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PALAEOBOTANICAL EVIDENCE FOR CORRELATING THE STRATIGRAPHY OF THE NEOGENE DEPOSITS OF BELARUS

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ABSTRACT. Three regional superhorizons (Brinev, Antopol and Kolochin) whose age ranges have been determined from palynological, palaeocarpological and diatom studies, are distinguished in a suggested stratigraphic scheme for the Neogene deposits of Belarus. The boundary between the Oligocene and Miocene is located just above the Krupeika set of horizons (23.8 Ma) and that between the Pliocene and Quaternary at the base of the Gomel superhorizon (1.76 Ma).

KEY WORDS: pollen analysis, seed flora, diatoms, stratigraphy, correlation, Neogene

INTRODUCTION

The first stratigraphic scheme for the Palaeogene and Neogene deposits of Belarus was provided by Manykin (1959). The next, which included two horizons (Brinev and Antopol), was accepted twenty-four years later (Resheniya 1983). The present suggested scheme represents a more precise version of that published most recently (Azhgirevich *et al*. 1996). More than 100 localities were reviewed, mostly palynologically and palaeocarpologically. Certain profiles were reviewed using scanning electron microscopy (principally for the identification of diatom species).

The Neogene deposits of Belarus are continental and formed on the periphery of the sedimentary basins of North-Western Europe and the Eastern Paratethys. The demarcation of these two sedimentation basins within Belarus took place at the end of the Oligocene. The Neogene continental deposits are represented by fluvial, lacustrine and marshy facies. They are widespread, mostly in the southern and western parts of Belarus. Their average thickness is 10–15 m, with maxima of up to 50.6 m in the Belarusian Anticline and up to 100 m in the south-western part of the Pripiat Trough. Palaeobotanical data (34 pollen zones, 17 palaeocarpological associations and 5 diatom assemblages) and some lithological features were used for chronostratigraphical correlation and determinations of geological age.

RESULTS AND DISCUSSION

Three regional superhorizons are distinguished in the suggested stratigraphic scheme for the Neogene deposits of Belarus, correlated with the international chronostratigraphic standard and the stratigraphic units of the Tethys and Paratethys (Table 1).

The Brinev superhorizon consists of two regional horizons. The Smoliarka horizon is composed of coaly sands and the largest brown coal seam (up to 30 m thick) accumulated during the Early Miocene and at the beginning of the Middle Miocene. In general, it can be correlated with Rawicz/Gorzów, Ścinawa/Krajenka and the lower part of Pawłowice/Adamów Formations within Poland. The Smoliarka horizon is characterized by eleven pollen zones (Table 2). Among them, the three lowest corresponding to the Aquitanian climatic cooling, can be compared with spore-pollen zone II (*Alnipollenites verus*) in Poland, while the eight uppermost (reflecting the main double thermal optimum of the Miocene) are comparable with zones III to VI which saw the most extensive coal-forming accumulation within the Polish Lowland (Piwocki & Ziembińska-Tworzydło 1995, 1997). The seed flora of the Smoliarka horizon is distinguished by the stability of its systematic composition and dominant plants, as well as by a considerable content of palaeotropical elements. The floristic complex (FC) of Rozhok 4 matches perfectly the FC of Wiesa in Germany (Mai 1994).

The Bukcha horizon consists of kaolinic clays with thin intercalations of brown coal formed in the middle part of the Middle Miocene. It synchronizes with the upper part of the Pawłowice/Adamów Formation and the 1st Middle Polish group of seams in the base of the Poznań Formation within Poland. Pollen zones of this horizon correspond to the spore-pollen zones VII (*Itea-*

Table 1. Correlation of stratigraphic units of the Neogene of Belarus with stages of Tethys and Paratethys. (Absolute dating, epochs and ages according to Berggren *et al*. 1995.)

Age, Ma	System	Epoch		TETHYS Stage	PARATETHYS WESTERN Stage	PARATETHYS EASTERN Stage		BELARUS Super-horizon	BELARUS Horizon
	QUATERNARY	PLEISTOCENE	LOWER	CALABRIAN	EOPLEISTOCENE	APSHERONIAN		GOMEL	VSELUB
1.76	NEOGENE	PLIOCENE	UPPER	GELASIAN	ROMANIAN	AKCHAGYLIAN		KOLOCHIN	DVORETS
2.6				PIACENZIAN		KIMMERIAN			KHOLMECH
3.56			LOWER	ZANCLEAN	DACIAN				
5.32 (5)		MIOCENE	UPPER	MESSINIAN	PONTIAN	PONTIAN		ANTOPOL	ASOKY
									DETOMLIA
7.12				TORTONIAN	PANNONIAN	MAEOTIAN			LOZY
(10)						SARMATIAN	KHERSONIAN		
11.2			MIDDLE	SERRAVALIAN	SARMATIAN		BESSARABIAN		BURNOSY
							VOLYNIAN		
					BADENIAN	KONKIAN		BRINEV	BUKCHA
14.8 (15)				LANGHIAN		KARAGANIAN			
						TCHOKRAKIAN			SMOLIARKA
16.4			LOWER	BURDIGALIAN	KARPATIAN	TARKHANIAN			
					OTTNANGIAN	KOTSAKHURIAN			
(20)					EGGENBURGIAN	SAKARAULIAN			
20.52				AQUITANIAN	EGERIAN	CAUCASIAN			
23.8 (20)	PALAEOGENE	OLIGOCENE	UPPER	CHATTIAN					KRUPEIKA SUITE

pollis angustiporatus) and VIII (*Celtipollenites verus*) described by M. Ziembińska-Tworzydło. The palaeocarpological associations of the Bukcha horizon are less stable. The Drogichin FC, with the latest appearance of Magnoliaceae, *Sequoia* and *Glyptostrobus* seeds is associated with the lowest part of the Bukcha horizon and the uppermost part of the Grodno FC. These complexes are apparently of similar age to the Klettwitz FC described by Mai (1994) in Lausitz. Among diatoms, the extinct species *Alveolophora jouseana* (a zonal species from the second half of the Early and the first half of the Middle Miocene of Eastern Russia (Moiseeva 1995)) was found at the bottom of the Bukcha horizon.

The Antopol superhorizon comprises four regional horizons, represented by mainly montmorillonite clays (from black to variegated in colour). The sedimentation of the Burnosy horizon dates from the second half of the Middle Miocene. It can be compared with the lowest part of the Poznań Formation in Poland. The Malishev layers which occurred at the base of the Burnosy horizon are characterized by a *Betula-Alnus-Quercus* pollen zone (Table 3), reflecting a substantial cooling of the climate (nearly 13 Ma). The global cooling of the time interval corresponding to pollen phase V was noted also by Kohlman-Adamska (1993). The seed flora, associated with the beginning of the formation of the Antopol superhorizon deposits is characterized by essential taphonomic changes affecting the composition of dominants,

Table 2. Biostratigraphy of the Lower and part of the Middle Miocene deposits of Belarus

Epoch		Super-horizon	Horizon	Pollen zones	Palaeocarpological associations	Diatom assemblages
MIOCENE	MIDDLE	BRINEV	BUKCHA	*Quercus – Ulmus – Carya*	Grodno FC: *Pilularia miocenica* Dorof. – *Scirpus tertiaerus* Dorof. – *Potamogeton firmicarpus* T.V. Jakub. – *Myrica goretskyi* Dorof. – *Comptonia costata* Dorof. – *Sparganium noduliferum* C. et E.M.Reid – Alismataceae gen. – *Typha* sp.	
				Betula – Nyssa		
				Pinus – Quercus – Ulmus		*Aulacoseira ambigua* (Grun.) Sim. – various species of *Fragilaria* sensu lato
				Quercus – Castanea – Ulmus	Droghichin FC: *Pilularia miocenica* Dorof. – *Naumburgia cupulisperma* Negru – Alismataceae gen. – *Typha* sp.	
				Quercus – Nyssa	Pruzhany FC: *Pilularia miocenica* Dorof. – Alismataceae gen.	*Alveolophora jouseana* (Moiss.) Moiss. – *Aulacoseira praegranulata* (Jousé) Sim. with varieties
			SMOLIARKA	*Pinus – Quercus – Tricolporopollenites exactus* – Rosaceae	Rozhok 6 FC: *Pinus* sp. – Taxodiaceae gen. – *Typha* sp. – *Azolla* cf. *interglacialis* P.Nikit. Rozhok 5 FC: *Brasenia bresciana* Dorof. – *Pinus* sp.; *Brasenia bresciana* Dorof. – *Caricoidea ovale* (Dorof.) E.M.Reid; *Pinus* sp. – *Brasenia dorofeevi* T.V.Jakub.	
	LOWER			*Pinus – Tricolporopollenites pseudocingulum – Quercoidites henrici*		
				Quercus – Pinus – Taxodiaceae		
				Pinus – Ericaceae		
				Alnus		
				Taxodiaceae – *Tricolporopollenites pseudocingulum – Quercoidites henrici – Araliaceoipollenites euphorii*	Rozhok 4 FC: *Caricoidea ovale* (Dorof.) E.M.Reid – *Brasenia bresciana* Dorof. – *Trapa* sp. – *Pinus* sp.; *Punica natans* (P.Nikit.) Mai – *Sequoia* sp.; *Brasenia dorofeevi* T.V.Jakub; *B. bresciana* Dorof. – *Caldesia proventitia* P.Nikit.	
				Quercus – Myrica – Alnus	Rozhok 3 FC: *Myrica sphaeroidea* T.V.Jakub. – *Caricoidea jugata* (P.Nikit.) Mai – *Boehmeria majuskula* T.V.Jakub.; *Glyptostrobus borysthenica* Dorof. – *Tubela lidiae* T.V.Jakub. – *Caricoidea jugata* (P.Nikit.) Mai–*Boehmeria majuskula* T.V.Jakub	
				Quercus – Liquidambar – Arceuthobium		
				Betula – Corylus – Nyssa		
				Taxodiaceae – *Engelhardtia* – Anacardiaceae		
				Betula – Ulmus		

resulting in uneven increases in the percentages of local genera as well as in the disappearance of the palaeotropical elements. These natural phenomena also reflect profound transformations of the ecosystems. The final pollen zone of the Burnosy horizon may be compared with spore-pollen zone IX (*Tricolporopollenites pseudocingulum*) and pollen phase VI described by Ziembińska-Tworzydło and A. Kohlman-Adamska from the deposits of the Polish Lowland. It reflects the climatic optimum of the Middle Miocene. The diatom assemblage of the Burnosy horizon abounds with ancient species of *Aulacoseira* and the extinct taxa of *Actinocyclus* known from the Middle Miocene of the Czech Republic (Khursevich & Rehŕkova 1994).

The age range of the Lozy, Detomlia and Asoky horizons is restricted to the Late Miocene. The Lozy horizon corresponds to the middle part of the Poznań Formation within Poland. The pollen zones of this horizon are probably comparable with the lower part of spore-pollen zone X (*Nyssapollenites*) described by Ziembińska-Tworzydło. The diatom flora of this horizon differs in the presence of extinct representatives of *Pseudoaulacosira, Actinocyclus, Mesodictyon, Tabellaria*, *Eunotia*, etc. Among them the extinct species of *Mesodictyon,* characteristic of the Late Miocene in different parts of world, have an important stratigraphic value.

The Detomlia horizon correlates with the upper part of the Green Clays Member of the Poznań Formation

Table 3. Biostratigraphy of part of the Middle and Upper Miocene deposits of Belarus

Epoch		Super-horizon	Horizon	Pollen zones	Palaeocarpological associations	Diatom assemblages
MIOCENE	UPPER	ANTOPOL	ASOKY	*Pinus* – *Betula* — *Alnus* – NAP	*Salvinia glabra* P.Nikit. – *S. tuberculata* P.Nikit. – *Azolla pseudopinnata* P.Nikit. – *Sagittaria* sp. – Alismataceae gen. – *Scirpus tertiaerus* Dorof.	
			DETOMLIA	*Pinus* – *Betula* – *Alnus* – *Quercus* – Poaceae	*Salvinia* cf. *petri* Dorof. – *Pinus* sp. – Alismataceae gen. – *Potentilla pliocenica* E.M.Reid; *Salvinia* cf. *petri* Dorof. – Alismataceae gen. – *Betula* sp. – *Pinus* sp. – *Rumex maritimus* L.	*Actinocyclus krasskei* Bradbury & Krebs – *Tetracyclus lacustris* Ralfs – *Tabellaria celatom* Khurs. – *T. flocculosa* (Roth.) Kütz. – *Eunotia* aff. *lavrovii* Tscher. – *Pinnularia viridis* (Nitzsch.) Ehr. – *Cymbella aspera* (Ehr.) Cl.
			LOZY	*Pinus* s/g *Diploxylon* – Taxodiaceae – *Quercus* – Poaceae	*Salvinia* cf. *petri* P.Nikit. – *Azolla aspera* var. *sulajensis* Dorof. – *Typha* sp. – Scirpus cf. *palibini* P.Nikit.; *Brasenia pripiatensis* Dorof. – *Scirpus* e gr. *melanospermus* C.A.Mey – *Myriophyllum parvicarpum* Dorof. – *Azolla parvula* Dorof. – *Typha miocenica* Dorof.	*Aulacoseira* from the „prae" group – *Pseudoaulacosira moisseevae* (Lupik.) Lupik. & Khurs. – *Actinocyclus* aff. *muticus* Khurs. & Řehak. – *A. krasskei* Bradbury & Krebs – *Mesodictyon nemanensis* (Khurs.) Khurs. – *Tabellaria celatom* Khurs. – *T. poretzkia*e Log. & Khurs. – *Eunotia goretskyi* Khurs. – *Actinella brasiliensis* Grun.
				Pinus s/g *Diploxylon* – *Quercus* – Poaceae	*Salvinia* cf. *petri* P.Nikit – *Azolla parvula* Dorof. – *Hypericum* cf. *cariaceum* P.Nikit	
	MIDDLE		BURNOSY	*Pinus* s/g *Haploxylon* – *Podocarpus* – Taxodiaceae – *Quercus*	*Azolla parvula* Dorof. – *Salvinia* cf. *petri* Dorof.; *Azolla poltavica* Dorof. – *Salvinia* cf. *petri* Dorof. – *Brasenia* sp. – *Typh*a sp. – Alismataceae gen.	*Aulacoseira praegranulata* (Jousé) Sim. with varieties and f. *curvata* – *Actinocyclus* aff. *muticus* Khurs. & Rehak.
				Quercus – *Alnus*	Hartziella miocenica Szafer – *Decodon* cf. *europaeus* Dorof. – *Selaginella tertiaria* Dorof. – *Salvinia* cf. *ruthenica* Dorof.; *Salvinia* cf. *petri* Dorof. – *Selaginella tertiaria* Dorof. – *Azolla poltavica* Dorof.	
				Pinus – *Quercus* – *Castanea* – *Alnus*	*Cladium europaeum* Dorof. – *Stratiotes intermedius* Chandl. – *Decodon* cf. *europaeus* Dorof.	
				Quercus – *Fagus* – *Carpinus* – *Corylus*	*Cladium* sp. – *Salvinia* cf. *petri* Dorof.	
				Betula – *Alnus* – *Quercus*	*Salvinia miocenica* Dorof. var. crispa Dorof. – *Selaginella tertiaria* Dorof. – *Scirpus longispermus* Dorof.	

within Poland. The pollen zone of this horizon corresponds to the upper part of the *Nyssapollenites* pollen zone providing a prelude to a considerable cooling. The qualitative diversity of the diatom flora essentially decreased. Moreover, the content of warm water exotics was reduced to a minimum.

The Asoky horizon may be compared with the O-Orłowo group of seams in the Poznań Formation. The pollen zone of this horizon can be correlated with spore-pollen zone XI (*Betulaepollenites*-*Cyperaceapollis*) described by Polish investigators from the upper part of the Poznań Formation.

The Kolochin superhorizon consists of two regional horizons. It is composed of sandy silt deposits showing the montmorillonite-hydromicaceous composition of the clay component. The formation of the Kholmech horizon took place in the Pliocene and corresponds to the Gozdnica Formation in Poland. This horizon is subdivided into two pollen zones (Table 4). One from them is comparable with spore-pollen zone XIII (*Sequoiapollenites*), the other with the spore-pollen zone XIV (*Faguspollenites*) (Piwocki & Ziembińska-Tworzydło 1995, 1997) and with phase I, described by Stuchlik (1987, 1994) within Poland. The Dvorets horizon (Gelasian) correlates with the Lower Pleistocene deposits in Poland. The pollen zones of this horizon are comparable with the phases

Table 4. Biostratigraphy of the Pliocene deposits of Belarus

Epoch		Super-horizon	Horizon	Pollen zones	Palaeocarpological associations
PLIOCENE	UPPER	KOLOCHIN	DVORETS	*Pinus – Picea – Betula –* NAP	*Caulinia palaeotenuissima* Dorof. – *C. minor* All. – *Scirpus atroviroides* Dorof. – *Elatine hydropiperoides* Dorof. et Wieliczk. – *Selaginella reticulata* Dorof. et Wieliczk. – *Alisma minima* (P. Nikit.) Dorof. – *Lysimachia nikitini* Dorof. *Eleocharis praemaximowiczi* Dorof. – *Betula felixi* Dorof.; *Scirpus atroviroides* Dorof. – *Lycopus pliocenicus* Dorof. – *Trapa* sp.– *Potamogeton digynoides* Dorof. – *Elatine hydropiperoides* Dorof. et Wieliczk. – *Chenopodium rubrum* L. – *Selaginella reticulata* Dorof. et Wieliczk.
				NAP – *Betula – Pinus*	*Selaginella selaginoides* (L.) Link – *S. helvetica (*L.) Spring. – *S. borysthenica* Dorof. et Wieliczk. – *Salvinia* cf. *tuberculata* P.Nikit. – *Azolla pseudopinnata* P.Nikit. – *Carex* sp. – *Caulinia palaeotenuissima* Dorof.
			KHOLMECH	*Quercus – Castanea – Betula – Tilia – Fraxinus*	Salvinia glabra P.Nikit. – *Azolla pseudopinnata* P.Nikit. – *Typha aspera* Dorof. – *Potamogeton longistylus* Dorof. – *Najas major* All. – *Caulinia palaeotenuissima* Dorof. etc.; *Caulinia palaeotenuissima* Dorof. – *Scirpus pliocenicus* Szafer – *Ludwigia* sp.; *Salvinia tuberculata* P.Nikit. – *Typha aspera* Dorof. – *Najas marina* L. – *Decodon bashkiricus* Dorof — *Brasenia tanaitica* Dorof. + *B.tuberculata* C. et E.M.Reid
	LOWER			*Pinus – Sequoia – Quercus – Betula*	*Salvinia glabra* P.Nikit. – *Azolla pseudopinnata* P.Nikit. – *Decodon bashkiricus* Dorof. – *Lycopus pliocenicus* Dorof. – *Ludwigia* sp. – *Typha pseudoovata* Dorof. – *Selaginella reticulata* Dorof. et Wieliczk.; *Salvinia* cf. *petri* Dorof. – *Azolla pseudopinnata* P.Nikit. var. *elegans* Dorof. – *Hartziell*a sp. – Taxodiaceae gen.; *Salvinia* cf. *petri* Dorof. – *Pilularia pliocenica* Dorof. – *Dulichium vespiforme* C. et E.M.Reid

II and III studied by Stuchlik (1987, 1994). A correspondence of the fossil flora of the Dvorets horizon with that of the Pretiglian and Tiglian of Western Europe may also be made, according to the palaeocarpological and palaeomagnetic investigations.

Thus, the lithofacial featureses of the stratigraphical units of the Neogen deposits of Belarus and the Polish Lowland, and their correlation on the basis of palaeobotanical data, reveal great similarities in the development of these territories during the Miocene and Pliocene.

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