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Givetian trilete spores of *Geminospora* from the Volyn–Podillya (Western Ukraine)

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Abstract. Givetian sediments are widely distributed within the Volyn-Podillia margin of the East-European platform (VPO EEP)**.** These are terrigenous-carbonate cyclically constructed formations with a thickness of 102 to 165 m, the stratification of which is complicated due to the facial variability of rocks. Therefore, when studying this stratum, palynology and the implementation of palynostratigraphic delimitation are of great importance. The initial stage of palynological research of Devonian VPO EEP deposits is clear identification of miospores and their monographic study, the main components of which are morphological and morphometric research, taxonomic determination of genera and species by morphological-comparative method, elucidation of their stratigraphic and geographical distribution. The object of research is dispersed miospores. During their taxonomic study, M.V. Oshurkova's artificial, or formal, taxonomy was used, which modernized the morphological classification of R. Potonier and G. Kremp, clarified palynological terminology, detailed diagnostics of taxa, and gave unified diagnoses of genus forms. For the first time, a monographic description of five species is given according to this classification. They are *Geminospora extensa* (Naumova) Gao (from 36 to 51%); up to 10%: *G. decora* (Naumova) Archangelskaja, *G. tuberculata* (Kedo) Allen, *G. micromanifesta* (Naumova) Archangelskaja, *G. notata* (Naumova) Obukhovskaja. belonging to the genus *Geminospora* (Balme) Owens of infraturma Pseudosacciti, subturma Zonocavatitriletes, suprasubturma Cavatitriletes turma Triletes. These are trilete radial zonate cavate hilate spores with ornamented exine. They are main indicators, key and characteristic species of palyzone **E** of the Givetian of the Middle Devonian.

Keywords: palynology, spores, Givetian, Devonian, Volyn-Podillya, the Eastern European platform.

Живетські трілетні спори *Geminospora* (Balme) Owens Волино-Поділля (Західна Україна)

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Анотація. Відклади живетського ярусу поширені повсюдно в межах Волино-Подільської окраїни Східноєвропейської платформи (ВПО СЕП). Це теригенно-карбонатні циклічно побудовані утворення товщиною від 102 до 165 м, стратифікація яких ускладнена внаслідок фаціальної мінливості порід. Під час вивчення цієї товщі велике значення має палінологія і виконання паліностратиграфічного розмежування. Початковим етапом палінологічних досліджень девонських відкладів ВПО СЄП є чітка ідентифікація міоспор та їхнє монографічне вивчення, головними складовими якого є морфологічне і морфометричне дослідження, таксономічне визначення родів і видів морфолого-порівняльним методом, з'ясуванням їхнього стратиграфічного і географічного поширення. Об'єктом досліджень є дисперсні міоспори. Під час їхнього таксономічного вивчення застосовували штучну, або формальну, систематику М.В. Ошуркової, яка модернізувала морфологічну класифікацію Р. Потонье і Г. Кремпа, уточнила палінологічну термінологію, деталізувала діагностику таксонів, навела уніфіковані діагнози форма-родів. За цією систематикою вперше для палінології девону ВПО СЄП наведено монографічний опис чотирьох видів *Geminospora extensa* (Naumova) G a o (від 36 до 51%); до 10%: *G. decora* (Naumova) Archangelskaja, *G. tuberculata* (Kedo) Allen, *G. micromanifesta* (Naumova) Archangelskaja, *G. notata* (Naumova) Obukhovskaja, які належать форма-роду *Geminospora* (Balme) Owens інфратурми Pseudosacciti, субтурми Zonocavatitriletes, супрасубтурми Cavatitriletes турми Triletes. Це трипроменеві радіальні зонатні каватні монопсевдосакатні спори з орнаментованою екзиною. Вони є чіткими індикаторами і керівними видами відкладів палінозони **E** живетського ярусу середнього відділу девонської системи.

Ключові слова: палінологія, спори, живетський ярус, Волино-Поділля, Східноєвропейська платформа.

Introduction.

This publication is one of the works that follow (Ivanina, 2004, 2018, 2019) devoted to the palynological characteristics of the Devonian sediments of the Volyn-Podillya margin of the East-European platform (VPM EEP).

The purpose of the palynological study is to improve the biostratigraphic substantiation of local stratons and stratigraphic schemes in general, which is impossible without the initial stage of any paleontological research, namely the study of the structure and taxonomic definition of genera and species of dispersed spores and its spreading.

The most important stage of palynological research is morphological investigations and identification of spores. The reliability of scientific elaboration and practical application of palynological data depends on the quality of the initial data the accuracy of the taxonomic definition. Morphological (artificial or formal) classifications are used in the study of Paleozoic spores and pollen. Today there are many modifications of morphological classification systems of Paleozoic spores, which differ in the principles of typification, volumes, and diagnoses of taxa, differences in the hierarchical sequence of systematic units, and so on. M. V. Oshurkova (Oshurkova, 2003) revised the existing taxonomies and, choosing the classification of R. Potonie and G. Kremp (Potonie, Kremp, 1955, 1956) as the base, clarified palynological terminology, detailed the diagnosis of taxa, gave unified diagnoses of form-genera and streamlined the taxonomy of Paleozoic spores by the restoring the rule of priority and returning to its composition valid taxa. Such modernization of the classification of Paleozoic spores by M. V. Oshurkova is a significant step forward, as it corresponds to the current state of the study of palynomorphs, is the best-generalized summary of unified genus diagnoses in their taxonomic and hierarchical subordination. According to this classification system, the study of Paleozoic spores was not performed in Ukraine.

Givetian sediments of the VPM EEP are terrigenous-carbonate with a thickness of 102 to 165 m, characterized by a cyclic structure with alternating of chemogenic and terrigenous rocks with different thicknesses. The main types of rocks – limestones, dolomites, anhydrite, argillites, sandstones, siltstones, form complicated paragenetic associations (Ivanina, Havrylets, Stokhmanska, 2000; Stratyhrafiia URSR, 1974; Stratyhrafiia verkhnoho proterozoiu, paleozoiu ta mezozoiu Ukrainy, 2013). Stratification of them is difficult because of the facial variability of rocks (Konstantynenko, Ivanina, 2004), low content of macrofossils and it is possible only by micropaleontological and spore-pollen data.

Palynological studies of the Devonian of the VPM EEP were initiated in the middle of the last century by G. I. Kedo, O. V. Chibrikova, I. I. Partyka (only manuscript), continued by A. V. Ivanina (Ivanina, 2004, 2018, 2019), who isolated and characterized the palynozone **Geminospora extensa** (**E**) and gave its generalized (Ivanina, 2004) and standardized (Ivanina, 2018) palynological characteristics.

Palynological zone **E** is the biozone – *Geminospora extensa* (Naum.) Gao index-species spreading zone. It is widespread in the VPM EEP. It occurs on the deposits of the palynozone **TL** (Middle Devonian, Eiffel) and is covered by Frasnian sediments (Ivanina, 2018). It corresponds to the palyzone **EX** (**Geminospora extensa**) of the East-European platform (Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plyt, 1985), Ural (Chibrikova, 1977), Pripyat depression (Kedo, Obukhovskaya, 1981.), upper part of zone **AD** (**acathomammillatus**–**devonicus**) and spore zone **TA** (**triangulatus**–**ancyrea**) the Ardenne-Rhenich regions (Streel, Higgs, Loboziak, Riegel, Steelmans, 1987).

The most important signs of this zone are:

- 65 taxa are recorded – 28 transit, 24 key and 13 characteristic (or typical) species (table 1);
- significant content (from 36 to 81 %) of spores of the genus *Geminospora* (Balme) Owens has been established among key taxa, and especially of index-species *Geminospora extensa* (Naum.) Gao (36–51 %);
- only in the sediments of the zone there are four species of the genus *Geminospora* – *Geminospora extensa* (Naum.) Gao, *G. decora* (Naum.) Archangelskaja, *G. tuberculata* (Kedo) Allen, *G. micromanifesta* (Naum.) Archangelskaja.
- one species – *Geminospora notata* (Naum.) Obukhovskaja is typical, because it has a wider range of existence; it appears in zone **E**; within its limits occurs in significant quantities, disappears in the Late Devonian.

The genus *Geminospora* (Balme) Owens was first described by Balme B. E. from the Upper Devonian sediments of Western Australia (Balme, 1962). Its diagnos was modernized by Owens W. during the study of Middle and Upper Devonian sediments in Canada (Owens, 1971).

Spores of the genus *Geminospora* (Balme) Owens from Givetian of the VPM EEP are trilete radial zonate cavate monopseudosaccate spores with ornamented exine and are similar in structure. Common morphological features are trilete suture, the presence of stratified layers of exine, and the growth of exoexina in the form of a pseudosaccus. They are distinguished by the ornamentation of the exine.

Table 1. Miospores' composition of the **Geminospora extensa (E)** Zone

Taxa	Dominant and subdominant	Accessory
Key	*Geminospora extensa*, *G. decora*, *G. tuberculata*, *Acanthozonotri-letes spinutissimus*	*Geminospora micromanifesta*, *Calyptosporites krestovnikovii*, *Aneurospora heterodonta*, *Hymenozonotriletes spinosus*, *H. argutus*, *H. polyacanthus*, *Speciososporites novus*, *Calyptosporites proteus*, *C. velatus*, *Sinuosisporis sinuosus*, *Rhabdosporites langii*, *Grandispora torezi*, *G. naumovae*, *Corystisporites multispinosus*, *Cymbosporites magnificus*, *Chelinospora timanica*, *Retusotriletes radiosus*, *Monilospora latemarginatus*, *Tuberculiretusispora subgibberosa*
Typical	*Geminospora notata*, *Lophozonotriletes curvatus*	*Acanthotriletes parvispinus*, *Trachytriletes*? *devonicus*, *Leiotriletes furcatus*, *Retusotriletes concinnus*, *Lophozonotriletes scurrus*, *L. curvatus*, *Auroraspora varia*, *Ancyrospora honesta*, *Retusotriletes simplex*, *Diaphanospora rugosa*
Transit	–	*Calamospora*, *Punctatisporites*, *Granulatisporites*, *Brochotriletes*, *Acanthotriletes*, *Trachytriletes*? *trivialis*, *Leiotriletes laevis*, *L. simplex*, *Retusotriletes minor*, *R. triangulatus*, *Foveolatisporites*, *Stenozonotriletes conformis*, *S. laevigatus*, *Ambitisporites pumilis*, *A. simplex*, *Lophotriletes*, *Verrucosisporites*, *Converrucosisporites*, *Reticulatisporites*, *Camptotriletes*, *Periplecotriletes*, *Spinozonotriletes*, *Apiculiretusispora*, *Anapiculatisporites*

Monographically from Devonian deposits of the VPM EEP they are not described.

Material and methods of the research.

The material for research is 270 samples of rocks with different lithology. Givetian sediments containing species of genus *Geminospora* (Balme) Owens are widespread within the VPM EEP.

During palynological studies of Devonian sediments of the VPM EEP taxonomic determination was performed by morphological-comparative method, the main purpose of which is to clarify the systematic position and determine taxa by their structure (Uziiuk, Ivanina, Hotsaniuk, Shainoha, Tuziak, 2007; Hotsaniuk, Ivanina, 2017). This method involves such operations: analysis of the spore's preservation; morphological description; morphometric observations (measuring the size of spores in general and their individual elements); taxonomic definition; detection of geographical and stratigraphic spreading.

The morphology of spores was studied on biological microscopes "Nicon-eclipse" and "Axiolab" and was accompanied by photographing spores with a digital camera "Optiphot-2". The external structure of the exina of five species of the genus *Geminospora* (Balme, 1962) Owens, 1971 from Givetian of the VPM EEP, selected by the method of V.K. Teteriuk (Teteriuk, 1964), was first studied and photographed on a scanning microscope "Geol" JSM-6400.

Results and their analysis.

The monographic description of species is given according to classical canons, in compliance with the International Code of Botanical Nomenclature (1974) and the procedure for describing species of fossil spores (Instructions for the description of fossil plant and animal organisms in paleontological works, 1971). The optimal set of morphological features was selected for the species characteristic, first of all, which can be recognized on the fossil material; secondly, they are necessary and sufficient to determine the species. For each species the full name, author, year of definition, synonymy, material, morphological characteristics (type of spore, outlines, the structure of aperture, exines, the character of sculpture, etc.), sizes, stratigraphic and geographical spreading are given.

Morphological descriptions of species of the genus *Geminospora* are based on the genus characteristics given in (Oshurkova, 2003). At the same time, reliable diagnostic features were found for each species, which serve as criteria for species identification.

This morphological description is the first generalized summary of unified diagnoses of the main spore's species of the genus *Geminospora* (Balme, 1962) Owens, 1971 from Givetian (palynological zone **E**) of the VPM EEP. It will help to correctly identify fossil species.

Anteturma **PROXIMEGERMINANTES** Potonie, 1970 (**Sporites** H. Potonie, 1893)

Turma**TRILETES** (Reinch, 1881) Potonie et Kremp, 1954

Suprasubturma **Cavatitriletes** Oshurkova et Pashkevich, 1990

Subturma **Zonocavatitriletes** Oshurkova et Pashkevich, 1990

Infraturma **Pseudosacciti** Oshurkova et Pashkevich, 1990

Genus *Geminospora* (Balme, 1962) Owens, 1971

Geminospora extensa (Naumova, 1953) Gao, 1981

Plate 1, fig. *1–3*

Archaeozonotriletes extensus Naumova: Naumova, 1953, p. 33, 86, pl. 3, fig. 5; pl. 13, fig. 20; Кедо, 1955, pl. 5, fig. 16, 17; Tchibrikova, 1962, pl. 17, fig. 25; Raskatova, 1969, pl. 14, fig. 48; Tchibrikova, 1977,

pl. 17, fig. 7; Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978, pl. 30, fig. 2, 23, 39; Kedo, Obukhovskaja, 1981, pl. 18, fig. 1, pl. 19, fig. 4, 21.

Geminospora extensa (Naumova) Gao: Gao, 1981, pl. 3, fig. 6; Archangelskaja, 1985, p. 46, pl. 5, fig. 2; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993, p. 108, pl. 7, fig. 1; p. 110, pl. 8, fig. 4; p. 112, pl. 9, fig. 4; Oshurkova, 2003, p. 207; Ivanina, 2004, p. 118, 150, pl. 1, fig. 1–3.

Palynological material. 37 well-preserved specimens.

Description. Small and medium-sized radial trilete zonate cavate mono-pseudo saccate spores with rounded-triangular amb. The exine is with separated layers. The central body is triangular-rounded, with convex sides and rounded corners and a moderately thick verrucate intexine on the distal side. Exoexina of the pseudosaccus of medium thickness, with verrucate ornamentation; at the equator of spores has the form of a very narrow zone. The surface of the pseudosaccus is densely covered with small, densely spaced verrucae – low growths of irregularly rounded or irregularly oval shape with flat or slightly rounded tips.

The edge of the spores is irregular, slightly wavy, due to the protrusion of sculptural elements along the equator of the spores.

The trilete suture is simple, the rays are straight, the length is equal to the radius of the spores.

Dimensions, μm. (19 measured specimens). Equatorial diameter: the spore body – 24–43, central body – 18–31; width of equatorial zone – 4–6; verrucae: width – 0,5–2,0; height – 1,0–1,5.

Localities. Boreholes: Gorochiv 6, 1 070–1 180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1 412–1 553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1 013 m, Reniv 24 c, 100–210 m, Tychotyn 1, 430–567 m, Tychotyn 3, 668–782 m and others.

Occurrence. Middle Devonian; Givetian of the East-European platform (zone **EX** of the general East-Europian palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plyt, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian of the VPM EEP (palynological zone **E**).

Geminospora micromanifesta
(Naumova, 1953) Owens, 1971
Plate 1, fig. *4–6*

Archaeozonotriletes micromanifestus Naumova: Naumova, 1953, p. 31, 79, 128, pl. 2, fig. 18; pl. 12, fig. 2–4; pl. 19, fig. 5; Tchibrikova, 1959, pl. 15, fig. 23; 1962, pl. 17, fig. 19; Nazarenko, 1964, pl. 1, fig. 8, 51, 64; Tchibrikova, 1977, pl. 16, fig. 9; pl. 19, fig. 12; Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978, pl. 30, fig. 9, 26; Kedo, Obukhovskaja, 1981, pl. 19, fig. 5, 22, pl. 21, fig. 9.

Geminospora lemurata Balme: Balme, 1962, p. 4, pl. 1, fig. 5, 7, 8.

Archaeozonotriletes micromanifestus Naumova var. *microtuberculatus* Tschibrikova: Tchibrikova, 1962, p. 414, pl. 7, fig. 5.

Archaeozonotriletes antaxios Tschibrikova: McGregor, Camfield, 1982, pl. 3, fig. 7.

Archaeozonotriletes cf. *antaxios* Tschibrikova: Bar, Riegel, 1974, pl. 1, fig. 10.

Geminospora micromanifesta (Naumova) Archangelskaja: Archangelskaja, 1985, p. 46, pl. 5, fig. 1; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993, p. 110, pl. 8, fig. 13; p. 112, pl. 9, fig. 8; p. 114, pl. 10, fig. 2; Ivanina, 2004, p. 118, 150, pl. 1, fig. 10.

Geminospora micromanifesta (Naumova) Owens: Owens, 1971, pl. 3, fig. 6; Oshurkova, 2003, p. 207.

Palynological material. 19 well-preserved specimens.

Description. Medium-sized trilete radial zonate cavate triangular-rounded spores with a triangular-rounded central body, which is sometimes shifted to the side. The exina is stratified around the equator and the distal side of the spores. The exoexina is thick, forming a pseudosaccus around the central body, which at the equator has the appearance of a medium-width zone. The surface of the pseudosaccus with verrucate ornamentation is densely covered with weakly expressed flat, very small, densely placed verrucae. The Interradial area is without sculptural elements, smooth.

The edge of the spores is uneven, weakly and slightly wavy.

The laesura is trilete, the rays are straight, its' length is equal to the radius of the spores.

Dimensions, μm. (based on 11 specimens). Equatorial diameter: the spore body – 43–72, central body – 31–51; width of equatorial zone – 9–14.

Localities. Boreholes: Gorochiv 6, 1 070–1 180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1 412–1 553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1 013 m, Reniv 24 c, 100–210 m, Tychotyn 1, 430–567 m, Tychotyn 3, 668–782 m and others.

Occurrence. Middle Devonian, Givetian of the East-European platform (zone **EX** of the general East-

Europian palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plyt, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian (palynological zone **E**) of the VPM EEP.

Geminospora decora (Naumova, 1953) Archangelskaja, 1980

Plate 1, fig. *7–9*

Archaeozonotriletes decorus Naumova: Naumova, 1953, p. 35, pl. 3, fig. 11, 12; Kedo, 1955, p. 39, pl. 5, fig. 20; Tchibrikova, 1959, pl. 15, fig. 28; Raskatova, 1969, pl. 14, fig. 24, 30; Kedo, Obukhovskaja, 1981, pl. 18, fig. 4.

Archaeozonotriletes pustulatus Naumova: Naumova, 1953, p. 35, pl. 3, fig. 10; Kedo, 1955, p. 38, pl. 5, fig. 19; Tchibrikova, 1959, pl. 15, fig. 27; Raskatova, 1969, pl. 14, fig. 22; Tchibrikova, 1977, pl. 15, fig. 5; pl. 16, fig. 10; pl. 17, fig. 9; Kedo, Obukhovskaja, 1981, pl. 18, fig. 3; pl. 20, fig. 8.

Geminospora decora Archangelskaja: Archangelskaja, 1985, p. 48, pl. 5, fig. 6. 7; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993, p. 110, pl. 8, fig. 11; p. 112, pl. 9, fig. 14; Oshurkova, 2003, p. 207; Ivanina, 2004, p. 118, 150, pl. 1, fig. 4.

Palynological material. 35 well-preserved specimens.

Description. Small and medium-sized trilete radial zonate cavate triangular-rounded spores with a pseudosaccus, which at the equator has the form of a narrow zone. The central body is triangular and rounded, with convex sides and rounded corners. Exina is fine-grained, thick, layered around the equator and the distal side of the spores, with conate ornamentation. Sculptural elements in the form of low coni with a rounded base and rounded tip, placed on the distal

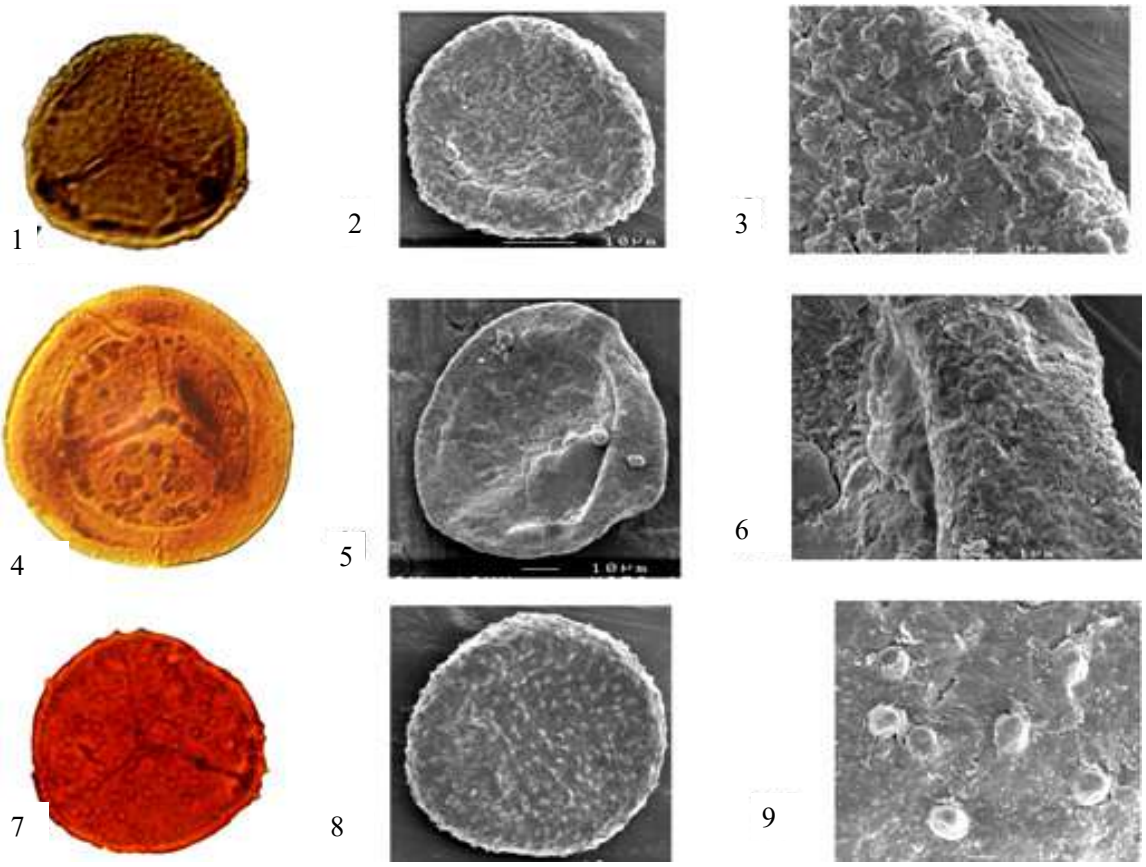

Plate 1. Key species of genus *Geminospora* (palynozone **E**, borehole Reniv 24 c, 100–210 m), Givetian, Middle Devonian of the VPM EEP. All figures in transmitted light x400. Magnification under the electronic microscope is on images.
1–3. *Geminospora extensa* (Naum.) Gao: *1* – view in transmitted light; *2*, *3* – view under the electronic microscope: *2* – from distal side; *3* – fragment of distal side with verrucate ornamentation; *4–6. Geminospora micromanifesta* (Naum.) Owens: *4* – view in transmitted light; *5*, *6* – view under the electronic microscope: *5* – from distal side; *6* – fragment of distal side with ornamentation from small verrucae; *7–9*. *Geminospora decora* (Naum.) Arkh.: *7* – view in transmitted light; *8*, *9* – view under the electronic microscope: *8* – from distal side; *9* – fragment of distal side with tuberculate sculpture.

side and along the equator of the spores evenly and at almost the same distance from each other. Intexin forms the central body, exoexina saccus.

The edge of the spores is uneven, finely conate due to the protrusion of sculptural elements along the equator of the spores.

The suture is trilete, the rays are straight, the length is equal to the radius of the spores.

Dimensions, μm. (29 measured specimens). Equatorial diameter: the spore body – 34–43, central body – 30–34; width of equatorial zone –2–4; coni: width – до 2,5, height – 1,5–2,0, distance between coni – 5–10.

Comparison. In the descriptions given in the works (Naumova, 1953; Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plyt, 1985) sculptural elements in the form of rounded tubercula. Electron microscopic studies have shown that the sculptural elements of this species are coni (narrowed upwards) with sharp but rounded tops, rounded bases, the diameter of which is equal to or slightly larger than the height.

Localities. Boreholes: Gorochiv 6, 1 070–1 180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1 412–1 553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1 013 m, Reniv 24 c, 100–210 m, Tychotyn 1, 430–567 m, Tychotyn 3, 668–782 m and others.

Occurrence. Middle Devonian; Givetian of the East-European platform (zone **EX** of the general East-Europian palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plyt, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian (palynological zone **E**) of the VPM EEP.

Geminospora tuberculata (Kedo, 1955) Allen, 1965

Plate 2, fig. *1–3*

Archaeozonotriletes meonacanthus Naumova: Naumova, 1953, pl. 22, fig. 100; Tchibrikova, 1959, p. 58, pl. 7, fig. 4; Nazarenko, 1964, pl. 1, fig. 32–34.

Archaeozonotriletes tuberculatus Kedo: Kedo, 1955, p. 35, pl. 5, fig. 6,7; Raskatova, 1969, pl. 14, fig. 28; Kedo, Obukhovskaja, 1981, pl. 18, fig. 9.

Geminospora tuberculata (Kedo) Allen: Allen, 1965, p. 696, pl. 94, fig. 10; Archangelskaja, 1985, p. 47, pl. 5, fig. 5; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993, p. 108, pl. 7, fig. 3; p. 110, pl. 8, fig. 5; p. 112, pl. 9, fig. 12; Oshurkova, p. 207; Ivanina, 2004, p. 118, 150, pl. 1, fig. 7–9.

Geminospora tuberculata (Kedo) Allen var. *tuberculata* McGregor: McGregor, Camfield, 1982, p. 110, pl. 8, fig. 5.

Palynological material. 17 well-preserved specimens.

Description. Medium-sized trilete radial zonate cavate triangular-rounded spores. The triangular-rounded central body, which has convex sides and rounded corners, is sometimes offset from the center. The exina is moderately thick, sometimes with single folds, stratified around the equator and the distal side of the spores. Exoexina with tuberculate ornamentation forms around the body a pseudosaccus, which at the equator looks as a medium-width, sometimes asymmetric zone. The surface of the saccus is covered with small, evenly, and occasionally placed, low tubercula, which are narrowed upwards, have a rounded base and rounded tops. The diameter of the base and the height of the tubercula are approximately the same.

The edge of the spores is uneven, tuberculate due to the protrusion of sculptural elements along the equator of the spores.

The suture is trilete, the rays are straight, with thin lips, equal in length to the radius of the spores.

Dimensions, μm. (based on 10 specimens). Equatorial diameter: the spore body – 52–63, central body – 32–41; width of equatorial zone – 10–15; coni: width – 0,5–2,0; height – 1,0–1,5.

Localities. Boreholes: Gorochiv 6, 1 070–1 180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1 412–1 553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1 013 m, Reniv 24 c, 100–210 m, Tychotyn 1, 430–567 m, Tychotyn 3, 668–782 m and others.

Occurrence. Middle Devonian; Givetian of the East-European platform (zone **EX** of the general East-Europian palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plyt, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian (palynological zone **E**) of the VPM EEP.

Geminospora notata (Naumova, 1953) Obukhovskaja, 1981

Plate 2, fig. *4–6*

1953 *Archaeozonotriletes notatus* Naumova: Naumova, p. 84, pl. 13, fig. 12; p. 116, pl. 17, fig. 25.

1978 *Archaeozonotriletes notatus* Naumova: Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, p. 220, pl. 31, fig. 20, 29.

1981 *Geminospora notata* (Naumova) Obukhovskaja: Obukhovskaja, p. 46, pl. 5, fig. 2.

1993 *Geminospora notata* (Naumova) Obukhovskaja: Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993, p. 112, pl. 9, fig. 15; p. 114, pl. 10, fig. 10; p. 116, pl. 11, fig. 11; p. 122, pl. 14, fig. 14.

2003 *Geminospora notata* (Naumova) Obukhovskaja: Oshurkova, p. 207.

Palynological material. 29 well-preserved specimens.

Description. Small and medium-sized radial trilete zonate cavate mono-pseudosaccate triangular-rounded spores. The exina is stratified around the equator and the distal side of the spores. The exoexina is thin, sometimes crumpled into folds, forming a pseudosaccus around the body. A pseudosaccus look as a narrow zone along the equator and is densely covered with small, densely spaced, verrucae (irregularly rounded outgrowths with flat tips). Ornamentation is verucate.

The edge of the spores is uneven, slightly wavy, due to the protrusion of sculptural elements along the equator of the spores.

The suture is trilete, the rays are straight, the length is equal to the radius of the spores.

Dimensions, μm. (21 measured specimens). Equatorial diameter: the spore body – 34–53, width of equatorial zone – 7–9.

Stratigraphic distribution. Characteristic in Middle and Upper Devonian: subdominant in Zone **E** (Givetian), rare in zones **HM, V** (Famenian) of VPM EEP (Ivanina, 2018).

Localities. Boreholes: Oglyadiv 1, 681–1 332 m, Oglyadiv 3, 460–1 020 m, Volytsa 1, 1 075–1 195 m, Vazhev 2, 1 124–1 340 m, Rajmysto 42, 128–180 m, Torchyn 201, 262–289 m, Gorochiv 1, 396–900 m, Gorochiv 2, 543–970 m, Gorochiv 6, 490–1 180 m, Lokachi 9, 883–986 m and others.

Occurrence. Middle, Upper Devonian; Givetian, Frasnian of the East-European platform (zones **EX–OG** of the general East-Europian palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziak, Streel, 1993); Upper Devonian, Frasnian of Pripyat depression (Stratigraficheskie

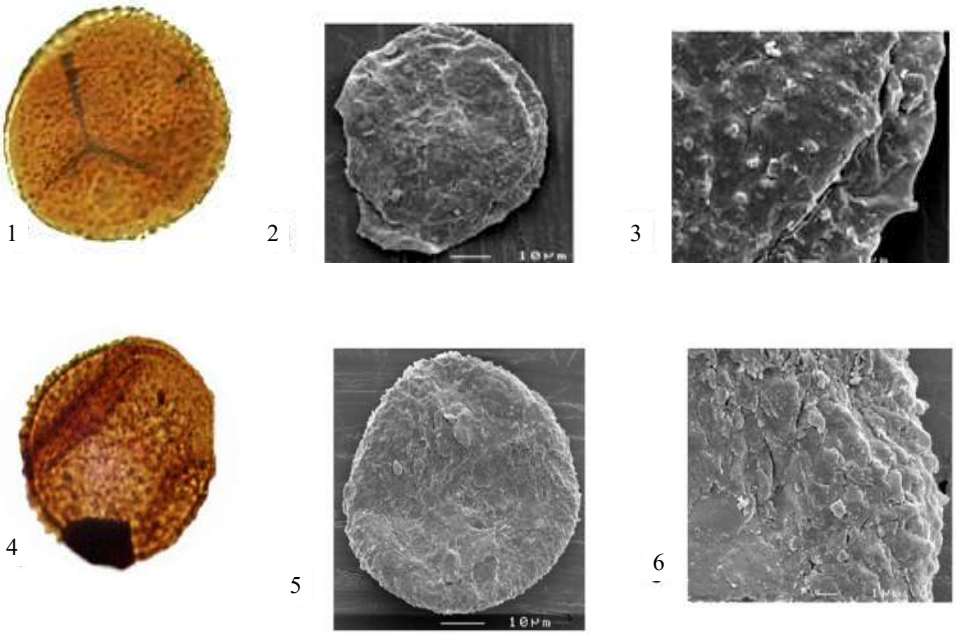

Plate 2. Some species of genus *Geminospora* (Balme, 1962) Owens. All figures in transmitted light x400. Magnification under the electronic microscope is on images.

1–3. Geminospora tuberculata (Kedo) Allen, borehole Reniv 24 c, 100–210 m; palynozone **E**; Givetian, Middle Devonian of the VPM EEP: *10* – view in transmitted light; *11*, *12* – view under the electronic microscope: *11* – from distal side; *12* – fragment of distal side with spinate ornamentation. *4–6. Geminospora notata* (Naumova) Obukhovskaja, Tychotyn 5 447, 188–214 m; palynozone **E**; Givetian, Middle Devonian of the VPM EEP: *4* – view in transmitted light; *5*, *6* – view under the electronic microscope: *4* – from distal side; *5* – fragment of distal side with verrucate ornamentation.

i paleontologicheskie issledovaniya v Belorussii, 1978), Givatian – lower part of Famenian (palynological zones **E–V**) of the VPM EEP.

Conclusions.

During palynological research of Devonian of the Volyn-Podillia margin of the East-European platform (VPM EEP):

– the systematic composition of the spores key species of the genus *Geminospora* (Balme, 1962) Owens, 1971 from Givetian, Middle Devonian (palynological zone **E**) of the VPM EEP was determined;

– according to the updated taxonomy of M. V. Oshurkova (2003) for the first time the ultrastructure of five species was described and studied monographically. These species are *Geminospora extensa* (Naum.) Gao, *G. decora* (Naum.) Arkh., *G. tuberculata* (Kedo) Allen, *G. micromanifesta* (Naum.) Arkh., *G. notata* (Naum.) Obukh.;

– diagnos of all spores species of the genus *Geminospora* (Balme, 1962) Owens, 1971 from Givetian of the VPM EEP are detailed and specified.

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