

## ZONATION AND SPORE COMPLEXES OF THE DEVONIAN AND CARBONIFEROUS BOUNDARY DEPOSITS OF THE PRIPYAT DEPRESSION (BYELORUSSIA).

by

Violet .I. AVCHIMOVITCH<sup>1</sup>

(11 plates)

**ABSTRACT.**- Zonal division of the Devonian and Carboniferous boundary deposits of the Pripyat Depression, based on detailed palynological study, has been achieved. The lateral extent of the palynozones in Eastern Russia and correlations with Western Europe are discussed.

### INTRODUCTION

Because of its stratigraphic completeness, the section representing the latest Famennian and earliest Tournaisian in the Pripyat Depression is one of the more important in Russia and more complete in the world. During this time interval, considerable changes in the biosphere took place, which are recorded in the biota. The section in the Pripyat Depression consists of siliciclastic and carbonaceous rocks, which is why its detailed stratigraphy is based on the study of the spores of higher plants, in particular on the determination of the vertical distribution of zonal species. The spore complexes extracted from rocks around the Devonian-Carboniferous boundary exhibit comparatively large steps in floral evolution, allowing the definition of successive palynozones that lead to the establishment of regional and global correlations (Kedo, 1978; Kedo & Golubtsov, 1971). The Polesky horizon of the Upper Famennian and the Kalinovs, Kalevsky and Upinsky horizons of the Lower Tournaisian comprise the Devonian and Carboniferous boundary deposits of the Pripyat Depression. Nine palynozones, two of them divided into subzones, are delimited within this succession.

### PALYNOSTRATIGRAPHY

#### *Retispora lepidophyta* - *Grandispora facilis* (LF) Zone (Plate 1)

The Lower Starobin beds of the Upper Famennian Polesky horizon are referable to this palynozone. The widespread occurrence of the main species, *Retispora lepidophyta* (Kedo) Playford, the appearance of the typical Carboniferous spores *Tumulispora malevkensis* (Kedo) Turnau and *T. rarituberculata* (Luber) Potonié, the increase in diversity of *Convolutispora* spp. and the consistent presence of the zonal species, *Grandispora facilis* (Kedo) Avchimovitch, are characteristic of the palynozone. The zone has been recognised widely in Eastern Russia (Avchimovitch, 1986b) but is not found in the sections of Western Europe (Avchimovitch *et al.*, 1988; Avchimovitch & Demidenko, 1985). In sections in the Timan-Pechora province, the palynozone occurs in rocks with foraminifera of the *Quasiendothyra regularis* Zone and conodonts of the upper half of the *Polygnathus styriacus* or lower *Bispathodus costatus* Zones (Durkina & Avchimovitch, 1988); in sections in the Dnieper-Donetz Depression, the palynozone corresponds to the *Eoendothyra communis* foraminiferal Zone (Bilyk *et al.*, 1988).

1. BelNIGRI Stariborisovski tr. 14, 220114, Minsk, Byelorussia

***Retispora lepidophyta* - *Apiculiretusispora verrucosa* (LV) Zone (Plate 2)**

The Upper Starobin beds of the Polesky horizon are referred to this palynozone. The spread of *Apiculiretusispora verrucosa* (Caro-Moniez) Streele, the emergence of isolated *Knoxisporites literatus* (Waltz) Playford and the diversity of *Convolutispora* and *Dictyotriletes* spp., together with the spread of *R. lepidophyta* (Kedo) Playford var. *tenera* Kedo, the most important species, is characteristic of this palynozone. In Eastern Russia, the zone has been recognised in sections in the Pripyat and Timan-Pechora province (Durkina & Avchimovitch, 1988). In the latter region, it is correlated with the *Quasiendothyra radiata* foraminiferal Zone and the middle *Bispathodus costatus* conodont Zone. On the basis of the spread of *Apiculiretusispora verrucosa*, the zonal species, the zone is correlated with the middle part, at least, of the Western European zone of the same name. The base of this zone in the Franco-Belgian basin corresponds to the Epinette Formation (Fa2d), or to the base of the Strunian (Avchimovitch *et al.*, 1988). The LV palynozone of Eastern and Western Europe is a useful correlative tool in comparing the late Devonian sections of the two regions.

***Retispora lepidophyta* - *Knoxisporites literatus* (LL) Zone (Plate 3)**

The Stvizh beds of the Polesky horizon are referred to this palynozone (Byvsheva, 1984). All varieties of the zonal species, *Retispora lepidophyta*, but especially *R. lepidophyta* (Kedo) Playford var. *tenera* Kedo, are represented in it; *R. lepidophyta* var. *minor* Kedo appears at this level. Heavily ornamented spores, amongst which *Knoxisporites literatus* (Waltz) Playford is dominant, occur in quantity in the assemblages. The LL Zone is widely recognised in Eastern Russian sections (Avchimovitch, 1986b). In the Timan-Pechora province, and in the Dnieper-Donetz Depression it corresponds to the *Quasiendothyra kobeitusana* foraminiferal Zone. Correlation of the LL Zone of Byelorussia with Western Europe is difficult. It may correspond to the upper part of the LV Zone, which characterises the Etroeungt Formation, or Tn1a, of the Franco-Belgian basin.

The LF, LV and LL palynozones of the Pripyat Depression correspond to the *R. lepidophyta typica* Zone and to part of the *R. lepidophyta tenera* Zone in the central regions of Eastern Russia. These characterise the Ozersky horizon of the Upper Famennian (Avchimovitch, 1986b).

***Retispora lepidophyta* - *Tholisporites mirabilis* (LMb) Zone. (Plate 4)**

The Lower Borov beds of the Polesky horizon are referred to this palynozone. *Retispora lepidophyta*, the dominant species, is represented mainly by the variety *R. lepidophyta* (Kedo) Playford var. *tenera* Kedo. *Tholisporites mirabilis* (Tschibrikova) Byvsheva, the other zonal species, represents the culmination of an evolutionary lineage. The palynozone is widely recognised throughout Eastern Russia and is noted for the widespread occurrence of the variety of *R. lepidophyta* referred to above.

In central regions, it is found in the Chovansky horizon of the Upper Famennian from which conodonts of the *Bispathodus costatus* Zone (Aristov, 1984) have been determined. In the Timan-Pechora province and the Dnieper-Donetz Depression, the palynozone occurs in rocks containing the foraminiferan *Quasiendothyra kobeitusana*. In Western Europe, it must correspond to the upper part of the LV Zone, or Tn1a (Etroeungt Formation), in the Franco-Belgian basin (Avchimovitch *et al.*, 1988a; Avchimovitch *et al.*, 1988b).

***Retispora lepidophyta* - *Hymenozonotriletes explanatus* (LE) Zone**

The zone is divided into two subzones.

***Retispora lepidophyta* - *Raistrickia ramiformis* (LRa) Subzone (Plate 5)**

The Upper Borov beds of the Polesky horizon are referred to this subzone. The spore assemblages are exceptionally diverse in their species composition. All the varieties of *R. lepidophyta* are developed, and the first *Hymenozonotriletes explanatus* (Luber) Kedo, *Cymbosporites minutus* (Kedo) Avchimovitch & Streele, *Tumulispora variverrucata* (Playford) Staplin & Jansonius, and *T. monstruosus* (Kedo) Avchimovitch appear. The distinguishing feature of spore assemblages of this subzone is the expansion in numbers of monolet spores (Kedo & Golubtsov, 1971). The subzone has not been widely recognised in Eastern Russia. It has been identified in the upper part of the Nymulgsky horizon of the Timan-Pechora province (corresponding to the *Quasiendothyra dentata* foraminiferal Zone) (Durkina & Avchimovitch, 1988) and in the Zigansk beds of the Lytvinsky horizon in the South Urals (corresponding to the *Siphonodella praesulcata* conodont Zone) (Kochetkova *et al.*, 1988). In central regions, the zone is not present due to a break in sedimentation. On the basis of the

appearance of the zonal species, *H. explanatus*, the subzone is compared with the LE Subzone, recognised in Ireland (Clayton *et al.*, 1978) and the Rhenish Slate Mountains (Higgs & Streel, 1984).

*Retispora lepidophyta* - *Cymbosporites minutus* (LMi) Subzone (Plate 4)

The Rubchan beds of the Polesky horizon are referred to this zone. *Retispora lepidophyta* is very abundant in the assemblages, predominantly in the variety *Retispora lepidophyta* (Kedo) Playford var. *minor* Kedo. *Hymenozonotriletes explanatus* (Luber) Kedo and *Cymbosporites minutus* (Kedo) Avchimovitch & Streel, the zonal species, become more abundant; and the typically Carboniferous spores *Vallatisporites pusillites* (Kedo) Dolby & Neves *emend* Byvsheva and *V. hystricosus* (Winslow) Byvsheva appear. The subzone has a limited geographical extent. It is recognised in the Timan-Pechora province, where it corresponds to the lower part of the Sotchemshor horizon, which contains rare foraminifera (Durkina & Avchimovitch, 1988); in the South Urals (lower part of the Humerovsky horizon with *Siphonodella praesulcata* Sandberg) and, probably, in the Volgo-Urals region (the lower part of the Udmurt beds) (Byvsheva *et al.*, 1984). In central regions and in the Dnieper-Donetz Depression, the LMi Subzone corresponds to a stratigraphic hiatus. The LMi Subzone is compared to the LE Zone of Western Europe (Mahlina *et al.*, 1988).

The LE palynozone of Eastern and Western Europe is the second level at which correlations between the two regions can be made.

***Vallatisporites pusillites* - *R. lepidophyta* - *H. explanatus* (PLE) Zone (Plate 7)**

The Povchin beds of the Tournaisian aged Kalinovsky horizon are referred to this palynozone. Components of the spore assemblages, which are dominated by *Vallatisporites pusillites* (Kedo) Dolby & Neves *emend* Byvsheva and which include *R. lepidophyta* with all its varieties, have a short time range and a global spread. *H. explanatus* (Luber) Kedo, *Cymbosporites minutus* (Kedo) Avchimovitch & Streel are also numerically significant. At this level, just as in Western Europe, *Verrucosisporites nitidus* (Naumova) Playford appears. In Eastern Russia, the subzone is recognised in the Volga-Urals region (Udmurt beds), in the Timan-Pechora province (upper clay bench of the Sotchemshor horizon); in the South Urals, it corresponds to the middle part of the Humerovsky horizon with the conodont *Siphonodella*

*praesulcata* Sandberg (Kochetkova *et al.* 1988). In the central regions and the Dnieper-Donetz Depression, the PLE Zone corresponds to a stratigraphic break. The palynozone corresponds to the lower part of the *R. lepidophyta* - *V. nitidus* (LN) Zone of Western Europe. The latter was defined in Ireland and has been identified in the Rhenish Slate Mountains (Clayton *et al.*, 1977; Higgs & Streel, 1984).

***Vallatisporites pusillites* - *Tumulispora malevkensis* (PM) Zone (Plate 8)**

The Velizh beds of the Kalinovsky horizon are referred to this zone, within which there was mass evolution of *Vallatisporites* spp. (*V. pusillites* (Kedo) Dolby & Neves *emend* Byvsheva, *V. vallatus* Hacquebard, *V. verrucosus* Hacquebard) against a background of impoverished spore assemblages. The quantity of *R. lepidophyta* (Kedo) Playford, represented by the varieties *tener* and *minor* decreases markedly and the content of different *Tumulispora* species increases. In the Eastern Russian territories, the palynozone has a restricted distribution. It corresponds to a subzone of the *V. pusillites* Zone in the upper part of the Udmurt beds in the Volga-Urals area; the upper part of the Humerovsky horizon of the South Urals, which contains the conodont *S. praesulcata* Sandberg; and the subzone *T. malevkensis* - *R. lepidophyta* (ML) in the Dzhanganin beds in Mugodzars, which contains the conodonts *S. praesulcata* Sandberg and *Pseudopolygnathus fusiformis* Branson & Mehl (Avchimovitch *et al.*, 1988; Barskov *et al.*, 1984). The PM Zone correlates with the upper part of the LN zone of Western Europe, identified in the highest part of the Hangenberg Schiefer, containing *Acutimitoceras prorsum prorsum*, in the Rhenish Slate Mountains.

***Tumulispora malevkensis* (M) Zone**

The zone is divided into two subzones.

*Tumulispora malevkensis* - *Spelaeotriletes balteatus* (MB) Subzone (Plate 9)

This subzone characterises the lower part of the Malevsky horizon. The spore complex is similar to the one identified in the stratotype of the Malevsky horizon in the regions near Moscow (Byvsheva, 1984). The zonal species, *T. malevkensis* (Kedo) Turnau, together with *T. variverrucata* (Playford) Staplin & Jansonius, *T. rarituberculata* (Luber) Potonié, *Lophozonotriletes excisus* Naumova, *Convolutispora major* (Kedo) Turnau are the predominant components of the spore assemblages. The

appearance at this level of the name-giving species, *Spelaeotriletes balteatus* (Playford) Higgs, is the characteristic feature of the spore assemblages of this age in the Pripyat Depression. In Western Europe, the species listed appear in the vicinity of the top of the *Vallatisporites vallatus* - *Retusotriletes incohatus* Zone (Clayton *et al.*, 1977), which we correlate with palynozone M.

*Tumulispora malevkensis*-*Apiculiretusispora rarispinosa* (MR) Subzone (Plate 10)

The subzone characterises the upper part of Malevsky horizon. *Apiculiretusispora rarispinosa* (Juschko) Byvsheva appears in the zone, together with spores of the lower subzone listed above. *Spelaeotriletes balteatus* (Playford) Higgs occurs consistently and the zonal species of Western Europe Tournaisian deposits, *Kraeuselisporites hibernicus* Higgs, makes its appearance. In the sections in the Pripyat Depression the species indicated appear earlier - at a level corresponding to the *Siphonodella duplicata* conodont Zone - than in Western Europe, where they are not known until the lower *S. crenulata* conodont Zone (Higgs & Strel, 1984). This question requires elucidation.

Overall, the *Tumulispora malevkensis* (M) Zone is widespread in the Eastern Russian sections and characterises the Malevsky horizon of Tournaisian age. The contrasts in the spore complex of the Malevsky horizon are also observed in the central regions of Eastern Russia. There the lower part of the section contains the conodont *Patrognathus crassus* (Kononova & Migdisova), which may correspond to the *Siphonodella sulcata* Zone of the standard conodont zonal scheme; in the upper part, *P. crassus* is joined by conodonts of the *P. variabilis* Zone, which correlates with the *S. duplicata* Zone (Barskov *et al.*, 1984; Mahlina *et al.*, 1988).

***Grandispora upensis* (U) Zone (Plate 11)**

The Upinsky horizon of the Tournaisian is referred to this palynozone. The zonal assemblage has many spores in common with that of the Malevsky horizon. The zonal species is distributed throughout the horizon, but not regularly. *Apiculiretusispora rarispinosa* (Juschko) Byvsheva and *Hymenozonotriletes explanatus* (Luber) Kedo are the most abundant spores. The U Zone is identified also in the regions near Moscow (Byvsheva, 1976) in rocks which contain conodonts of the *Patrognathus andersoni* Zone, which is correlated with the S.

*sandbergi* Zone (Barskov *et al.*, 1984); in the Dnieper-Donetz Depression (Avchimovitch 1986c); in the Timan-Pechora province (Durkina & Avchimovitch 1988); and in the Volga-Urals area (Byvsheva 1984). The U Zone may partly correspond to the *Kraeuselisporites hibernicus* - *Umbonatisporites distinctus* (HD) Zone of Western Europe, identified in sections in the Rhenish Slate Mountains (Higgs & Strel, 1984).

**BIBLIOGRAPHY**

- ARISTOV, B. A., 1984.- The conodonts of the Devonian/Carboniferous boundary of the Russian Platform. *In: Biostratigraphic research of the Devonian-Carboniferous boundary deposits. Magadan: SVK NII DVNTs USSR Academy of Sciences: 1-6.* (in Russian).
- AVCHIMOVITCH, V. I., 1986a. - Zonal differentiation and correlation of the Devonian and Carboniferous boundary deposits in Byelorussia (Pripyat Depression) with the standard sections of the Franco-Belgian basin by spores. *In: Palaeontology and its role in the knowledge of the geological structure of Byelorussia. Minsk, "Nauka i Technika": 145-165.* (in Russian).
- AVCHIMOVITCH, V. I., 1986b. - Palynological basis of the Devonian-Carboniferous boundary in the Pripyat Depression. *Minsk, BelNIGRI. All Union conference materials: 9-13.* (in Russian).
- AVCHIMOVITCH, V. I., 1986c. - Spores of the Devonian and Carboniferous boundary deposits in the East-European platform. *In: Reference sections and correlation of the Devonian-Carboniferous boundary in Euroasia. Magadan: SVK NII DVNTs USSR Academy of Sciences: 125-146.* (in Russian).
- AVCHIMOVITCH, V. I., BYVSHEVA T. V., HIGGS, K., STREEL, M. & UMNOVA, V. T., 1988. - Miospore systematics and stratigraphic correlation of Devonian-Carboniferous boundary deposits in the European part of the USSR and Western Europe. *Cour. Forsch.-Inst. Senckenberg, 100: 169-191.*
- AVCHIMOVITCH, V. I. & DEMIDENKO, E. K., 1985. - Biostratigraphy of the Devonian-Carboniferous boundary deposits of Byelorussia (Pripyat Depression). *Magadan, SVK NII DVNTs USSR Academy of Sciences: 54 p.* (in Russian).
- AVCHIMOVITCH, V. I., GOLUBTSOV, V. K., & DEMIDENKO, E. K., 1988. - The typical section of the Devonian and Carboniferous boundary deposits occurring in the Pripyat Depression. *In: Golubtsov, V.K. et al. (eds). The Devonian-Carboniferous boundary in the territory of the USSR. Minsk, "Nauka i Technika": 40-53.* (in Russian).
- BARSKOV, I. S., KONONOVA, L. I., MIGDISOVA, A. V., 1984.- Conodonts of the Lower Tournaisian of the Moscow Basin. *In: Paleontology characteristic and biostratigraphy of the reference sections of the Carboniferous deposits of the Moscow syncline. Moscow: 3-27.* (in Russian).
- BILYK, A. A., CHIZHOVA, V. A., LUKIN, A. E., RAZNITSIN, V. A., *et al.* 1988. - The Devonian-Carboniferous boundary deposits in the Dnieper-Donetsk Depression. *In: Golubtsov, V.K. et al. (eds). The Devonian-Carboniferous boundary in the territory of the USSR. Minsk, "Nauka i Technika": 53-62.* (in Russian).

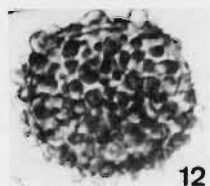
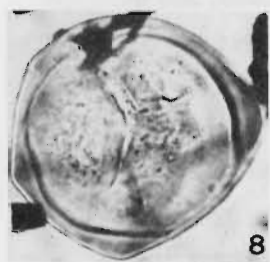
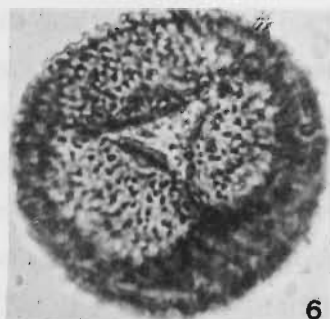
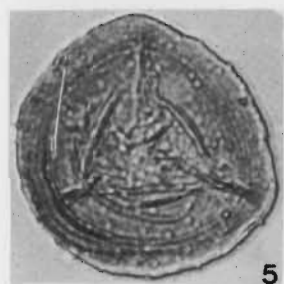
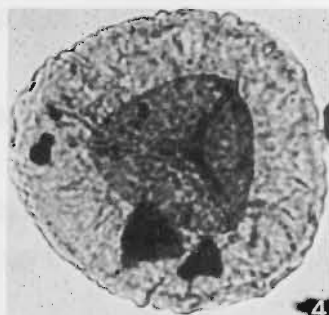
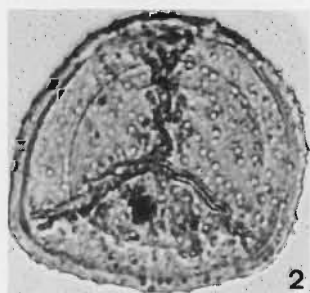
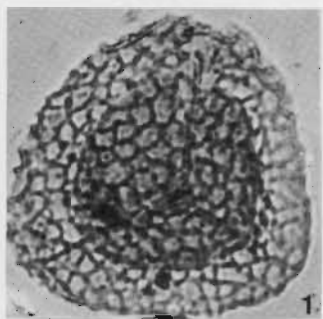
- BYVSHEVA, T.V., 1976. - Zonation of spore complexes of the Tournaisian Stage from the eastern part of the Russian Platform. *In* : Palynology in the USSR (1976-1980). *Moscow, Nauka*: 53-55. (in Russian).
- BYVSHEVA, T.V., 1984. - The Malevsky horizon in the Russian Platform and its analogue in Western Europe. *In*: Biostratigraphic research of the Devonian-Carboniferous boundary deposits Russian Platform. *Magadan, SVK NII DVNT's USSR Academy Sciences*: 18-27. (in Russian).
- BYVSHEVA, T.V., HIGGS, K., & STREEL, M., 1984. - Spore correlation between the Rhenish Slate Mountains and the Russian Platform near the Devonian-Carboniferous boundary. *Cour.Forsch.-Inst. Senckenberg*, 67: 37-45.
- CLAYTON, G., COQUEL, R., DOUBINGER, J., GUEINN, K. J., LOBOZIAK, S., OWENS, B. & STREEL, M., 1977. - Carboniferous miospores of Western Europe: illustration and zonation. *Meded.rijks Geologische dienst*. 29, 71 pp.
- CLAYTON, G., HIGGS, K., KEEGAN, J. B. & SEVASTOPULO, G. D., 1978. - Correlation of the palynological zonation of the Dinantian of the British Isles. *Palinologia*, 1: 137-147.
- DURKINA, A.V. & AVCHIMOVITCH, V.I., 1988. - The reference sections of the Devonian-Carboniferous boundary deposits in the Timan-Pechora Province. *In*: Golubtsov, V.K. *et al.* (eds). The Devonian-Carboniferous boundary in the territory of the USSR. *Minsk, "Nauka i Technika"* : 87-101. (in Russian).
- HIGGS, K. & STREEL, M., 1984. - Spore stratigraphy at the Devonian-Carboniferous boundary in the Northern "Rheinisches Schiefergebirge", Germany. *Cour. Forsch.-Inst. Senckenberg*, 67: 157-179
- KEDO, G. I., 1978. - The palynological characteristics of the Pripjat Depression Tournaisian stage and the substantiation of its lower boundary. 8eme Congr. Int. Strat. Geol. Carb. Moscow (1975), 1: 234-239. (in Russian).
- KEDO, G. I. & GOLUBTSOV, V. K., 1971. - Palynological criterion of the search for the solution of the Devonian-Carboniferous boundary in the Pripjat Depression. *In*: Palynology research in Byelorussia and others regions of the USSR. *Minsk, "Nauka i Technika"* : 5-34. (in Russian).
- KOCHETKOVA, N. M., REITLINGER, E. A., PAZUKHIN, V. N. & AVCHIMOVITCH, V. I., 1988. - The Devonian - Carboniferous boundary in the Southern Urals. *In*: Golubtsov, V. K. *et al.* (eds). The Devonian-Carboniferous boundary in the territory of the USSR. *Minsk, "Nauka i Technika"* :157-166. (in Russian).
- MAHLINA, M. H., RODIONOVA, G. D., UMNOVA, V. T. *et al.*, 1988. - The Devonian - Carboniferous boundary deposits of the Central Regions of the Russian Platform. *In*: Golubtsov, V. K. *et al.* (eds). The Devonian-Carboniferous boundary in the territory of the USSR. *Minsk, "Nauka i Technika"* : 78-87. (in Russian).

All figures of plates 1 to 11 : x 500

**PLATE 1**

***Retispora lepidophyta* - *Grandispora facilis* (LF)**

1. *Retispora lepidophyta* (Kedo) Playford, Starobin 756, 1747/22, 270 m.
2. *Grandispora facilis* (Kedo) Avchimovitch, Starobin 756, 1747/22, 270 m.
3. *Diducites poljessicus* (Kedo) Van Veen, Turov, 115, 4862/18, 267 m.
4. *Diducites versabilis* (Kedo) Van Veen, Turov, 123, 9153/12a, 227 m.
5. *Grandispora distinctus* (Naumova) Avchimovitch, Starobin 239, 1071/7, 239 m.
6. *Endoculeospora setacea* (Kedo) Avchimovitch et Higgs, Turov 123, 9143/5B, 177 m.
7. *Tumulispora malevkensis* (Naumova) Turnau, Lelchitsy 345, 4043/45, 595 m.
8. *Knoxisporites dedaleus* (Naumova) Moreau-Benoît, Lelchitsy 345, 4043/45, 595 m.
9. *Convolutispora usitata* Playford, Turov 107, 4739/5a, 75,2 m.
10. *Grandispora famenensis* (Naumova) Streeel, Starobin 756, ,1747/22, 270 m.
11. *Grandispora flavus* (Kedo) Avchimovitch comb. nov., Starobin 756 ,1747/22, 270 m.
12. *Lophozonotriletes proscurrus* Kedo, Starobin 756, 1747/22, 270 m.
13. *Stenozonotriletes tersus* (Waltz) Naumova, Lelchitsy 345, 4048/45, 595 m.

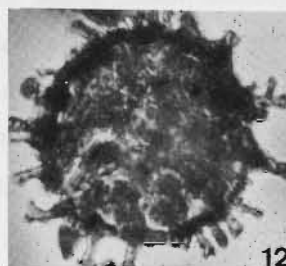
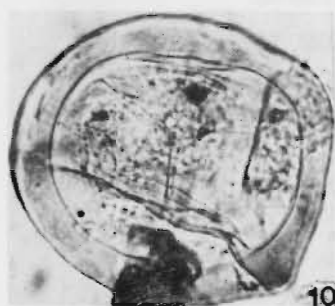
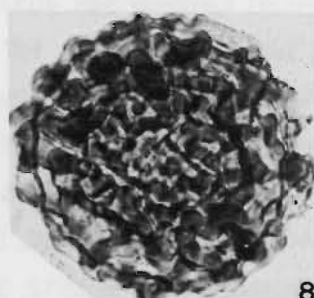
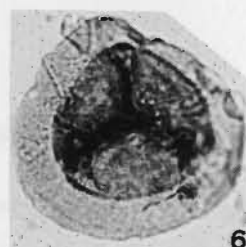
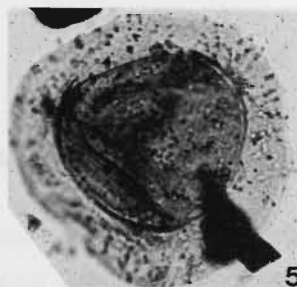
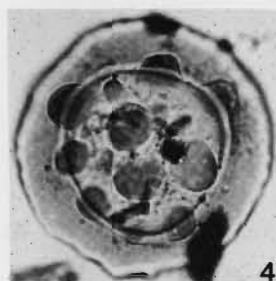
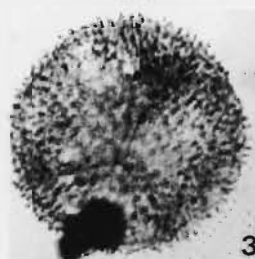
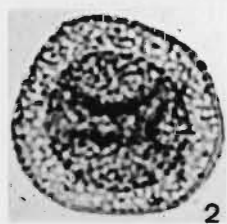
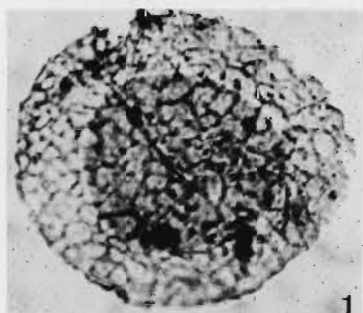


## PLATE 2

***Retispora lepidophyta* - *Apiculiretusispora verrucosa* (LV)**

1. *Retispora lepidophyta* (Kedo) Playford, Lelchitsy 354, 381/21, 421,3 m.
2. *Retispora lepidophyta* (Kedo) Playford var. *tenera* Kedo, Lelchitsy 354, 381/21, 421,3 m.
3. *Apiculiretusispora verrucosa* (Caro-Monieze) Streeel, Starobin 756, 1747/22 , 270m.
4. *Tumulispora rarituberculata* (Luber) Potonie, Turov 123, 9153/12a, 227 m.
5. *Endoculeospora gradzinskii* Turnau, Turov123, 9354/5, 176 m.
6. *Auroraspora evanida* (Kedo) Avchimovitch, Turov 123, 9142/4, 175,6 m.
7. *Diducites poljessicus* (Kedo) Van Veen, Turov 123, 9153/12a, 227 m.
8. *Convolutispora usitata* Playford, Turov 123, 9142/4v, 176 m.
9. *Umbonatisporites abstrusus* (Playford) Clayton, Lelchitsy 345, 4117/40, 570,3 m.
10. *Knoxisporites hederatus* (Ischenko) Playford, Lelchitsy 345, 4043/45, 595 m.
11. *Auroraspora luteola* (Naumova) Avchimovitch comb. nov., Starobin 239, 10713/7, 239 m.
12. *Raistrickia variabilis* Dolby et Neves, Turov 123, 9364/5, 176 m.
13. *Convolutispora vermiformis* Hughes et Playford, Lelchitsy 354, 381, 421,3 m.
14. *Tumulispora malevkensis* (Kedo) Turnau, Starobin 756, 1747/22 , 270 m.
15. *Diducites commutatus* (Naumova) Avchimovitch, Starobin 239, 10713/7, 239 m.

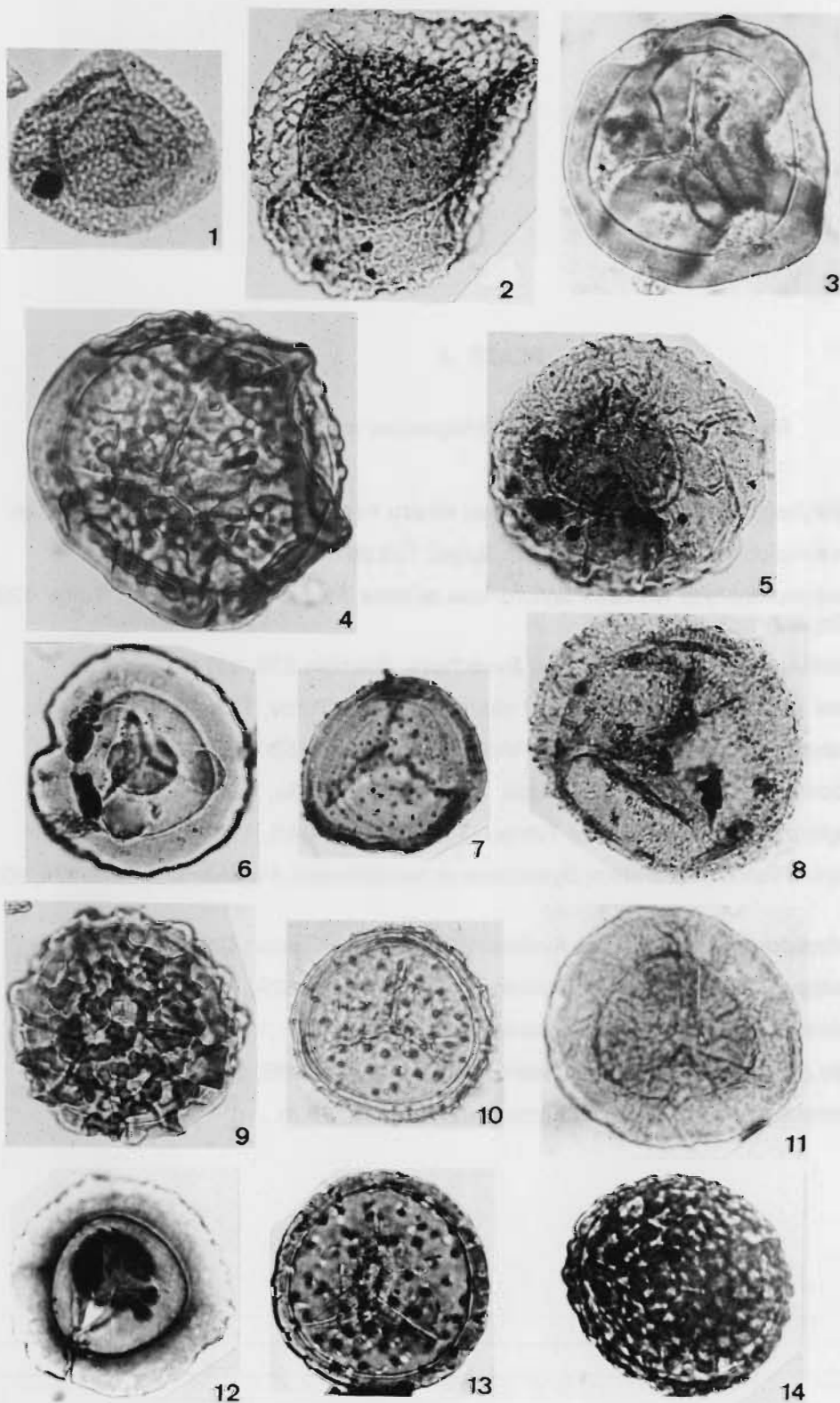




## PLATE 3

***Retispora lepidophyta - Knoxisporites literatus (LL)***

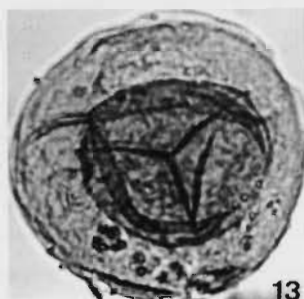
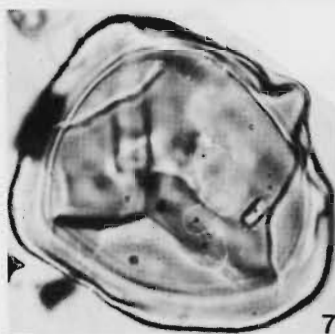
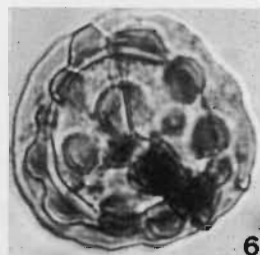
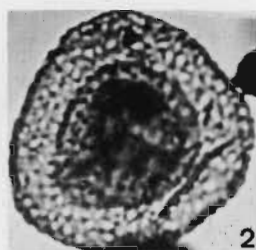
1. *Retispora lepidophyta* (Kedo) Playford var. *tenera* Kedo, Turov 123, 9153/12a, 227 m.
2. *Retispora lepidophyta* (Kedo) Playford, Zhitkovitchi 505, 3228/38, 454 m.
3. *Knoxisporites literatus* (Waltz) Playford, Lelchitsy 345, 4037/29, 465 m.
4. *Convolutispora harlandii* Playford, Turov 123, 9143/5B, 177 m.
5. *Diducites versabilis* (Kedo) Van Veen, Turov 123, 9153/12a, 227 m.
6. *Tumulispora rariturberculata* (Luber) Potonie, Turov 123, 9153/12, 227 m.
7. *Grandispora echinata* Hacquebard, Turov 123, 9364/5, 176 m.
8. *Endoculeospora setacea* (Kedo) Avchimovitch, Turov 123, 9364/5, 176 m.
9. *Convolutispora usitata* Playford, Shestovitchi 10, 9202/12, 314 m.
10. *Grandispora gracilis* (Kedo) Streel, Starobin 239, 10713/7, 239 m.
11. *Diducites commutatus* (Naumova) Avchimovitch, Starobin 239, 10713/7, 239 m.
12. *Tumulispora varia* (Kedo) Byvscheva, Lelchitsy 354, 377/17, 375,7 m.
13. *Dictyotriletes scrobiculatus* Kedo, Turov 123, 9153/12a, 227 m.
14. *Convolutispora mellita* Hoffmeister, Staplin et Malloy, Petricov 329, 1376/16a, 311 m.



## PLATE 4

***Retispora lepidophyta* - *Tholisorites mirabilis* (LMb)**

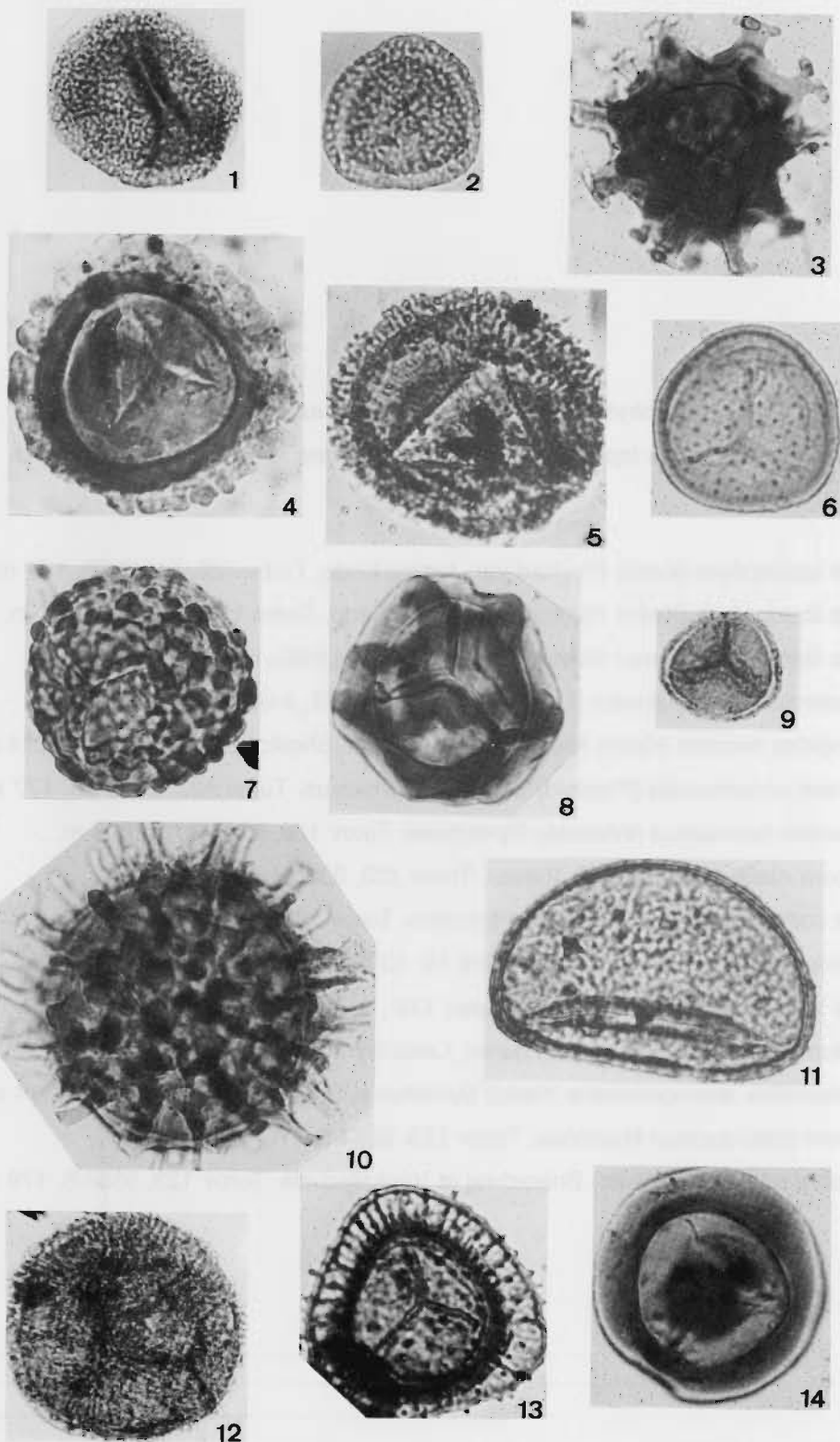
1. *Retispora lepidophyta* (Kedo) Playford var. *tenera* Kedo, Turov ,123, 9145/6B, 183 m.
2. *Retispora lepidophyta* (Kedo) Playford, Turov, 123 , 9145/6b, 183 m.
3. *Retispora lepidophyta* (Kedo) Playford var. *minima* Avchimovitch vr. nov. Turov 123, 9153/12a, 231 m.
4. *Tholisorites mirabilis* (Tschibrikova) Byvscheva, Starobin 239, 10713/7, 239 m.
5. *Retispora lepidophyta* (Kedo) Plaforde var. *minor* Kedo, Turov, 123, 9147/6e, 187 m.
6. *Tumulispora rarituberculata* (Luber) Potonie, Turov 123, 9153/12a, 227 m.
7. *Knoxisporites literatus* (Waltz) Playford, Turov ,123, 9150/8a, 227 m.
8. *Tumulispora malevkensis* (Kedo) Turnau, Turov ,123, 9364/5, 176 m.
9. *Grandispora valida* (Nazarenko) Byvscheva et Avchimovitch, Petricov 329, 1375/17a, 306 m.
10. *Endoculeospora setacea* (Kedo) Avchimovitch et Higgs, Turov ,123, 9143/5B, 177 m.
11. *Reticulatisporites amplexus* (Naumova) Teteruk, Petricov 329 , 1375/17a, 306 m.
12. *Verrucosisporites mesogrumosus* (Kedo) Byvscheva, Turov ,123, 9147/6e, 187 m.
13. *Diducites poljessicus* (Kedo) Van Veen, Turov, 123, 9145/6B, 183 m.
14. *Zonomonoletes scabratus* Kedo, Turov, 107, 4734/1a, 59 m. .



## PLATE 5

***Retispora lepidophyta* - *Hymenozonotriletes explanatus* (LE) Subzone*****Retispora lepidophyta*-*Raistrickia ramiformis* (LRa)**

1. *Retispora lepidophyta* (Kedo) Playford var. *tenera* Kedo, Turov 123, 9153/12a, 227 m.
2. *Retispora lepidophyta* (Kedo) Playford var. *minor* Kedo, Turov 123, 9143/5B, 177 m.
3. *Raistrickia ramiformis* (Kedo) Avchimovitch et Higgs, Turov 123, 9364/5, 176 m.
4. *Tumulispora monstrosa* (Kedo) Avchimovitch comb. nov., Lelchitsy 345, 4037/29a, 466 m.
5. *Endoculeospora setacea* (Kedo) Avchimovitch et Higgs, Turov 123, 9143/5B, 174 m.
6. *Grandispora echinata* Hacquebard, Turov 123, 9143/5B, 174 m.
7. *Verrucosisorites mesogrumosus* (Kedo) Byvscheva, Turov ,123, 9364/5, 176 m.
8. *Knoxisporites literatus* (Waltz) Playford, Turov ,123, 9143/5B, 177 m.
9. *Auroraspora asperella* (Kedo) Van der Zwan, Turov 123, 9364/5, 176 m.
10. *Raistrickia corynoges* Sullivan, Turov 123, 9364/5, 176 m.
11. *Zonomoletes turovensis* Kedo, Turov 123, 9143/5B, 177 m.
12. *Apiculiretusispora verrucosa* (Caro-Monie) Streeel, Turov 123, 9143/5B, 177 m.
13. *Hymenozonotriletes explanatus* (Luber) Kedo, Turov 123, 9143/5B, 177 m.
14. *Tumulispora varia* (Kedo) Byvscheva, Turov 123, 9364/5, 176 m.

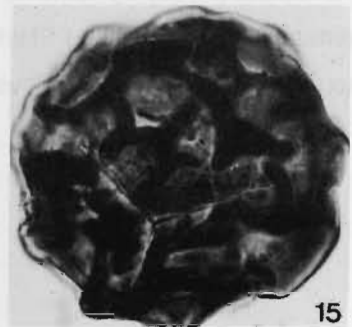
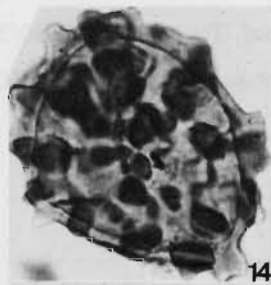
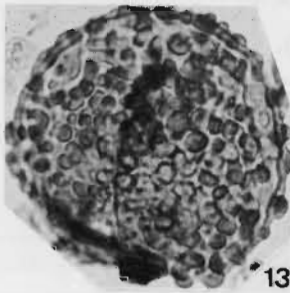
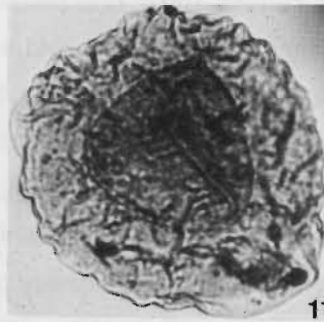
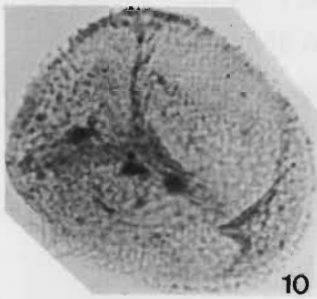
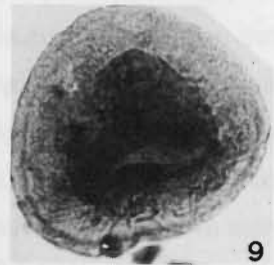
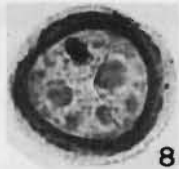
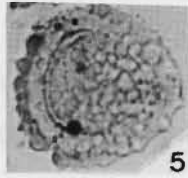
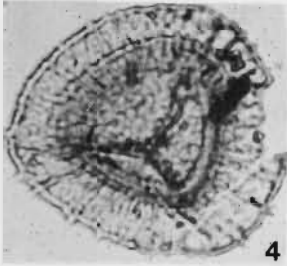
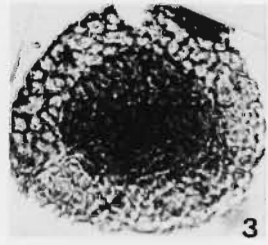
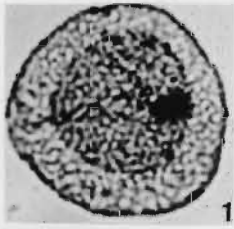


## PLATE 6

***Retispora lepidophyta* - *Hymenozonotriletes explanatus* (LE)****Subzone *Retispora lepidophyta* - *Cymbosporites minutus* (LiMi)**

1. *Retispora lepidophyta* (Kedo) Playford var. *tenera* Kedo, Turov 123, 9/143/5B, 177 m.
2. *Retispora lepidophyta* (Kedo) Playford var. *minor* Kedo, Turov 123, 9143/5B, 177 m.
3. *Retispora lepidophyta* (Kedo) Playford, Turov 123, 9143/5B, 177 m.
4. *Hymenozonotriletes explanatus* (Luber) Kedo, Turov 123, 9142/4v, 175 m.
5. *Cymbosporites minutus* (Kedo) Avchimovitch et Streel, Shestovitchi 10, 9202/12, 314 m.
6. *Tumulispora variverrucata* (Playford) Staplin et Jansonius, Turov 123, 9143/5B, 177 m.
7. *Vallatisporites hystricosus* (Winslow) Byvscheva, Turov 123, 9360/3g, 172, 5 m.
8. *Tumulispora malevkensis* (Kedo) Turnau, Turov 123, 9363/4a, 173, 8 m.
9. *Diducites commutatus* (Naumova) Avchimovitch, Turov 123, 9364/5, 176 m.
10. *Spelaeotriletes obtusus* Higgs, Shestovitchi 10, 9202/12, 314 m.
11. *Diducites versabilis* (Kedo) Van Veen, Turov 123, 9142/4v, 175,6 m.
12. *Convolutispora fromensis* Balme et Hassel, Leichitsy 240, 3752/28g, 437, 5 m.
13. *Verrucosisporites mesogrumosus* (Kedo) Byvscheva, Shestovitchi 10, 9202/12, 314 m.
14. *Lophozonotriletes excisus* Naumova, Turov 123, 9364/5, 176 m.
15. *Corbulispora cancellata* (Waltz) Bharadwaj et Venkatachala, Turov 123, 9364/5, 176 m.

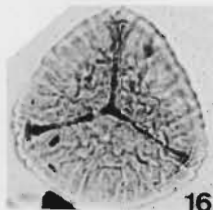
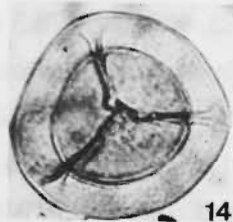
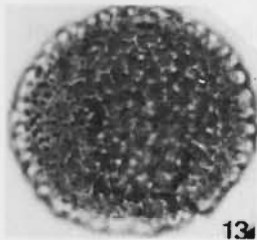
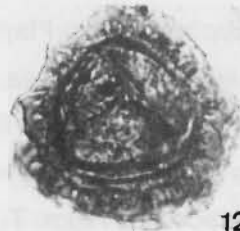
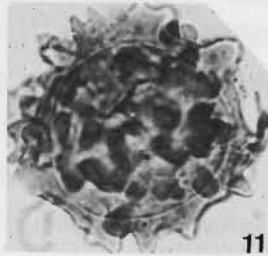
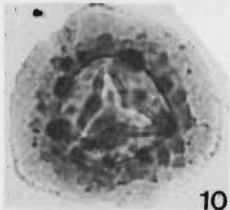
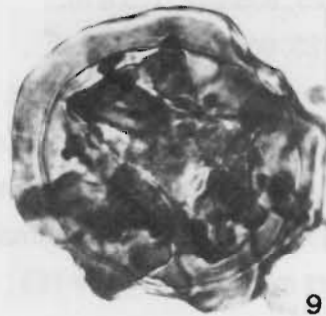
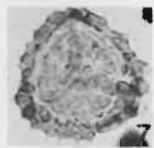
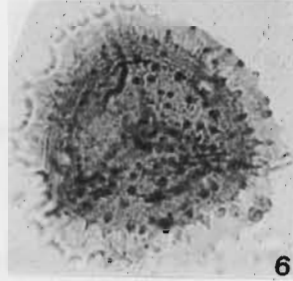
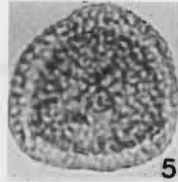
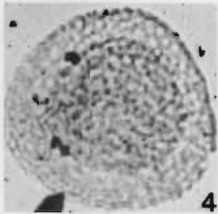
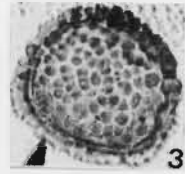
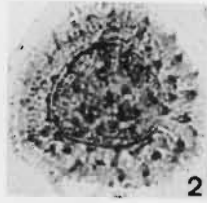
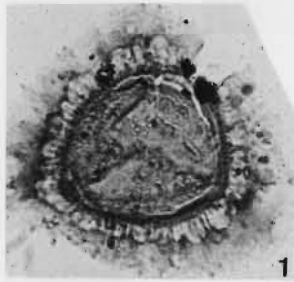




## PLATE 7

*Vallatisporites pusillites* - *Retispora lepidophyta* -  
*Hymenozotriletes explanatus* (FLE)

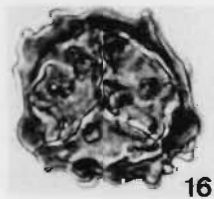
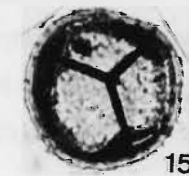
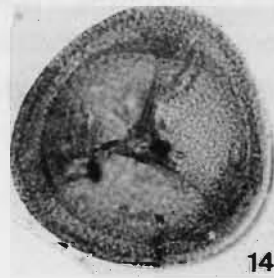
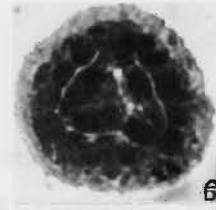
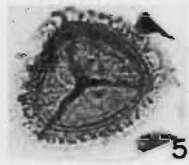
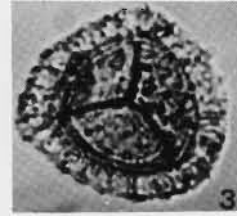
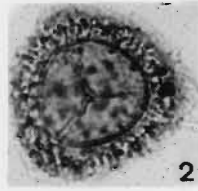
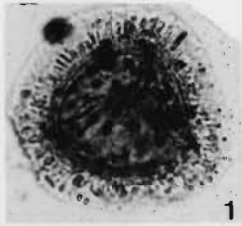
- 1-2. *Vallatisporites pusillites* (Kedo) Dolby et Neves, Turov 123, 9360/3g, 172,5 m.
3. *Vallatisporites verrucosus* Hacquebard, Turov 123, 9360/3g, 172,5 m.
4. *Retispora lepidophyta* (Kedo) Playford Var. *tenera* Kedo, Turov 123, 9153/12a, 227 m.
5. *Retispora lepidophyta* (Kedo) Playford var. *minor* Kedo, Turov 123, 9143/5B, 177 m.
6. *Hymenozotriletes explanatus* (Luber) Kedo, Turov 123, 9142/4v, 175,6 m.
7. *Cymbosporites minutus* (Kedo) Avchimovitch et Streel, Shestovitchi 10, 9202/12, 314 m.
8. *Tumulispora malevkensis* (Kedo) Turnau, Turov 123, 9363/4a, 173,8 m.
9. *Convolutispora major* (Kedo) Turnau, Lechitsy 345, 3941/14v, 352,6-357,7 m.
10. *Tumulispora variverrucata* (Playford) Staplin et Jansonius, Turov 123, 9360/3g, 172,5 m.
11. *Lophozotriletes excisus* Naumova, Turov 123, 9142/4v, 175,6 m.
12. *Cristatisporites colliculus* Playford, Lechitsy 240, 3750/27g, 436 m.
13. *Convolutispora* cf. *cerebra* Butterworth et Williams, Turov 123, 9360/3g, 172, 5 m.
14. *Endosporites granulatus* (Naumova) Byvscheva, Lechitsy 240, 3720/7B, 364 m.
15. *Stenozotriletes minor* Naumova, Turov 123, 9360/3g, 172,5 m.
16. *Rugospora radiata* (Kedo) Byvscheva, Turov 123, 9363/4, 173,8 m.
17. *Vallatisporites nitidus* (Naumova) Playford, Turov 123, 9360/3g, 172, 5 m.
18. *Punctatisporites angularis* (Kedo) Byvscheva, Turov 123, 9360/3g, 172,5 m.



## PLATE 8

***Vallatisporites pusillites* - *Tumulispora malevkensis* (PM)**

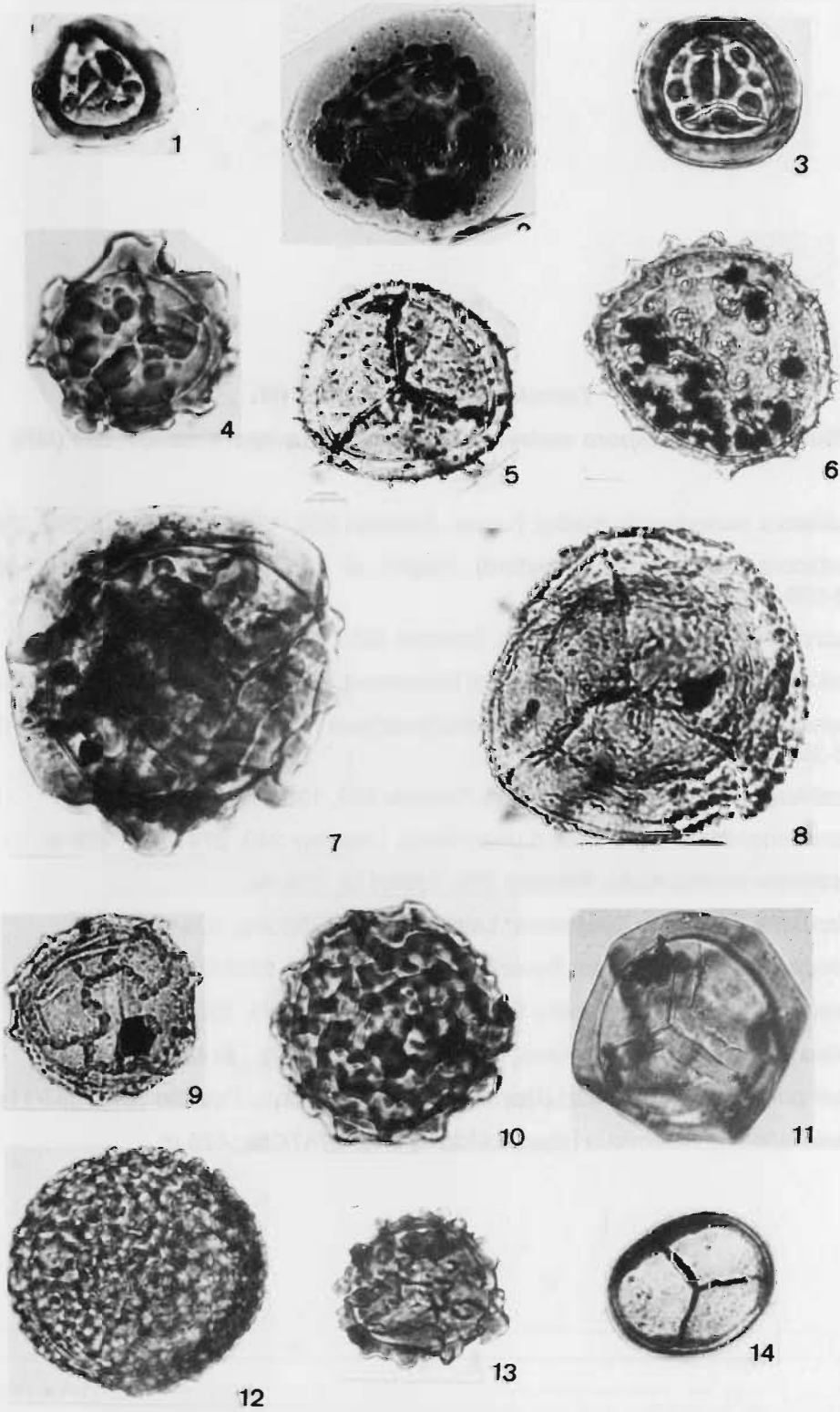
- 1-3. *Vallatisporites pusillites* (Kedo) Dolby et Neves
  - 1,2. Turov 123, 9363/4a, 173,8 m.
  3. Turov 123, 9360/3g, 172,5 m.
4. *Vallatisporites verrucosus* Hacquebard, Shestovitchi 10, 9203/12, 310 m.
5. *Vallatisporites vallatus* Hacquebard, Turov 123 , 9360/3g, 172, 5 m.
6. *Tumulispora variverrucata* (Playford) Staplin et Jansonius, Turov 123, 9360/3g, 172,5 m.
7. *Tumulispora malevkensis* (Kedo) Turnau, Lelchitsy 240, 3747/28a, 428 m.
8. *Retusotriletes minor* Kedo, Turov 123 , 9360/3g, 172, 5 m.
9. *Punctatisporites angularis* (Kedo) Byvscheva, Shestovitchi 10, 9200/11a, 305 m.
10. *Retispora lepidophyta* (Kedo) Playford var.minor Kedo, Turov 123, 9143/5g, 177 m.
11. *Stenozonotriletes minor* Naumova, Turov 123 , 9360/3g, 172, 5 m.
12. *Campotriletes paprothii* Higgs et Streele, Turov 123, 9363/4a, 173,8 m.
13. *Cymbosporites acutus* (Kedo) Byvscheva, Lelchitsy 345, 4010/18g, 373, 1-377,8 m.
14. *Spelaeotriletes crustatus* Higgs, Turov 123, 9363/4a, 173,5 m.
15. *Apiculiretusispora spinosa* (Byvscheva) Byvscheva, Petricov 329, 1363/12g, 278 m.
16. *Lophozonotriletes excisus* Naumova, Turov 123, 9360/3g, 172,5 m.
17. *Retusotriletes incohatus* Sullivan, Turov 123 , 9142/4B, 175, 6 m.
18. *Punctatisporites glaber* (Naumova) Playford, Turov 123 , 9360/3g, 172,5 m.



## PLATE 9

*Tumulispora malevkensis* (M)Subzone *Tumulispora malevkensis-Spelaotriletes balteatus* (MB)

1. *Tumulispora malevkensis* (Kedo) Turnau, Lelchitsy 240, 3747/28a, 428 m.
2. *Tumulispora variverrucata* (Playford) Staplin et Jansonius, Turov 123, 9360/3g, 172,5 m.
3. *Tumulispora rarituberculata* (Luber) Potonie, Starobin 260, 13508/18a, 302,9-306,9 m.
4. *Lophozotriletes excisus* Naumova, Shestovitchi 10, 9203/12, 310 m.
5. *Grandispora echinata* Hacquebard, Petricov 329, 1362/12, 2735 m.
6. *Cymbosporites acutus* (Kedo) Byvscheva Starobin 260, 12505/16, 234,8-298,2 m.
7. *Convolutispora major* (Kedo) Turnau, Lelchitsy 240, 3747/26a, 428 m.
8. *Spelaotriletes balteatus* (Playford) Higgs, Petricov 329, 1361/13, 274, 8 m.
9. *Bascaudaspora mischkinansis* (Byvscheva) Byvscheva, Turov 123, 9363/4a, 173, 8 m.
10. *Convolutispora usitata* Playford, Turov 123, 9142/4v, 175,6 m.
11. *Knoxisporites literatus* (Waltz) Playford, Turov 123, 9360/3g, 172,5 m.
12. *Convolutispora mellita* Hoffmeister, Staplin et Malloy, Lelchitsy 240, 3747/28a, 428 m.
13. *Lophozotriletes curvatus* Naumova, Lelchitsy 354, 367/7, 330,5 m.
14. *Retusotriletes incohatus* Sullivan, Lelchitsy 345, 3939/13a, 347,5-352,6 m.

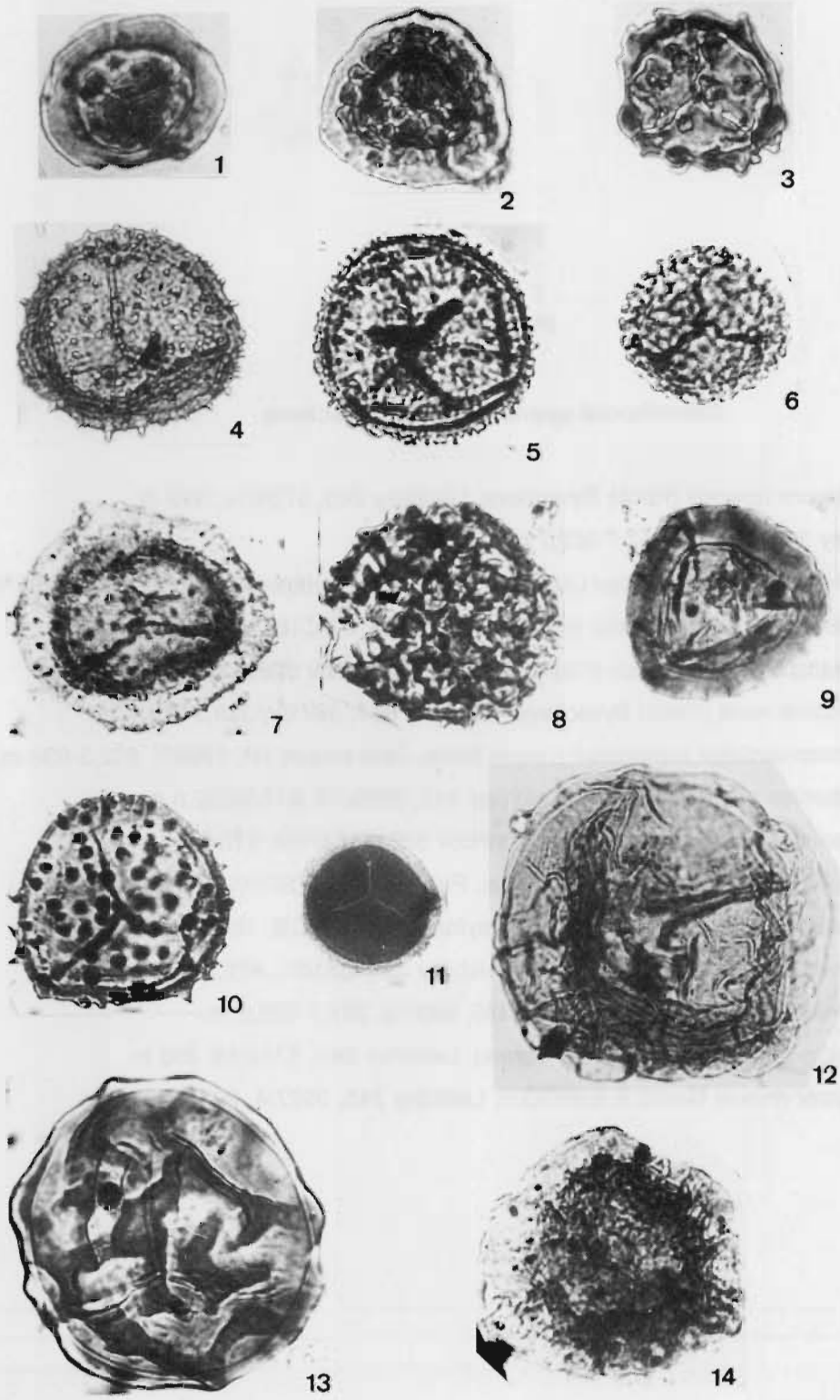


## PLATE 10

*Tumulispora malevkensis* (M)Subzone *Tumulispora malevkensis*-*Apiculiretusispora rarispinosa* (MR)

1. *Tumulispora malevkensis* (Kedo) Turnau, Starobin 260, 13505/16, 294, 8-298, 2 m.
2. *Tumulispora variverrucata* (Playford) Staplin et Jansonius, Starobin 260, 13505/16, 294,8-298,2 m.
3. *Lophozonotriletes excisus* Naumova, Starobin 260, 13505/16, 294,8-298,2 m.
4. *Apiculiretusispora rarispinosa* (Juschko) Byvscheva, Starobin 260, 13505/16, 294,8-298,2 m.
5. *Umbonatisporites regidesetosus* (Kedo)Byvscheva et Streel, Starobin 260, 13505/16, 294,8-298,2 m.
6. *Dictyotriletes submarginatus* Playford, Petricov 329, 1356/11d, 270 m.
7. *Hymenozonotriletes explanatus* (Luber) Kedo, Lelchitsy 240, 3747/26a, 428 m.
8. *Dictyotriletes trivialis* Kedo, Petricov 329, 1326/11d, 270 m.
9. *Tholisporites esenensis* Byvscheva, Lelchitsy 240, 3752/28g, 436-440 m.
10. *Cymbosporites acutus* (Kedo) Byvscheva, Petricov 329, 1361/13, 274,8 m.
11. *Auroraspora rugosiuscula* (Kedo) B3vscheva, Lelchitsy 240, 3720/7B, 364 m.
12. *Diaphanospora submirabilis* (Kedo) Byvscheva, Turov 123, 9142/4B, 175,6 m.
13. *Corbulispora cancellata* (Waltz) Bharadwaj et Venkatachala, Petricov 329, 1357/11e, 270 m.
14. *Kraeuselisporites hibernicus* Higgs, Lelchitsy 240, 3747/26a, 428 m.





## PLATE 11

***Grandispora upensis* (Kedo) Byvscheva**

- 1-2. *Grandispora upensis* (Kedo) Byvscheva, Lelchitsy 240, 3734/1v, 399 m.  
Lelchitsy 345, 3931/6, 317,7-322,7 m.
3. *Apiculiretusispora rarispinosa* (Juschko) Byvscheva, Petricov 329, 1362/12a, 273,5 m.
4. *Cymbosporites acutus* (Kedo) Byvscheva, Petricov 329, 1351/9a, 264,5 m.
5. *Umbonatisporites abstrusus* (Playford) Clayton, Petricov 329, 1362/12a, 273,5 m.
6. *Tumulispora varia* (Kedo) Byvscheva, Lelchitsy 354, 367/6v, 329,3 m.
7. *Hymenozonotriletes explanatus* (Luber) Kedo, Zaozernaya 1P, 1366/5, 832,3-838 m.
8. *Knoxisporites pristinus* Sullivan, Lelchitsy 345, 3939/13, 347,5-352,6 m.
9. *Kraeuselisporites hibernicus* Higgs, Petricov 329, 1362/12a, 273,5 m.
10. *Raistrickia minor* (Kedo) Dolby & Neves, Petricov 329, 1357/11e, 270 m.
11. *Verrucosisporites nitidus* (Naumova) Playford, Petricov 329, 1342/3v, 228 m.
12. *Umbonatisporites distinctus* Clayton, Lelchitsy 354, 381/21, 421,3 m.
13. *Dictyotriletes trivialis* Kedo, Lelchitsy 345, 3937/8, 327,7-332,6 m.
14. *Tumulispora malevkensis* (Kedo) Turnau, Lelchitsy 240, 3734/18, 399 m.
15. *Rugospora minuta* Neves & Ioannides, Lelchitsy 345, 3927/4, 293,2-307,2 m.

