikovii* (Naumova) Oshurk., sample 193-1; 10 — *Densosporites sorokinii* Obukh., sample 127-1; 11 — *Cristatisporites pseudodeliquescentis* Telnova et Marshall, sample 127-1; 12 — *Cristatisporites deliquescentis* (Naumova) Arkh., sample 127-1; 13 — *Ancyrospora furcula* Owens, sample 127-2; 14 — *Archaeoperisaccus verrucosus* Pashk., sample 317-1; 15 — *Acanthotriletes bucerus* Tchib., sample 193-1; 16 — *Acanthotriletes eximius* Naumova, sample 315-1; 17 — *Archaeoperisaccus ovalis* Naumova, sample 315-1.

The numbers of spore preparations correspond to the numbers of the samples [8]. Scale bar 10 µm

Номера палинологических препаратов соответствуют номерам образцов [8]. Длина масштабной линейки 10 µm

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