GEOLOGICA BALCANICA, 37. 1–2, Sofia, Iun. 2008, p. 97–101.

The ecology of Upper Westphalian microflora from Dobrudzha Coal Basin, Bulgaria

Tatyana Dimitrova

Geological Institute, Bulgarian Academy of Sciences, Sofia 1113; E-mail: tania_d@geology.bas.bg
(Submitted: 24.09.2007; accepted for publication: 16.11.2007)

Т. Димитрова. Экология поздневестфальской микрофлоры из Добруджанского угольного бассейна, Болгария. Проведено исследование 55 образцов угля с вестфальской растительностью. Они собраны из трех свит: Македонской, Крупенской и Гурковской. В работе обсуждается эволюционное и филогенетическое значение установленных ископаемых растений. На основании определения состава и распространения миоспоровых ансамблей сделаны реконструкции флоры. Исследование предоставляет важную информацию о детальной структуре углеобразующей болотной растительности. Установлено, что глобальные климатические изменения, главным образом засуха, ускорили изменения растительного мира и что это нашло выражение в повсеместно повышенной представительности семенных растений. Результаты работы помогут при оценке роли разных групп растительности (микрофлористических ансамблей) в процессах становления сухоземных палеоэкосистем и дадут возможность лучше понять современное сухоземное биоразнообразие.

Abstract. The study is based on coal samples from Makedonka, Krupen and Gurkovo Formations. More than 55 specimens were collected, which represent the Westphalian plants and have been recorded in the field for ecological purposes. This research considers the evolutionary and phylogenetic importance of the fossil plants identified, where determination of the composition and distribution of the miospore assemblages allows reconstruction of the flora. The study provides important information on the detailed structure of coal swamp vegetation. Global climate changes, mainly droughts, have forced vegetational changes, resulting in seed-plant world domination. The current result helps to assess the role of the different plant groups (microfloristic assemblages) in the shaping of terrestrial ecosystems over time, and provides insight into the origins of modern day terrestrial biodiversity.

Dimitrova, T. 2008. The ecology of Upper Westphalian microflora from Dobrudzha Coal Basin, Bulgaria. – *Geologica Balc*., 37, 1–2; 97–101.

Key words: Dobrudzha Basin, Late Westphalian, ecology, coal swamp vegetation.

Introduction

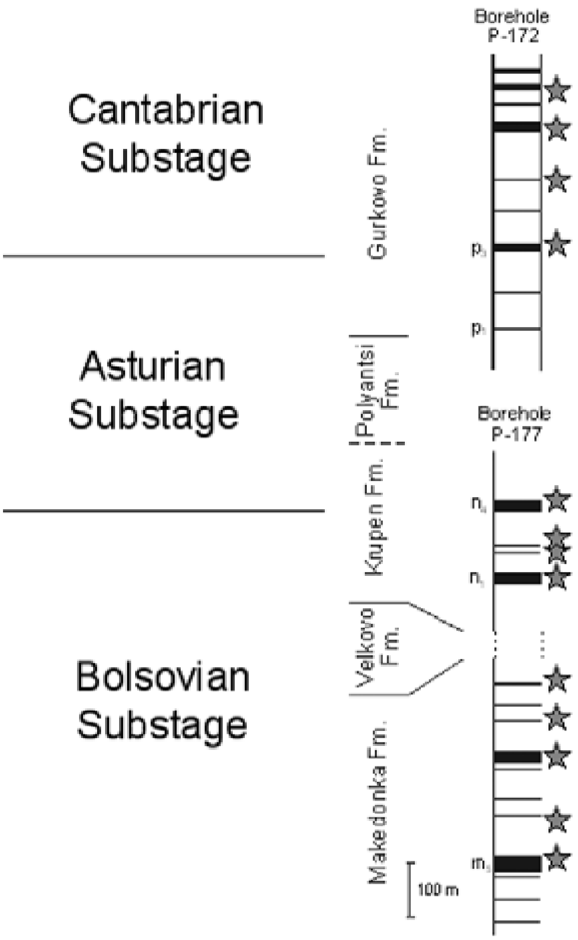
This area of coal deposits is near the Black Sea coast in northeastern Bulgaria (Fig. 1). Late Westphalian wetland ecosystems in the Dobrudzha Coal Basin were dominated by spore-producing plants and early gymnospermous seed plants. Global climate changes (Falcon-Lang, 2005), largely drying, forced vegetational changes, resulting in a change to a seed plant dominated world, beginning first at high latitudes during the Westphalian time, reaching the tropics near the Stephanian-Westphalian boundary.

Methods and material

This study is based on the coals samples from:

– Makedonka Formation – up to about 290 m thick with 12 coal seems, divided into two members at the level of coal seam m5 (Dimitrova et al., 1997).

Fig. 1. Geographical position of the Dobrudzha Basin



– Krupen Formation – the normal thickness found in the type section is 92 m. There are also four coal-bearing cycles.

– Gurkovo Formation – divided into three formal subunits: the Topola, Brestovo, and Kabalak Members (Nikolov et al., 1989).

The specimens of the microflora were set apart to form a separate collection relative to each horizon from the coal formations. In this manner, more than 55 specimens were brought together, representing the Westphalian plants which had been recorded in the field for ecological purposes (Cleal, 2004).

Palaeoecosystems

Westphalian plants (introduced in the study by species and genera with their microflora) have formed in their natural conditions of existence ancient communities (paleophytocenosis). Being in constant dependence on the environment, they represented sophisticated natural systems (palaeoecosystems). On their side, those palaeoecosystems prove the taphonomic type of the deposit, regularities in the fossilization of the plant groups, which are part of the reconstruction of the respective paleo-landscape. Palaeoecology of swamp accumulation (Wnuk, Pfef-

←

Fig. 2. Samples and coal seams

ferkorn. 1984, DiMichele et al., 2001) is a new field of study for palynology and palaeoecology. It concerns directly the problems of ecological niches of ancient plants, the general principles of the theory and practice of coal petrology, related to factual data from palynology.

The initial analysis of the palynological data was based on the recognition of changes in distribution of five general morphological groups of palynomorph (Dimitrova, Cleal, 2007) by Borehole 172 (Table 1).

1. TRILETES. These are mainly spores of lycophytes, calamostachyalean equisetes, bowmanitaleans and some ferns (Cleal, 2004).

2. MONOLETE SPORES. These consist of marattialean fern spores, and may be mainly taken to represent the lowland clastic-substrate habitats such as levees.

3. MONOLETE POLLEN. These consist of medullosalean pteridosperm pollen.

4. MONOSACCATES. These include mainly cordaite and some conifer pollen, and represent the vegetation from the drier, marginal habitats within the swamp forests.

5. BISACCATE. These include mainly conifer and possibly some peltasperm pollen from the lowland vegetation.

Coal seems and vegetation

The coals from Dobrudzha Basin are with rang carbonization high volatile bituminous coal and they hold out appropriate material for phyteral analysis. The microlithotype composition reflect maceral composition.

Beds overlying the tonstein under m5 are characterised by a more significant occurrence of trimacerite (10%). The part of inertite concentrated in trimacerite is in connection only to a minimum in durite (Konstantinova, Peeva, Stephanova, Pancheva – reports). The observed vitrain with a telnite microstructure comes from cortical tissues mainly of the Lepidophyta vegetation. The palynology was successfully used for coal seem correlation and coal petrography and palynological data played an important role and the evoluation of the results gathered was established by several autors (Oplustil, Cleal, 2007). Petrographic analyses were used for three coal formations in Dobrudzha Coal Basin based on maceral and microlithotype classification of the ICCP 1975 and maceral subgroups adopted from ICCP, 1994. Petrology, palynology, coal facies, and depositional environments of the Westphalian coal seams (Kalkreuth et al., 2000) are the proportions of habitats that change at the landscape-breakpoint boundaries.

During the research process, attention has been paid on the amount of petrographic groups in the coal seam and the dominant composition of miospores after the parallel palynological study. The composition of the miospore spectra has been statistically calculated after counting in durable preparations from samples taken in vertical succession from seam m5 (Fig. 3). Coal petrology (Pancheva unbibl. data) and palynology of the m5 coal seam enable depositional environments of the swap to be established in terms of facies-critical maceral ratios, maceral assemblages, and spore and pollen assemblages.

The most often dominants in the assemblage are: *Lycospora* (Lepidodendraceae, Bothrodendraceae), *Densosporites* (Selaginelaceae), *Crassispora kozankei* (Sigilariaceae). The consecutive and regular alternation through the layer section of the intervals (or the tendency of increase) of the content of miospores of hygrophytic or less hygrophytic to mesophytic plants affects the paleoecological cycle of swamp formation. These cycles can be separated in two phases: lower regressive and upper transgressive in every coal seem. The microflora repeatedly chanched in response to transgressive-regressive phases – Lycophase and Densophase by Smith, 1968.

Table 1
General morphological groups of polymorphs

Sample Depth (m)	Dominant Microfloristic Genera	Petrographic study
1949.90	*Lycospora, Microreticulatisporites Crassispora, Calamospora, Triquitrites*	clarite 65%
1950.40	*Vestispora, Wilsonia, Florinites Torispora, Punctatosporites, Densosporites, Raistrickia*	durite 30%, clarite 30%, carbargillite 10%, vitrinite 10%
1951.20	*Punctatosporites, Triquitrites, Torispora Leiotriletes, Lycospora, Cirratriradites*	duroclarite/vitrinite 40%, clarite 20%
1951.60	*Torispora, Cassispora, Lycospora, Alatisposporites, Raistrickia, Punctatosporites, Triquitrites*	torispore/durite 25%, clarite 40%
1951.90	*Endosporites, Florinites, Leiotriletes, Laevigatosporites, Raistrickia*	aleurite/argillite 80%
1952.30	*Lycospora, Torispora, Microreticulatisporites, Leiotiletes Crassispora,*	crassispore/clarite 40%
1953.60	*Endosporites globiformis, Florinites, Crassispora, Calamospora*	carbargillite 55%

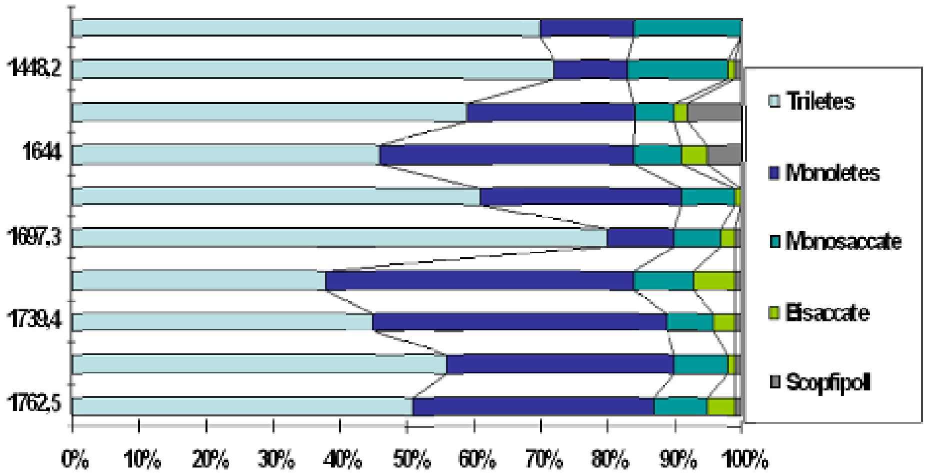


Fig. 3. The palynology of the coal seam m5 and correlation with coal petrography data

Coal swamp environment

The association would suggest a coal swamp environment in which small lycopsids (*Endosporites*) and arboreus Lycopsids (*Lycospora*) were very common in the Bolsovian (seams m5, m9) in lower part in the coal seems and maximum of the genus *Densosporites* is characterized in middle to the top of the some coals. The *Cadiospora* (Lycopsids) is typical genus for Westphalian D, upper part. The Lycopsids of coal swamps exhibited a broad spectrum of heterosporous reproductive morphology. The subdominance of the Cordaites (Group Pollenites) in the assemblages in some coal seems in of the Gurkovo Formation relate to the top of the coal seems.

Habitats and ecology

– The swamp area is inundated with dentritus, possibly from river system, including the plants which were actually living in the swaps (m9 coal, p3 coal).

– *Lepidodendron* was a heterosporous tree common in coal swamps.

– The plants incorporated may have either been brought in with the sediments or lived elsewhere in the area (Makedonka Formation – coals m10–m12).

Estimation of the relationship between species turnover and habitat patterns, however, suggests an intermediate level of organization. A forest of lycopsid trees and tree ferns was uniformly developed throughout this area, and an understudy of horsetails, seed ferns, and cordaitaleans (seed plants related to conifers) filled in under and around (Pfefferkorn, 1980) the tree fern-lycopsid forest where the land was drier.

The general conclusion that the miospores from the basis of the layer belong to grass plants, and the zone from the middle to the cover of the layer is assigned to arborescent lycopsids is confirmed. These intervals could be named conditionally paleoecological cycles of coal accumulation. In the intervals studied, groups of dominant microspores, respectively swamp plants alternate.

Calculation of standard diversity indices indicates that growing conditions were generally stressful, consistent with a seasonal environment. The composition of these dryland (Pfefferkorn et al., 2000) communities differs markedly from lycopsid-dominated wetland communities (Thomas, Tenchov, 2004) known from gray, coal-bearing successions at other intervals in the Krupen and Gurkovo Formation.

The vegetation Index and maceral assemblages suggest both limnic conditions and somewhat drier conditions in the Gurkovo Formation. The change in dominance pattern (Cleal, Dimitrova, 2002) in compression-impression plant-fossil assemblages occur half a stage earlier than the previously reported change from lycopod-dominated to fern-dominated assemblages (Evans et al., 2003; Cleal et al., 2006) at the Westphalian-Stephanian boundary (Cleal et al., 2003) in coal swamps.

Conclusions

1. The result will help to assess the roles of different plants groups in shaping terrestrial ecosystems over time, and will provide insights into the origins of modern day terrestrial biodiversity.
2. The study will provide important information on the detailed structure of coal swamp vegetation (Greb et al., 2006).
3. Carboniferous wetland ecosystems were dominated by spore-producing plants and early gymnospermous seed plants (Pfefferkorn, 1980).
4. Global climate changes (DiMichele et. al., 2001, Falcon-Lang, 2005), largely drying, forced vegetational changes, resulting in a change to a seed plant—dominated world.

References

Cleal, C., 2004. Late Westphalian terrestrial biotas and environments of the Variscan Foreland and adjacent intramontane basins. – *Geologica Balc.*, 34, 3–4; 3–10.

Cleal, C. J., Dimitrova, T. 2002. A new approach to interpreting palynological data from the Late Carboniferous tropical coal forests. Univ. Cambridge, 46th Annual Meeting Palaeont. Assoc. – *Newsletter* 51; p. 124.

Cleal., C., Dimitrova, T., Zodrow, E. 2003. Macrofloral and palynological criteria for recognising the Westphalian-Stephanian boundary. – *Newsletter of Stratigraphy*, 39, 2/3; 181–208.

Cleal, C. J., Tenchov, Y. G., Dimitrova, T. Kh., Thomas, B. A. & Zodrow, E. L. 2006. Late Westphalian – early Stephanian vegetational changes across the Variscan Foreland. – *Proceedings XVth International Congress on Carboniferous and Permian Stratigraphy* (Utrecht, 2003); 1–11.

DiMichele, W. A., Phillips, T. L., 1994. Paleobotanical and paleoecological constraints on models of peat formation in the Late Carboniferous of Euramerica. – *Palaeogeography, Palaeoclimatology, Palaeoecology*., 106, 1–4; 39–90.

DiMichele, W. A., Pfefferkorn, H. W. and Gastaldo, R. A. 2001. Response of Late Carboniferous and Early Permian plant communities to climate change. – *Annual Review of Earth and Planetary Sciences*, 29; 461–487.

Dimitrova, T. Kh., Cleal, C. J. 2007. Palynological Evidence for Late Westphalian – Early Stephanian vegetation change in the Dobrudzha Coalfield, NE Bulgaria. – *Geol. Mag.*144, 3; 513–524.

Dimitrova, T., Peeva, R., Popov, A. 1997. Coalbearing, macro- and microfloristic successions from Late Westphalian in Ne Bulgaria. –In: *Proceedings 2nd Intern. Symp. Petroleum Geol. Black Sea area*. Sile-Istanbul, 1996; p. 97–98.

Evans, B., Cleal, C., Thomas, B., Wimpledon, W. P. A. 2003. The Westphalian succession of the Glyn-neath area, South Wales: an internationally important geological resource. – *Proc. Geol. Assoc.* 114, 291–305.

Falcon-Lang, H. J. 2005. Global climate analysis of growth rings in woods, and its implications for deep-time paleoclimate studies. – *Paleobiology*, 31, 3; 434–444.

Greb, S. F., DiMichele, W. D., and Gastaldo, R. A. 2006. Evolution of Wetland Types and the Importance of Wetlands in Earth History. – In: *Wetlands Through Time* (DiMichele, W.A., Greb, S., eds.), *Geological Society of America, Special Publication*, 399; 1–40.

Kalkreuth, W., D. Marchioni, J. Utting. 2000. Petrology, palynology, coal facies, and depositional environments of an Upper Carboniferous coal seam, Minto Coalfield, New Brunswick, Canada. – *Can. J. Earth Sci.,* 37, 9; 1209–1228.

Nikolov., Z., Tenchov, Y., Popova, K., Dimitrova, T., Popov, A. 1989. Subdivision and correlation of Gurkovo Formation from Carboniferous of Dobrudzha Coal Deposit. – *Rev. Bulg. geol. Soc.*, 1; 1–14.

Oplustil, S., Cleal, C. J. 2007. A comparative analysis of some Late Carbonifrous basins of Variscan Europe. – *Geol. Mag.* 144, 3; 417–448.

Pfefferkorn, H. W. 1980. A note on the term "upland flora". – *Review of Paleobotany and Palynology*, 30, 157–158.

Pfefferkorn, H. W., Gastaldo, R. A., DiMichele, W. A. 2000. Ecological stability during the Late Paleozoic cold interval. – In: *Phanerozoic terrestrial ecosystems* (Gastaldo, R. A., DiMichele, W. A., eds.), *Paleontological Society Papers*, 6; 63–78.

Smith, A. H. V., 1968. Seam profiles and seam characters. – In: *Coal and coal-bearing strata* (D. G. Murchison and T. S. Westoll, eds.); 31–40.

Thomas, B. A., Tenchov, Y. G. 2004. The Upper Westphalian lycophyte floras of the Dobrudzha Coalfield (Bulgaria) and a comparison with those of southern Britain and Cape Breton (Canada). – *Spec. Pap. Geologica Balc.*, 34, 1–2; 105–110.

Wnuk, C., Pfefferkorn, H.W.. 1984. The life habits and paleoecology of Middle Pennsylvanian Medullosan Pteridosperms based on an in situ assemblage from the Bernice Basin (Sullivan County, Pennsylvania, U.S.A.). – *Review of Paleobotany and Palynology*, 41; 329–351.

Т. Димитрова – Екология на късновестфалската микрофлора от Добруджанския въглищен басейн, България. Изследването е основано на въглищни образци от Македонската, Крупенската и Гурковската свита. Над 55 образеца от вестфалска растителност са намерени и събрани на терена за палеоекологична обработка. Проучването разглежда еволюционното и филогенетично значение на идентифицираните фосилни растения; определянето на състава и разпространението на миоспоровите ансамбли позволява да се реконструира флората. Това изследване дава важна информация за детайлната структура на въглищната блатна растителност. Глобалните климатични промени, главно засушаването, са ускорили промените в растителния свят, изразяващи се в повсеместното налагане на семенните растения. Настоящият резултат ще помогне да се оцени ролята на различните групи растителност (микрофлористични ансамбли) при формирането на сухоземните екосистеми във времето, и ще спомогне разбирането за произхода на съвременното сухоземно биоразнообразие.