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, suburma Zonocavatitriletes, suprasuburma 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.
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; Stratyhrafiiia URSR, 1974; Stratyhrafiiia verkhnoho proterozoizu, paleozoou ta mezozoou 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. Chibrikovka, 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 palynozone EX (Geminospora extensa) of the East-European platform (Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Manturova, Lobozik, Streel, 1993; Atlas spor i pylyts nefehazonomnyh tolsch caneranozoi 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, Loboziaik, 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 diagnosis 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 monospinosaccate 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.
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 “Nikon-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.

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

| Taxa | Dominant and subdominant | Accessory |
|------|--------------------------|-----------|
| Key  | Geminospora extensa, G. decora, G. tuberculata, Acanthozonotriletes spinatissimus | Geminospora micromanifesta, Calyptosporites krestovnikovi, Aneuropora heterodonta, Hymenozonotriletes spinosus, H. argutus, H. polycanthus, Speciososporites novus, Calyptosporites proteus, C. velatus, Sinuosispors spinosus, Rhabdosporites langii, Grandispora torezi, G. naumovae, Corysispores multispinosus, Cymbosporites magnificus, Chelinospora timanica, Retusotriletes radiatus, Monilospora latemarginatus, Tuberculutatisporites subgibbosa |
| Typical | Geminospora notata, Lophozonotriletes curvatus | Acanthotriletes parvipinaceus, Trachytriletes? devonicus, Leiotriletes furcatus, Retusotriletes concinnus, Lophozonotriletes scurrus, L. curvatus, Auroraspora varia, Ancyrospora hestena, Retusotriletes simplex, Diaphanospora rugosa |
| Transit | — | Calamospora, Punctatisporites, Granulatisporites, Brochotriletes, Acanthotriletes, Trachytriletes? trivialis, Leiotriletes laevis, L. simplex, Retusotriletes minor, R. triangulatus, Foveolatrisporites, Stenozonotriletes conformis, S. laevigatus, Ambitspores pumilis, A. simplex, Lophotriletes, Verrucosispores, Converrucosispores, Retulatisporites, Camptotriletes, Periplecotriletes, Spinozonotriletes, Apiculatisporites |
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, 1070–1180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1412–1553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1013 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-European palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziat, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolsch 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 Е).

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: Tschibrikova, 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, Loboziat, 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 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, 1070–1180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1412–1553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1013 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-European palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziat, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolsch 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 Е).
Europian palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboiak, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolsheh fanerozoia Russkoi i Turanskoi plyt, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian (palynological zone Е) of the VPM EEP.

_Geminispora 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.

_Geminispora decora_ Archangelskaja: Archangelskaja, 1985, p. 48, pl. 5, fig. 6. 7; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboiak, 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 sides of the spores. The sculpture is fine-grained, thick, layered around the equator and the distal side of the spores, with conate ornamentation.

Plate 1. Key species of genus _Geminispora_ (palynozone Е, 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. _Geminispora 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. _Geminispora 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. _Geminispora 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 tuberculata. 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, 1070–1180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1412–1553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1013 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-European palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Lobozik, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plety, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian (palynological zone Е) 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, Lobozik, 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 cave 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 tuberculata 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 tuberculata, which are narrowed upwards, have a rounded base and rounded tops. The diameter of the base and the height of the tuberculata are approximately the same.

The edge of the spores is uneven, tuberculata 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, 1070–1180 m, Gorochiv 2, 875–970 m, Ludyn 1, 1412–1553 m, Lokachi 9, 883–986 m, Lokachi 27, 830–930 m, Markovychi 1, 922–1013 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-European palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Lobozik, Streel, 1993; Atlas spor i pyltsy neftehazonosnykh tolshch fanerozoia Russkoi i Turanskoi plety, 1985), Upper Givetian and Lower Frasnian of Pripyat depression (Stratigraficheskie i paleontologicheskie issledovaniya v Belorussii, 1978), Givetian (palynological zone Е) 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 Belorusii, 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, Loboziat, 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 verrucate.

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 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-European palynostratigraphic scales) (Naumova, 1953; Avkhimovitch, Tchibrikova, Obukhovskaja, Nazarenko, Umnova, Raskatova, Mantsurova, Loboziat, Streel, 1993); Upper Devonian, Frasnian of Pripyat depression (Stratigraficheskie...
References

Allen, K. C., 1965. Lower and Middle Devonian spores of North and Central Vestspitsbergen. Palaeontology. 8, 687–748.

Atlas spor i pyltsy nefehazonosynkh tolschh fanezoa Rossi k i Turansky spoy, 1985. [Atlas of spores and pollen of oil and gas bearing strata of the Phanerzoic of the Russian and Turan plates]. VNIHNI. 253. (In Russian).

Arkhangels’kaya, A. D., 1980. Spory’ rastenij iz nekotoryh [Plant spores from some Lower Devonian sections of the western regions of the Russian Plate]. VNIHNI. 217, 26–46. (In Russian).

Avkhimovitch, V. L., Tchibrikova, E. V., Obukhovskaja, T. G., Nazarenko, A. M., Unnova, V. T., Raskatova, L. G., Mantsurova, V. N., Loboziak, S., Streel, M., 1993. Middle and Upper Devonian miospore zonation of Eastern Europe. Bull. Centres Research. Explor. Prod. Elf Aquitaine. 17, 79–147.

Balme, B. E., Hassel, C. W., 1962. Upper Devonian (Fransian) spores from the Canniug Basin, Western Australia. Micropaleontology. 8, 1, 1–28.

Balme, B. E., 1962. Upper Devonian (Fransian) spores from the Canniug Basin, Western Australia. Palaeobotanist. 9, 1–2.

Chibrikova, E. V., 1959. Spory’ iz devonizhnoh oblasti’ [Plant spores of Devonian and older deposits of Bashkiria]. Materialy’ po palaeontologii i stratigrafii devonizhnykh i bolee devonizhnykh oblasti’ Bashkirii. Moskva, 3–116. (In Russian).

Chibrikova, E. V., 1962. Spory’ terrigennogo tolschha’ devona Zapadnoj Bashkirii i zapadnogo sklona Yuzhnogo Urala [Spores of the Devonian terrigenous strata of Western Bashkiria and the western slope of the Southern Ural]. Brakhiopty’, ostrakhiopty’ i spory’ srednego i verkhnego devona Bashkirii. M.: Izd-vo AN SSSR. 351–476. (In Russian).

Chibrikova, E. V., 1972. Rastitel’nye mikrofossil’i Yuzhnogo Urala i Priural’ya [Plant microfossils of the Southern Urals and the Urals]. Moskva: Nauka. (In Russian).

Chibrikova, E. V., 1977. Stratigrafiya devona i bolee devonizhnykh paleozoizhskih oblasti’ Yuzhnogo Urala i sosednikh ploshhadh [Stratigraphy of the Devonian and older Paleozoic deposits of the South Urals and neighboring areas]. Moskva: Nauka. (In Russian).

Gao, L., 1981. Devonian spore assemblages of China. Review of Palaeobotany and Palynology. Elsevier. 34. 11–23. https://doi.org/10.1016/0034–6667(81)90063–4

Hotsaniuk, H. I., Ivanina, A. V., 2017. Istoriychna heolohiia z osnovamy paleolohiia. Chastyna 1 Paleolohiia (u skhemakh, rysunkakh i tablytsiakh). [Historical geology with the basics of palynology. Part 1. Paleontology (in diagrams, figures and tables)]. Lviv: Vydavn. tsent LNU im. I. Franka. (In Ukrainian).

Ivanina, A. V., Havrylets L. V., Stokhamska O. H., 2000. Budova ta osoblyvosti vidkladiv serednogo devonu pivnichnoh chastyny Volyno-Podilskoi naftzhazonosnoyi oblasti [Structure and features of Middle Devonian deposits of the northern part of Volyn-Podilsky oil and gas region]. Heolohiia i heokhimiia horiuchyk kopalyn. 1, 17–25 (In Ukrainian).

Ivanina, A. V., 2004. Miospory z zhvyetskykh (serednii devon) vidkladiv Volyno-Podillia [Miospores from Devonian (Middle Devonian) deposits of the Volyn–Podillya]. Paleontol. Zb. 36, 117–123.

Ivanina, A., 2018. Famenian palynostratigraphy of the Volyn–Podillia margin of the East–European platform. Dnprop. Univer. Bulletin. Geology, geography. 26 (1), 71–78. doi: 10.15421/11808

Ivanina, A., 2019. Methodolohichni zasady zastosuvannia palinolohii u stratyhrifi [Methodological bases of application of palynology in stratigraphy]. Visnyk Lvivskoho universytetu. Ser. heol. 32, 30–53. (In Ukrainian).

Ivanina, A., 2019. Palinolohichna kharakterystyka serednopaleozoizkykh vidkladiv Volyno-Podillia [Palynological characteristics of Middle Paleozoic sediments of Volyn-Podil]ya. Visnyk Lvivskoho universytetu. Ser. heol. 33, 47–59. (In Ukrainian).

Ivanina, A., 2018. Standartyzovana kharakterystyka palinolohii [Standardized characteristics of Devonian palynozones of the Volyn-Podilskyi margin of the Eastern European platform]. Visnyk Lvivskoho universytetu. Ser. heol. 32, 30–53. (In Ukrainian).

Instruktsiya po opisaniu iskopamykh rastitelemykh’ i zhivotnykh’ organizmov v paleontologicheskikh rabotakh [Instructions for the description of fossil plant and animal organisms in paleontological works]. Moskva, 1971. (In Russian).
