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## STRATIGRAPHICAL AND FACIAL DISTRIBUTION OF FORAMINIFERA IN MIOCENE DEPOSITS OF THE WESTERN PART OF UKRAINIAN SSR

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Стратиграфическое и фаціальное распределение фораминифер  
в миоценовых отложениях западных областей УССР

**Abstract.** In this paper, the author presents the detailed stratigraphy of the Fore-Carpathian Miocene deposits and compares them with analogous sediments of the Trans-Carpathians and the Volyno-Podolian margin of the Russian Platform. On the basis of micropalaeontological data several key zones are distinguished, among which planktonic Foraminifera zones are of particular importance. The following foraminiferal zones are distinguished: 1) Chattian-Aquitainian — the small *Globigerina*, *Chilogümbelina* and *Bolivina* zone and the siliceous microfauna zone; 2) Burdigalian — the *Globoquadrina dehiscens* zone and *Porosononion insignis* zone; 3) Helvetian — the *Globigerina bollii* zone and the *Quinqueloculina distorta* zone; 4) Lower Tortonian — the *Candorbulina universa* zone and the *Uvigerina asperula* zone; 5) Upper Tortonian — the *Radiolaria* zone, the *Globigerina bulloides* and *Spirialis* zone, the *Bogdanowiczia pocutica* zone, the *Cassidulina crista* zone and the *Streblus galicianus* zone; 6) Sarmatian — the *Cibicides badenensis* zone and the *Quinqueloculina reussi* zone.

Paleontological analysis has revealed some variations in the salinity of waters in the Miocene basin. Hypersaline conditions seem to have existed during the Chattian-Aquitainian and the Tortonian in facies of the Tyrassa and Tereblya suites.

On the other hand, the Helvetian Berez hany Beds, Tortonian Ervilia Beds and Sarmatian Dashava suite were deposited in an environment of reduced salinity.

Miocene deposits are widely developed within the western part of the USSR. Their most complete sections occur in the Fore-Carpathian depression, where the stratigraphic distribution of the Foraminifera permits distinction of well defined, microfauna key zones. These are as follows: the small *Globigerina*, *Chilogümbelina* and *Bolivina* zone in the Chattian-Aquitainian Beds of the Polanitsa suite and the Lower Vorotyshcha sub-suite and the siliceous microfauna zone in the Upper Vorotyshcha sub-suite; the *Globoquadrina dehiscens* and the *Porosononion insigne* zones in the Burdigalian Stebnik suite; the *Globigerina bollii* and the *Quinqueloculina distorta* zones in the Helvetian Balich Beds; the *Candorbulina universa* and the *Uvigerina asperula* zones in the Lower Tortonian Bogorodchany suite; the *Radiolaria*, the *Globigerina*

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*bulloides* and *Spirialis*, the *Bogdanowiczia pocutica*, the *Cassidulina crista* and the *Streblus galicianus* zones in the Upper Tortonian Kossov suite; the *Cibicides badenensis* and the *Quinqueloculina reussi* zones in the Lower Sarmatian Dashava suite (V. S. Burov and oth. 1966).

Among the distinguished zones those established on the basis of planktonic Foraminifera are of special importance as each of them corresponds to a new sedimentary cycle in the Oligocene-Miocene marine basin, connected with a new transgression and reflects a sequential changes of microfauna with time.

The distinction of these zones permitted presentation of a more detailed correlation of the Miocene sequence in various parts of the Fore-Carpathian depression, and also a new approach to some stratigraphic problems of the Trans-Carpathians and Volyno-Podolian margin of the Russian platform. These zones are used for correlation of the sediments examined with the coeval deposits of the Paratethys. (Alexandrowicz S., 1961, Baldi T., 1958; Bieda F., 1951; Buday T., Cicha I., 1965; Cita M. B., 1960; Drooger C. W., 1964; Friedberg W., 1939; Łuczowska E., 1964; Ney R., 1968; Trashliew S., 1964; Voicu Sh., 1953).

The Upper Oligocene-Miocene microfauna assemblages of the western districts of the Ukr. SSR have much more in common with those of the western Europe than with those of the Euxino-Caspian province. For this reason the western European scheme of stratigraphic subdivision is applied here. Nevertheless, the range of the stages is considered differently, new data from regions adjacent to the typical Miocene areas in the Paratethys being taken into account.

Palaeontological analysis provided evidence of hypersaline, marine conditions for the Polanitsa and Vorotyshcha suites of Chattian-Aquitania age. In Burdigalian, Helvetian and Tortonian times, a normal salinity and normal temperature and gas regime seems to have existed in the basin on the other hand, some periods were marked by reduced salinity (the fresh water Helvetian Berezhany Beds and Tortonian Ervilia Beds on the Volyno-Podolian margin of the Russian Platform) or by increased salinity (the Tyrassa suite in the Fore-Carpathians and the Tereblya suite in the Trans-Carpathians, both of which are saliferous). In the Sarmatian sediments, numerous indices of brackish character of the basin are observed.

#### CHATTIAN — AQUITANIAN

The Polanitsa suite, up to 400 m thick, consists of grey carbonaceous sandstones, argillites and clays, with conglomerates at the base. The Polanitsa sediments overly the Oligocene Menilite suite. They are developed mainly in the Fore-Carpathian depression and in the Skole unit of the Eastern Carpathians. In the Trans-Carpathians and on the Volyno-Podolian, the equivalents of the Polanitsa Beds are lacking.

The Polanitsa suite contains the following considerably diversified Foraminifera:

*Siphonodosaria* aff. *exilis* (Neugeb.), *S. inexculta* Subb., *S. stricticollum* Subb., *Valvulineria ignorabilis* Subb., *Gyroidina marina* Pishv., *Eponides binominatus* Subb., *E. octocameratus* Subb., *Alabama typica* Subb., *Cibicides borislavensis* Ais., *C. sigmoidalis* Subb., *Nonion postgraniferum* Subb., *Florilus vitriumbonatus* Subb., *Melonis praevious* Subb., *Globigerina pseudoedita* Subb., *Subbotina*

Table 1

Miocene deposits of the western districts of the UkrSSR

Age	Fore-Carpathians	Trans-Carpathians	Volyno-Podolian margin of the Russian platform	Microfaunal zone	
Sarmatian	Dashava suite	Almash Beds	Bessarabia Beds	Porosonion subgranosum	
		Lukov Beds	Listvin Beds	Quinqueloculina reussi	
		Dorobratov Beds	Zalesk Beds	Cibicides badenensis	
		Kovalev Beds	Buglov Beds	Streblus galicianus	
Upper Tortonian	Kossov suite	Kolomya Beds:		Cassidulina crista	
		Prut Beds	Kleparov Beds	Agglutinated Foraminifera	
	Verbovets Beds	Teresva suite		Bogdanowiczia potica	
				Globigerina bulloides and Spiralis	
Lower Tortonian	Tyrassa suite	Tereblya suite		Radiolaria	
	Bogorodchany suite		Tyrassa suite		
			Ervilla Beds		Uvigerina asperula
			Nikolaev Beds		Candorbulina universa
Helvetian	Balich suite		Baranov Beds		
			Berezhany Beds	Quinqueloculina distorta	
Burdigalian	Stebnik suite		Magoryany / Oncophora / Beds	Globigerina bollii	
		Dobrotov suite		Porosonion insignis	
		Sloboda suite		Globoquadrina dehiscens	
Chattian-Aquitanian	Polanitsa suite	Upper subsuite Zagorsk congl.		siliceous microfauna	
		Lower subsuite		small Globigerina, Chilo-gümbelina and Bolivina	

*trilocularis* (d'Orb.), *Globigerinella evoluta* Subb., *G. praemicra* Subb., *Cassigerinella globolocula* L. Ivanova, *Catapsydrax venzoi* Borsetti, *Globorotalia tetracamerata* Subb., *G. brevispira* (Subb.), *G. denseconnexa* Subb., *Globoquadrina* aff. *rohri* (Bolli), *Acarinina inaequiconica* Subb., *Streblus alius* Subb., *Buliminella rara* Pishv., *Baggatella divulgata* Subb., *B. altiuscula* Subb., *Caucasina tenebricosa* Pishv., *Uvigerinella hybridica* Subb., *Cassidulina convexilocula* Subb., *Bolivina dentelata* Subb., *B. spathulata* Williamson, *B. subdilata* Pishv., *B. hebis* Macfadyen, *B. angusta* Pishv., *B. cognata* Subb., *B. aenariensiformis* Miatluk, *Bolivinita cuneolus* Subb., *Chilogümbelina gracillima* (Andreae), *Ch. plana* L. Ivanova, *Ch. pseudostriata* L. Ivanova.

In addition to Foraminifera, siliceous sponges of the Lithistida group occur. Molluscs are not found, except for the rare *Spirialis* in the lowermost part of the suite.

The foraminiferal assemblage of the Polanitsa suite is characterized by an abundance of species and by numerous specimens of very small dimensions. Planktonic species are most characteristic and frequent. Both the microfaunal assemblage and the lithological features of the Polanitsa suite are very similar to those of the overlying Lower Vorotyshcha sub-suite.

The Vorotyshcha suite is also developed in the Fore-Carpathians and in the Skole unit in the eastern Carpathians. In the Trans-Carpathians, the saliferous Negrov suite seems to correspond to it. The Vorotyshcha suite is subdivided into the Lower and Upper Vorotyshcha sub-suites.

The Lower Vorotyshcha sub-suite, which is locally replaced by the Polanitsa suite, consists of grey, gypsum-bearing clays and of sandstones. The thickness of the sub-suite amounts to 300 m. Molluscs have not been found in it. The foraminiferal assemblage consists of the following forms:

*Ammodiscus tenuiculus* Subb., *Spiroplectamina angustilocula* Subb., *Nodosaria* sp., *Frondicularia* sp., *Gyroidina marina* Pishv., *Eponides binominatus* Subb., *E. alabaminaeformis* Subb., *Alabama typica* Subb., *Asterigerina planorbis* (d'Orb.), *A. falcilocularis* Subb., *Cibicides borislavensis* Ais., *C. sigmoidalis* Subb., *Nonion postgraniferum* Summ., *Florilus* aff. *boueanus* (d'Orb.), *Melonis praevious* Subb., *Globigerina pseudoedita* Subb., *Subbotina trilocularis* (d'Orb.), *Globigerinella evoluta* Subb., *G. praemicra* Subb., *Cassigerinella globolocula* L. Ivanova, *Globorotalia tetracamerata* Subb., *G. brevispira* (Subb.), *G. hexacamerata* Subb., *G. denseconnexa* Subb., *Globoquadrina* aff. *rohri* (Bolli), *Acarinina inaequiconica* Subb., *Streblus alius* Subb., *Buliminella rara* Pishv., *B. elegantissima* (d'Orb.), *Baggatella divulgata* Subb., *B. altiuscula* Subb., *Reussella regularis* Subb., *Caucasina tenebricosa* Pishv., *Uvigerinella hybridica* Subb., *Cassidulina globosa* Hantken, *Cassidulina subglobosa* Brady, *Bolivina subdilata* Pishv., *B. aff. arta* Macfadyen, *B. aenariensiformis* Miatluk, *B. angusta* Pishv., *B. scalprata* (Schwager), *Bolivina cuncolus* Subb., *Chilogümbelina gracillima* (Andreae), *Ch. plana* L. Ivanova, *Gümbelitra* sp. Moreover sponges of the Lithistida group are present.

Close similarity between the Polanitsa and Lower Vorotyshcha Foraminifera assemblages permitted the distinction of a common foramini-

feral zone of small *Bolivina*, *Globigerina* and *Chilogümbelina* (Subbotina 1960). This common foraminiferal assemblage is as follows: *Eponides octocameratus* Subb., *Alabamina typica* Subb., *Cibicides borislavensis* Ais., *Globigerina pseudoedita* Subb., *Subbotina trilocularis* (d'Orb.), *Globoquadrina* aff. *rohri* (Bolli), *Globigerinella evoluta* Subb., *G. praemicra* Subb., *Cassigerinella globolocula* Ivanova, *Globorotalia brevispira* (Subb.), *Baggatella altiuscula* Subb., *Caucasina tenebricosa* Pishv., *Trifarina* sp., *Bolivina aenariensisformis* Miatl., *B. subdilata* Pish., *Chilogümbelina cubensis* (Palm.), *Ch. gracillima* Andreae.

A striking development of this fauna is observed within Polanitsa and the first half of Lower Vorotyshcha time, while its gradual disappearance begins in the second half of Lower Vorotyshcha time and in Upper Vorotyshcha time. This extinction seems to be associated with increasing salinity of the basin, preceding a new sedimentation cycle.

The Polanitsa suite and the Lower Vorotyshcha subsuite contain an oligohaline microfauna assemblage, which is characterized by small tests and by the abundance of *Globigerina*, *Chilogümbelina*, *Bolivina* and *Cibicides* with a fine wall. The occurrence of numerous specimens of *Chilogümbelina cubensis* Palmer, *Ch. gracillima* Andreae, *Cassigerinella globolocula* L. Ivanova indicates the Oligocene age of these beds (Vialov, Pishvanova 1959).

The Upper Vorotyshcha sub-suite, like the Lower Vorotyshcha one, is represented by grey brecciated clays, with intercalations of light grey sandstones. In contrast with the Lower Vorotyshcha sub-suite, it is without carbonate rocks and contains intercalations of conglomerates (Zagorsk conglomerates) and lenses of potassium and sodium salts. The brecciated, saliferous clays of this sub-suite contain numerous fragments of siliceous sponge spicules and Radiolaria, arenaceous Foraminifera and rare small, calcareous Foraminifera of the Polanitsa-Vorotyshcha type. A microfaunal assemblage of this type allows the siliceous microfauna zone (Subbotina, 1960) to be distinguished within the Upper Vorotyshcha sub-suite.

In some sections, it is impossible to distinguish the Upper Vorotyshcha sub-suite from the Lower Vorotyshcha one. Thus, for both those sub-suites, as well as for the Polanitsa suite the same age (Chattian-Aquitania) is accepted. The thickness of the Upper Vorotyshcha sub-suite is more than 1000 m.

The microfaunal assemblage of the Upper Vorotyshcha sub-suite consists of the following forms:

*Rhabdammina exilis* Miatluk, *Proteonina bucculenta* Subb., *Glomospira charoides* (Parker et Jones), *G. gordialis* (Parker et Jones), *G. pileolus* Subb., *Ammodiscus aequispiralis* Subb., *Spiroplectammina* aff. *spectabilis* (Grzyb.), *Arenobulimina tertiaria* Subb., *Nodosaria* sp., *Lagena* cf. *striata* d'Orb., *Dentalina* sp., *Cristellaria* sp., *Eponides binominatus* Subb., *E. umbonatus* (Reuss), *E. octocameratus* Subb., *Asterigerina* aff. *planorbis* d'Orb., *Cibicides borislavensis* Ais., *C. sigmoidalis* Subb., *C. pygmeus* (Hantken), *Florilus* ex gr. *boueanus* (d'Orb.), *Globigerina pseudoedita* Subb., *Globigerinella praemicra* Subb., *G. evoluta* Subb., *Globorotalia hexacamerata* Subb., *G. brevispira* (Subb.), *G. denseconnexa* Subb., *Globoquadrina* sp., *Streblus* sp., *Elphidium* sp., *Hopkinsina* sp., *Cassidulina margareta* Karrer., *C. punctata* Reuss, *Bolivina subdilata*

Pish., *B. fastigia* C u s h., *Chilogümbelina* aff. *globifera* (R e u s s), *Ch. pseudostrata* L. I v a n o v a, *Ch. plana* L. I v a n o v a. Moreover, numerous Radiolaria occur: *Cenosphaera semisphaerica* S u b b., *Xiphostylus* sp., *Spongiomma* sp., *Cenellipsis* aff. *elliptica* L i p m a n, *Cyrtocalpis saccula* S u b b., *Dictyocephalus* sp., *Dicolocapsa pupoides* S u b b., *D. bicamerata* S u b b., *D. piriformis* S u b b., *Dictyomitra cellulata* S u b b., *D. ex gr. striata* L i p m a n, *Lithomitra turriiformis* S u b b.

The presence of the above microfaunal assemblage in the saliferous sediments of the Upper Vorotyshcha sub-suite may be explained by the supposition that the calcareous Foraminifera tests were dissolved in the hypersaline waters while the siliceous and arenaceous ones had been well preserved. The sponge spicules in the Fore-Carpathian depression may be considered as a characteristic index of saliferous sediments.

#### BURDIGALIAN

The Sloboda suite consists of coarse conglomerates. The suite unconformably overlies the Palaeogene flysch deposits, indicating that the folding phase preceded accumulation of the conglomerates mentioned above.

The sandy-argillaceous Dobrotov suite overlies the Sloboda Beds. It is linked by gradual transition with the underlying Sloboda and overlying Stebnik suites. The Dobrotov suite is represented by a flyschoid alternation of sandstones, argillites, marls and grits. The occurrence of ripple marks, distinct hieroglyphs, numerous bird traces, artiodactyl and other animal footprints indicates the proximity of a shore line. In the microfauna, rare *Eponides umbonatus* (d' O r b.), *Globorotalia mayeri* C u s h m a n e t E l l i s., *Porosononion insignis* P i s h v., *Streblus pseudobeccarii* P u t r j a and *Cassidulina margareta* K a r r e r were found.

The Sloboda and the Dobrotov suites are easy to distinguish lithologically from the upper Vorotyshcha sub-suite and Zagorsk conglomerates; they are tentatively assigned to the Burdigalian stage.

The Stebnik suite consists of variegated (pink, brown, grey and greenish) clay marls, alternating with grey, occasionally reddish, cross-bedded sandstones. They are up to 2500 m. thick. In the area between the Tysmenitsa and Viar rivers (north-western Fore-Carpathians), a layer of exotic conglomerate, equivalent to the Dubnik conglomerate of Poland, occurs at the base of this suite. In the Nadvorna region (south-eastern Fore-Carpathians), sandstones and clays of this suite contain desiccation cracks, ripple marks, and the foot imprints of birds. In the upper part of the Stebnik suite within the Bogorodchany region, a horizon of Sadzava sandstones occurs. Elsewhere (Kalush, Drohobych, Utoropy) the saliferous series is developed at the top of this suite. It should be noted here, that some geologists place this saliferous series in the middle of the Stebnik suite as the Kalush Beds or assign it to the Upper Vorotyshcha sub-suite (S u b b o t i n a 1960). In some sections, the upper part of the Stebnik suite contains some grey tuff intercalations, 10—30 m. thick.

Numerous, typically Miocene Foraminifera appear in the variegated clay marls and sandstones of the Stebnik Beds. Molluscs are not found in them. The microfauna assemblage consists of the following forms:

*Rhabdammina* sp., *Hyperammia* sp., *Glomospira charoides* (Parker et Jones), *Spiroplectammia minuscula* Pishv., *Pyrgo affinis* (d'Orb.), *Lagena vulgaris* d'Orb., *Cristellaria* ex gr. *initata* (d'Orb.), *Siphonodosaria elegantissima* Miatluk, *Glandulina laevigata* d'Orb., *Asterigerina* aff. *planorbis* (d'Orb.), *Gyroidina marina* Pishv., *G. soldanii* d'Orb., *Eponides umbonatus* (Reuss), *E. nanus* (Reuss), *E. octocameratus* Subb., *E. binominatus* Subb., *Cancris brongniarti* d'Orb., *Siphonina reticulata* (Czjzek), *Cibicides ungerianus* (d'Orb.), *Cibicides boueanus* (d'Orb.), *C. borislavensis* Ais., *Nonion tumidulus* Pishv., *Porosonion insigne* Pishv., *Melonis soldanii* (d'Orb.), *Pullenia bulloides* (d'Orb.), *Florilus boueanus* (d'Orb.), *Globigerina altispira* (Cush. et Jarv.), *G. bulloides* d'Orb., *G. pseudoedita* Subb., *Subbotina woodi connecta* (Jenkins), *Globigerinella praemicra* Subb., *G. evoluta* Subb., *Globigerinoides trilobus* (Reuss), *Globoquadrina langhiana* Cita et Gelati, *G. quadraria* (Cush. et Ellisor), *G. dehiscens* (Chap., Parr et Coll.), *G. proxima* (Pishv.), *Globorotalia hexacamerata* Subb., *G. brevispira* (Subb.), *G. tetracamerata* Subb., *G. mayeri* Cush. et Ellis., *G. denseconnexa* Subb., *G. eximia* Pishv., *Streblus eobeccarii* Putrja, *Elphidium macellum* (Fich. et Moll), *E. stebnicaensis* Pish., *Buliminella rara* Pishv., *Virgulina schreibersiana* Czjzek, *Bulimina elongata* d'Orb., *Virgulina conspicua* Pishv., *Caucasina tenebricosa* Pishv., *Uvigerina bononiensis* Forn., *Cassidulina punctata* Reuss, *C. subglobosa* Brady, *Bolivina subdilata* Pishv., *B. miocaenica* (Macfadyen), *B. fastigia* Cush., *B. punctata* Reuss, *B. floridana* Cush.

In some sections of the suite (at Novitsa village), *Lepidocyclina* and *Miogypsina* were found in the upper part. Moreover, in numerous sections of this suite, sponge spicules, spines of echinoderms and charophytes occur.

The distribution of microfauna within the thick Stebnik series is uneven. In its lower part, some small Foraminifera of Vorotyshcha type and sponge spicules are present. The upper part of the Stebnik suite is characterized by a more abundant microfaunal assemblage; in approximately the middle part of the suite accumulations of ostracods, charophytes and disc-shaped forms are observed.

The *Porosonion insigne* zone is developed in the upper part of the Stebnik suite (the Sadzava sandstones). In this zone, the characteristic Stebnik Foraminifera are present, associated with the ostracod *Loxconcha dromax* Livalent and rare charophytes. They are represented by the following forms: *Siphonina reticulata* Czjzek, *Cibicides ungerianus* (d'Orb.), *Florilus boueanus* (d'Orb.), *Melonis soldanii* (d'Orb.), *Porosonion insigne* Pishv., *Globigerina bulloides* d'Orb., *Globoquadrina dehiscens* (Chap., Parr et Coll.), *Streblus pseudobeccarii* Putrja, *Elphidium stebnicaense* Pishv., *Caucasina tenebricosa* Pishv.

The above foraminiferal assemblage as a whole and *Lepidocyclina* in particular indicate a Miocene, most probably Lower Miocene (Burdigalian) age of the suite. The Miocene Foraminifera in the Stebnik sediments are accompanied by redeposited Cretaceous and Eocene forms. There are: *Rhabdammina lineariformis* Miatluk, *Globigerinoides conglobatus* Brady, *Hantkenina alabamensis* Cush., *Globo truncana* sp. and *Rotalia lithotamnica* Uhlig.

The appearance and development of the planktonic form *Globoqua-*

*drina dehiscens* in the Stebnik suite permits correlation of this suite with the Burdigalian *Globoquadrina dehiscens* zone in Italy (Pishvanova 1965).

The Burkalo suite in the Trans-Carpathians is referred to the Burdigalian. The microfaunal assemblage of this suite differs from that of the Stebnik one in the presence of numerous representatives of the Lagenidae and Buliminidae families. The following forms were found in the Burkalo deposits: *Haplophragmoides* aff. *rotundidorsatum* Hantk., *Spiroplectamina carinata* (d'Orb.), *Clavulina communis* d'Orb., *Robulus cultratus* (d'Orb.), *R. inornatus* (d'Orb.), *Marginulina subbullata* Hantk., *Nodosaria pyrula* d'Orb., *N. aff. budensis* Hantk., *N. longiscata* d'Orb., *Dentalina pauperata* d'Orb., *Quinqueloculina* aff. *carinata* d'Orb., *Bulimina inflata* Seg., *Florilus boueanus* (d'Orb.), *Globigerina* sp. This assemblage is very similar to that of the Lower Tortonian Korytnica clays in Poland. It is supposed that the Burkalo suite, being an equivalent of the Korytnica clays, should be assigned to Lower Tortonian.

#### HELVETIAN

The Balich suite differs from the Stebnik one in grey and green colouration of rocks, mostly coarse-grained sandstones, conglomerates and tuffs. It is up to 1600 m. thick. The Balich suite is developed in the Fore-Carpathian trough. It is coeval with the Tereshul conglomerates in the Trans-Carpathians and with the Nagoryany (Oncophorian) and Berezhany fresh-water beds of the Volyno-Podolian margin of the Russian platform.

The Balich microfaunal assemblage includes numerous species, common to the Stebnik suite. These are *Cibicides ungerianus* (d'Orb.), *Nonion tumidulus* Pishv., *Melonis soldanii* (d'Orb.), *Globigerinoides trilobus* (Reuss), *Subbotina woodi connecta* (Jenkins), *Globorotalia brevispira* (Subb.), *Globoquadrina dehiscens* (Chap., Parr et Coll.), *Streblus pseudobeccarii* Putrja, *Elphidium stebnicaensis* Pishv., *Bolivina miocaenica* Macf. Numerous, redeposited Cretaceous Foraminifera and Radiolaria are also present. The forms mentioned above, are accompanied by abundant *Globigerina bollii* Cita et Gelati, occurring in the lower part of the Balich suite, and *Quinqueloculina distorta* Pishv., *Q. mayerina* d'Orb., *Q. ovula* Karrer, Gastropoda and Ostracoda in its upper part. These assemblages are distinguished as the *Globigerina bollii* and the *Quinqueloculina distorta* zones.

The *Globigerina bollii* zone, besides numerous specimens of the zonal index form, contains such species as *Globigerinoides bisphaerica* Todd, *Globorotalia scitula* Brady, *G. mayeri* Cush. et Ellis., *Cibicides ungerianus* (d'Orb.), *Cassidulina crassa* d'Orb. This zone was first established in beds of the middle part of the Langhiano in Italy, which resembles the lower part of the Fore-Carpathian Balich suite.

The salinity of the Fore-Carpathian basin decreased at the end of the Helvetian cycle of sedimentation. This phase is marked by the oligohaline *Quinqueloculina distorta* zone. Extensive development of abundant Miliolidae and the presence of Gastropoda and Charophyta in the upper part of the Balich suite confirm the supposition about a change in the salinity of the sea water at that time.



The Nagoryany Beds in the Trans-Carpathians consist of grey to brownish sandstones, unconformably overlying grey limestones of Turonian age. The Nagoryany Beds are only 0,12—0,15 m. thick. In these beds, a poor assemblage of Foraminifera was found corresponding to normal salinity environment. It consists of the following forms: *Triloculina gibba* d'Orb., *Florilus boueanus* (d'Orb.), *Elphidium fichtelianum* (d'Orb.), *Discorbis obtusus* (d'Orb.), *Rosalina viennensis* d'Orb., *Cibicides bogdanovi* Ser., *Cibicides lobatulus* (Walk et Jacob), *Globigerina bulloides* d'Orb., *Globigerinoides trilobus* (Reuss), *Globorotalia mayeri* Cush. et Ellis., *Streblus eobeccarii* Putrja.

The Berezhaný Beds are represented by grey, marly limestones, 6—8 m thick, containing abundant Charophyta, Ostracoda and Gastropoda. Scarce *Florilus boueanus* (d'Orb.), *Discorbis obtusus* (d'Orb.), *Cibicides bogdanovi* Ser., *Rosalina viennensis* d'Orb. are found in these beds.

#### LOWER TORTONIAN

Lower Tortonian sediments are represented by the Bogorodchany suite in the Fore-Carpathians, the Novoselitsa suite in the Trans-Carpathians and the Baranov, Nikolaev and Ervilia Beds, within the Volyno-Podolian margin of the Russian Platform.

Within the entire folded Carpathian area, the Lower Tortonian sediments rest unconformably on the Burdigalian and Helvetian deposits, but mainly on the Palaeogene, Cretaceous, Jurassic and Palaeozoic formations. They begin a new, Middle Miocene sedimentary cycle, which was accompanied by volcanism and the formation of thick key horizons of tuffs (Novoselits — Danilov tuffs in the Fore-Carpathians, Dej tuff in Rumania).

The well known *Candorbulina universa* zone is associated with the beginning of this cycle. It was established in the Fore-Carpathians and later observed in the Lower Tortonian Beds of the Trans-Carpathians and Volyno-Podolian, as well as in Roumania, Poland, Hungary, Bulgaria, Syria, Italy, Albania, New Zealand and Australia.

In the western territory of the USSR, the *Candorbulina universa* zone is best developed in the Bogorodchany suite, where it corresponds to the lower marl-tuff member of the suite. The *Uvigerina asperula* zone is distinguished in the upper sandy-argillaceous member of the suite.

The lower part of the suite, i.e. the *Candorbulina universa* zone, consists of grey-whitish tuffs, alternating with grey-greenish marls and occasionally with argillites and sandstones. These sediments contain Foraminifera of the Globigerinidae family in such abundance that to name them Globigerina marls would be appropriate. The most characteristic forms in this zone are: *Candorbulina universa* Jedl., *Biorbulina bilobata* (d'Orb.), *Beella opinata* (Pishv.), *Globigerinoides transitoria* Blow, *G. bisphaerica* Tood, *G. trilobus* (Reuss), *Globoquadrina altispira* (Cush. et Jarv.), *Globorotalia mayeri* Cush. et Ellis., *G. scitula* Brady, *Spiroloculina tenuissima* Reuss, *Cibicides ungerianus* (d'Orb.), *C. ungerianus ukrainica* Pishv., *Bulimina buchiana* d'Orb., *Pleurostomella alternans* Schwag., *Bolivina scalprata retiformis* Cushm., *Pseudoparella nova* Pishv.

Nearly all the species mentioned above are typical Lower Tortonian forms, which are not found in the overlying Upper Tortonian deposits, or occur there only as very rare specimens.

The *Candorbulina* zone is distinguished by the marl-tuff complex, characteristic planktonic Foraminifera assemblage and relatively small thickness (60—100 m).

Since this zone is observed, not only in the Soviet Carpathians, but also in the Middle Miocene deposits of many regions throughout the world, it may be called a global zone. It can be used for correlation with even very distant Middle Miocene deposits, containing tuffogenic rocks.

In the overlying *Uvigerina asperula* zone, the petrographic composition of rocks changes considerably. Clays become more sandy, numerous intercalations of sandstones appear. The upper part is marked by Lithothamnium limestones. The composition and distribution of Foraminifera in this part of the section differs somewhat from those in the *Candorbulina universa* zone. Such globigerinids as *Candorbulina universa* Jedl., *Globoquadrina altispira* (Cush. et Jarv.), *Biorbulina bilobata* (d'Orb.), *Globigerinoides transitoria* Blow, *G. bisphaerica* Todd still occur, but here they are rather rare. Moreover, numerous tests of *Nodosaria* sp., *Robulus* sp., *Spiroplectammia carinata* (d'Orb.), *Clavulina communis* (d'Orb.), *Bulimina inflata* Seq., *Uvigerina asperula* Czjzek, *Sphaeroidina bulloides* d'Orb. and *Cibicides ungerianus* (d'Orb.) appear.

In the Novoselitsa suite of the Trans-Carpathians, as in the Bogorodchany suite, two microfaunal zones are distinguished: the *Candorbulina universa* and the *Uvigerina asperula* zones with microfaunal assemblages analogous to those of the Fore-Carpathians (Petrashkevich, Pishvanova, 1968).

On the Volyno-Podolian margin, the Baranov Beds, which consist of sands, sandstones, marls and limestones, approximately 25 m. thick, contain *Pseudamussium corneum denudatum* Reuss, *Cardium baranovense* Hilb., *Amussium comitatum* F. As to the microfauna, *Triloculina gibba* d'Orb., *Lagena striata* d'Orb., *Dentalina elegans* d'Orb., *Cibicides lobatulus* (Walk et Jacob.), *C. ungerianus* (d'Orb.), *Florilus boueanus* (d'Orb.), *Gyroidina soldanii* (d'Orb.), *Nonion umbostelligerum* Ser., *Globigerinoides trilobus* (Reuss), *Candorbulina universa* Jedl., *Biorbulina bilobata* (d'Orb.), *Globorotalia mayeri* Cush. et Ellis. and *Ehrenbergina podolica* Wolsch. occur there.

In the Nikolaev Beds, represented by friable sandstones and marls, with abundant Bryozoa, Serpula and Heterostegina, the following microfaunal assemblage was found: *Globulina gibba* d'Orb., *Discorbis squamula* (Reuss), *Globigerinoides transitoria* Blow, *Amphistegina hauerina* d'Orb., *Heterostegina costata* d'Orb., *Heterostegina prae-costata* Papp et Küpper, *Uvigerina asperula* Czjzek, *Gypsina vesicularis* (Park. et Jones), *Elphidium fichtellianum* (d'Orb.).

*Candorbulina universa* occurs only occasionally here.

Among Foraminifera of the Baranov and the Nikolaev Beds *Lagenidae* and *Heterostegina* play an important role in addition to *Globigerina* (Pishvanova, 1963).

UPPER TORTONIAN

The earliest phase of Upper Tortonian sedimentation is the Tyrassa suite in the Fore-Carpathians and the Tereblya suite in the Trans-Carpathians.

The Tyrassa suite consists of anhydrite, gypsum and halite with clay intercalations: it overlies either Cretaceous beds or various Miocene deposits and the thickness reaches 200—250 m.

In the clays intercalated with evaporites, abundant Upper Tortonian Foraminifera were found: *Quinqueloculina akneriana* d'Orb., *Biloculina clypeata* d'Orb., *Spiroloculina canaliculata* d'Orb., *Cibicides lobatulus* (Walker et Jacob), *Melonis soldanii* (d'Orb.), *Globigerina bulloides* d'Orb., *Globorotalia mayeri* Cushm. et Ellis., *Bulimina elongata* d'Orb., *B. longa* (Vengl.), *Uvigerina semiornata* d'Orb., *Sphaeroidina austriaca* d'Orb. This microfauna is characteristic for the younger sediments of the overlying Kossov suite and indicates a gradual passage from the saliferous, lagoonal, Tyrassa sediments into the polyhaline Kossov Beds.

The Tereblya suite is represented by saliferous sediments with the clayey intercalations, containing rare, badly preserved *Quinqueloculina* sp., *Globorotalia mayeri* (Cush. et Ellis.), *Bulimina elongata* d'Orb., *B. subulata* (Cush. et Jarv.), *Bolivina dilatata* Reuss.

The overlying Kossov suite in the Fore-Carpathians is subdivided into the Verbovets, Prut, Kolomya and Kovalev Beds (from bottom to top). The foraminiferal assemblage of this suite as a whole differs considerably from that of the Lower Tortonian Bogorodchany suite in having Mediterranean characteristics. It is distinguished by diversification of various calcareous and arenaceous species and by the abundance of well preserved specimens. The arenaceous Foraminifera group with predominance of *Bogdanowiczia pocutica* Pishv., *Hyperammia granulosa* Vengl., *Haplophragmoides pinguis* Pishv., *Textularia subangulata* d'Orb. and *Cyclammia pleshakovi* Pishv., occurs abundantly only in the middle part of the Kossov suite. In the higher part of the section the arenaceous forms are represented by rare specimens and have no stratigraphical significance. Calcareous Foraminifera are characteristic for the whole Kossov suite. The representatives of Buliminidae, Rotaliidae and Cassidulinidae are well developed. The planktonic forms are well represented here, but they are completely different from those of the Lower Tortonian sediments. These are: *Globigerina bulloides* d'Orb., *G. globosa* Pishv., *G. paula* Pishv., *Subbotina cognata* Pishv., *Globigerinoides indigena* Łuczka. The most characteristic and frequent species of the calcareous Foraminifera are: *Valvulineria complanata* (d'Orb.), *V. marmaroschensis* Pishv., *Bulimina elongata* d'Orb., *B. ovata* d'Orb., *B. intonsa* (Liv.), *B. longa* (Vengl.), *Caucasina gutsulica* Liv., *Uvigerina semiornata* d'Orb., *U. perornata* Pishv., *Angulogerina angulosa* (Will.), *Cassidulina crista* Pishv., *Bolivina dilatata* Reuss, *Sphaeroidina austriaca* d'Orb., *Gyroidina soldanii* (d'Orb.), *Cibicides dutemplei* (d'Orb.), *C. incelebratus* Pishv., *Quinqueloculina akneriana* d'Orb., *Biloculina clypeata* d'Orb., *Melonis soldanii* (d'Orb.), *Florilus boueanus* (d'Orb.), *Reussella tortonica* Pishv., *Cibicides lobatulus* (Walk. et Jacob.), *Reussella spinulosa* (Will.), *Globorotalia* aff. *nepenthes*

(T o d d). They are accompanied by Radiolaria, Ostracoda and spines and test fragments of Echinodermata. The distribution of the Foraminifera in the Kossov suite is fairly regular, permitting the distinction of a series of microfaunistic zones. These are as follows (from bottom to top): the *Radiolaria* zone, the *Globigerina bulloides* and *Spirialis* zone, the *Bogdanowiczia pocutica* zone, the *Cassidulina crista* zone and the *Streblus galicianus* zone.

In the Verbovets Beds, two microfaunal zones, the *Radiolaria* zone and the *Globigerina bulloides* and *Spirialis* zone, are distinguished. These beds consist of grey clays, with thin intercalations of sandstones and tuffs. Tuff intercalations are developed, especially in the lower part of the beds. The presence of abundant pyrite and glauconite granules is also a characteristic feature of the Verbovets Beds. The microfaunal tests are often completely pyritised.

The first *Radiolaria* zone occurs at the base of the Verbovets Beds immediately above the Tyrassa suite. Numerous Radiolaria such as *Rhopalastrum* sp., *Euchitonia* sp., *Panartus* sp., *Cenosphaera* sp., are confined to the ash tuffs, which form the key horizon in the Upper Tortonian deposits of the Fore-Carpathians.

In the *Globigerina bulloides* and *Spirialis* zone, abundant tests of the zonal markers are accompanied by numerous planktonic Foraminifera, such as *Globigerina regularis* d'Orb., *G. paula* Pishv., *G. globosa* Pishv., *Subbotina cognata* (Pishv.), *Globigerinoides indigena* Luczk. Similar microfaunal assemblage is also found in the Trans-Carpathians in Roumania.

The overlying Prut Beds are represented by grey poorly arenaceous clays. They contain rich assemblages of both planktonic and benthonic arenaceous and calcareous Foraminifera. The arenaceous Foraminifera are: *Bogdanowiczia pocutica* Pishv., *Hyperammina granulosa* Vengl., *Haplophragmoides undosus* Pishv., *H. pinguis* Pishv., *H. planus* Pishv., *Cyclammina pleshakovi* Pishv. Among the calcareous Foraminifera, the families Discorbidae, Globigerinidae, Anomalinidae and Buliminidae are well represented. The abundance of tests of arenaceous Foraminifera and of *Bulimina elongata* d'Orb. permits the easy recognition of the Prut Beds and their separation from the sediments of other horizons. These beds are distinguished as *Bogdanowiczia pocutica* zone. In the Trans-Carpathians, this zone is recognized in the Teresva suite. On the Volyno-Podolian margin of the Russian platform, the Kleparov Beds correspond to the *Bogdanowiczia pocutica* zone (Pishvanova, 1963).

The overlying Kolomya Beds consist of clays, containing a little coarse-grained material. The elements of typical deep water euryhaline fauna begin to disappear in these beds. The arenaceous Foraminifera, which occurred below, disappear almost entirely, except for *Textularia subangulata* d'Orb. and *Cyclammina pleshakovi* Pishv. The Buliminidae are impoverished, while *Bulimina ovata* d'Orb., *Caucasina gutsulica* Liv., *C. lucera* Pishv. and various *Uvigerina* disappear. The representatives of the families Discorbidae and Globigerinidae are less diversified. Numerous test of *Cassidulina crista* in the Kolomya Beds allow them to be distinguished as the *Cassidulina crista* zone. This zone may be definitely traced in the lower part of the Vulkhovets suite in the Trans-Carpathians.

The Kovalev Beds are distinguished in the upper part of the

Kossov suite. They consist of sandstones, clays and conglomerate, with intercalations of carbonized plants. These beds contain a mixed foraminiferal assemblage, including oligohaline and polyhaline forms. These forms are: *Streblus galicianus* Putrja, *Porosononion granosum* (d'Orb.), *Nonion rotundum* Pishv., *Elphidium advenum* (Cushm.), *E. brevisculum* Putrja, *Discorbis imperator* (d'Orb.), *Bulimina subulata* (Cushm. et Park.), *B. intonsa* Liv. When compared with the fauna of the underlying beds, this assemblage is characterized by an absence of thick-walled, arenaceous tests, a sharp decrease in the number of Buliminidae and by almost complete disappearance of the planktonic Foraminifera. At the same time, a considerable enrichment of representatives of the genera *Streblus*, *Porosononion* and *Elphidium* is observed, indicating a significant reduction in the salinity of the basin. This reduction seems to have been caused by an increased influx of fresh water, which resulted in a change in the test structure of the fauna, their dimensions becoming smaller and the walls finer.

The Volyno-Podolian equivalent of the Kovalev Beds is the Buglov Beds, which contain following microfaunal assemblage: *Quinqueloculina akneriana* d'Orb., *Q. consobrina* (d'Orb.) var. *nitens* Reuss, *Q. longirosta* d'Orb. *Q. planicarinata* (Vengl.), *Q. seminulum* Linné, *Nodobaculariella buglovensis* Vengl., *N. costata* Vengl., *N. podolica* Didk., *Nummuloculina contraria* (d'Orb.), *Spiroloculina bidentata* Didk., *Globulina gibba* d'Orb., *Discorbis imperator* (d'Orb.), *Conorbina miocaenica* Krash., *Eponides haidingeri* (d'Orb.), *Nonion rotundum* Pishv., *Rotalia magnifica* Krash., *Streblus galicianus* Putrja, *Elphidium aculeatum* (d'Orb.), *E. advenum* Cushm., *E. angulatum* Egger, *E. antonium* (d'Orb.), *E. incertum* (Will.), *Bulimina aculeata* d'Orb. and *Reussella spinulosa* (Reuss); Ostracoda, Bryozoa and the spines of Echinodermata are also found. In the upper part of the Buglov Beds, such typical Sarmatian species as *Quinqueloculina sarmatica* Karrer, *Q. reussi* Bogd., *Articulina sarmatica* (Karrer) are occasionally present.

For both Kovalev and Buglov Beds the presence of abundant tests of *Streblus galicianus* is particularly important, since it forms the basis for their distinction as the *Streblus galicianus* zone. The same zone is recognized in the Beshikur suite of the Trans-Carpathians.

The above analysis of Foraminifera of the Fore-Carpathians Tortonian sediments and correlation of the microfaunal assemblages distinguished with the coeval West European sediments indicate, that Tortonian sedimentation displays a two-stage evolution, marked by two marine transgressions. The first of these took place in the Lower Tortonian, the second in the Upper Tortonian.

#### SARMATIAN

In the western parts of the Ukrainian SSR, Sarmatian deposits are represented by its lower division, while the middle part is not yet confirmed palaeontologically. In the Fore-Carpathians the Lower Sarmatian is distinguished as the Dashava suite. In the Trans-Carpathians, the Sarmatian sediments are represented by the Dorobratov, Lukov and Almash Beds. On the Volyno-Podolian margin of the Russian platform, the Zalesk, Listvinsk and Bessarabia Beds are developed.

On the basis of microfauna, the Dashava suite is subdivided into two parts, the lower corresponding to the *Cibicides badenensis* zone and the upper to the *Quinqueloculina reussi* zone. Both zones display the same lithological composition, but contain quite different microfaunal assemblages. They consist of grey and yellowish-grey clays, argillites with intercalations of grey and light grey tuffs, tuffites and sandstones, which overlie various horizons of the Kossov suite.

The microfaunal composition of the Dashava suite, when compared with that of the Tortonian Beds, is poorer in terms of both genera and species. Characteristically it consists of oligohaline Foraminifera.

The *Cibicides badenensis* zone is characterized by abundant specimens of the zonal index and of the accompanying species *Cibicides transcarpaticus* Pishv. and also by numerous *Quinqueloculina consobrina nitens* Reuss, *Articulina problema* Bogd., *Rotalia stellifera* Pishv., *Elphidium advenum* Cushman. This assemblage is marked by the almost complete disappearance of stenohaline Foraminifera of the Kossov suite typical for the basins of normal salinity. Significant impoverishment in genera and species seems to be connected with a reduction in the salinity of the basin more considerable than that at the end of the previous period.

The *Quinqueloculina reussi* zone contains numerous Miliolidae, among which following species should be mentioned: the zonal marker *Quinqueloculina reussi* Bogd., *Q. costata* Karrer, *Q. complanata* (Gerke et Issaeva), *Articulina sarmatica* Karrer, *A. problema* Bogd. Besides those forms, Nonionidae with *Porosonion subgranosum* (Egger) and Elphidiidae with *Elphidium reginum* (d'Orb.) and *E. obtusum* (d'Orb.) are present. Ostracoda and Algae (*Ovulites renata* Liv.) were also found. The Tortonian species are present too, but these are of minor importance.

In the Trans-Carpathians, the *Cibicides badenensis* zone is recognized in the Dorobratov Beds and the *Quinqueloculina reussi* zone in the Lukov Beds. The Sarmatian sequence of the Trans-Carpathians closes with the Almash suite, in which the *Porosonion subgranosum* zone is distinguished. In the *Cibicides badenensis* zone of the Trans-Carpathians, as well as of the Fore-Carpathians the Anomaliniidae, *Quinqueloculina*, *Articulina*, *Nodobaculariella*, *Elphidium* are developed. The presence of some Mediterranean elements of *Nodosaria*, *Globigerina*, *Bulimina*, *Caucasina* and *Bolivina* is characteristic for this zone. In the *Quinqueloculina reussi* zone, the Mediterranean elements are nearly absent altogether. The *Porosonion subgranosum* zone is characterized by various facies and diversified genera of Foraminifera. The abundance of the genus *Porosonion* is here associated with the development of the genera *Bolivina*, *Cassidulina*, *Buliminella*, coarser *Cornuspira*, *Hauerina*, *Articulina*, *Elphidium*, *Streblus*, *Rotalia*, numerous molluscs and Ostracoda.

On the Volyno-Podolian margin of the Russian platform, the Sarmatian deposits are developed as oolitic limestones and sandstones, containing numerous Foraminifera. The tests of *Quinqueloculina* occur in cores of calcareous oolites. The limestones contain the following Foraminifera: *Elphidium reginum* (d'Orb.), *Sarmatiella buglovensis* Vengl., *Cibicides lobatulus* (Walk. et Jacob), *C. badenensis* (d'Orb.), *Wiesnerella plana* Bogd., *Articulina problema* Bogd., *Quinqueloculina reussi* Bogd. In the sandy-argillaceous intercalation, *Quinqueloculina akneriana* d'Orb. var. *longa* (Gerke), *Cibicides* aff. *badenensis*

(d'Orb.), *Streblus beccarii* (Linné), *Elphidium angulatum* Egger, *E. listeri* (d'Orb.), *E. obtusum* (d'Orb.), *Porosononion subgranosum* (d'Orb.) are present.

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Table 1 — Miocene deposits of the western districts of the USSR after L. Pishvanova's data — is prepared by Mrs E. Łuczowska, Kraków (Editor's note).

Ukr. NIGRI, Lvov

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## РЕЗЮМЕ

Миоценовые отложения на территории западных областей Украины имеют очень широкое распространение. Наиболее полно их разрез представлен в Предкарпатском прогибе, где детальное изучение фораминифер и их стратиграфическое распределение позволило выявить и проследить несколько маркирующих микрофаунистических зон. Это следующие зоны: зона мелкорослых *Globigerina*, *Chiloguembelina* и *Bolivina* в хат-аквитанских осадках поляницкой и нижней воротыщенской свит и зона кремневых микроорганизмов в верхней воротыщенской свите; зоны *Globoquadrina dehiscens* и *Porosonion insignis* в стебникской свите бурдигала; зоны *Globigerina bollii* и *Quinqueloculina distorta* в баличской свите гельвета; зоны *Candorbulina universa* и *Uvigerina asperula* в богородчанской свите нижнего тортонa, зоны с радиоляриями, с *Globigerina bulloides* и *Spiralis*, *Bogdanowiczia pocutica*, *Cassidulina crista* и *Streblus galicianus* в косовской свите верхнего тортонa, и зоны с *Cibicides badenensis* и *Quinqueloculina reussi* в дашавской свите нижнего сармата.

Среди зон особое значение имеют планктонные зоны, каждая из которых соответствует новому этапу в жизни морского олигоцен-миоценового бассейна, связанного с новой морской трансгрессией, и отражает ряд резких смен комплексов микрофауны во времени.

Палеонтологический анализ позволил установить морские условия с признаками осолонения для поляницкой и воротыщенской свит хат-аквитана; в бурдигале, гельвете и тортоне бассейн был морской с нормальной соленостью, нормальной температурой и нормальным газовым режимом, временами опресняющийся (бережанские слои- гельвет- и эрвильевые- тортон- слои на Вольно Подольской окраине Русской платформы) или осолоняющийся (тереблянская в Закарпатье и тирасская в Предкарпатье соленосные свиты). В сармате наблюдается изменение солености бассейна в сторону опреснения.