

Biostratigraphy of Sarmatian Sediments from the Košická kotlina depression on the basis of Foraminifers

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Abstract. The article is dealing with distribution of foraminifers in the individual lithostratigraphical units of the Sarmatian from the Košická kotlina depression, their correlation with foraminifer biozones and taxonomy of forms typical of this stage. The results of study may be summarized as follows :

1. In the Upper Badenian there was lowering salinity and gradual shallowing of the sedimentation area. The Klčov Formation (Upper Badenian to lowermost Sarmatian) contains a marine and marine-brackish microfauna of the *Bulimina-Bolivina* and *Ammonia* biozones.

2. The Stretava Formation (Lower to Middle Sarmatian) is characterized by shallow-water brackish foraminifers (mainly of the genus *Elphidium*) belonging in microfauna to the *Elphidium reginum* and *Elphidium hauerinum* biozones. In the area under study, however, *E. hauerinum* (Orb.) appears untypically already in the Lower Sarmatian, indicating the possibility of stratigraphic limitation of this formation to the Lower Sarmatian. The molluscs in the Stretava Formation correspond to the microfaunistic Zone (Lower Sarmatian).

3. Kochanovce Formation (Middle to Upper Sarmatian) contains only freshwater ostracodes of the ostracode D₃ Zone from the original microfauna.

Key words: foraminifers, Sarmatian, Košická kotlina depression

Introduction

The goal of the article is to establish the composition and character of foraminifer associations in the individual lithostratigraphical units of the Sarmatian in the Košická kotlina depression, their correlation with foraminifer biozones and taxonomy of typical Sarmatian species.

Biozonation was based upon foraminifer zonation according to Grill (1941) in the Vienna Basin. The lithostratigraphical units are identical with the units worked out by Vass and Čverčko for the Sarmatian of the East Slovakian Lowland (1985).

The total number of microfaunistic samples, from which we set out in the work, varies around 250. Some samples contained, besides foraminifers, also ostracodes, Bryozoa and Dasycladaceae.

A particular part is devoted to the system of foraminifers typical of the Sarmatian. It includes synonyms, remarks, stratigraphic range, occurrence in the Košická kotlina depression and ecology of 16 foraminifer species belonging to 8 genera and 6 families. In this part the foraminifer system of Loeblich and Tappan (1988) was used. A part of this system is the table of

distribution of the individual foraminifer species in the Neogene of the East Slovakian Basin (Tab. 13) and photographic plates.

Delimitation of the Sarmatian stage

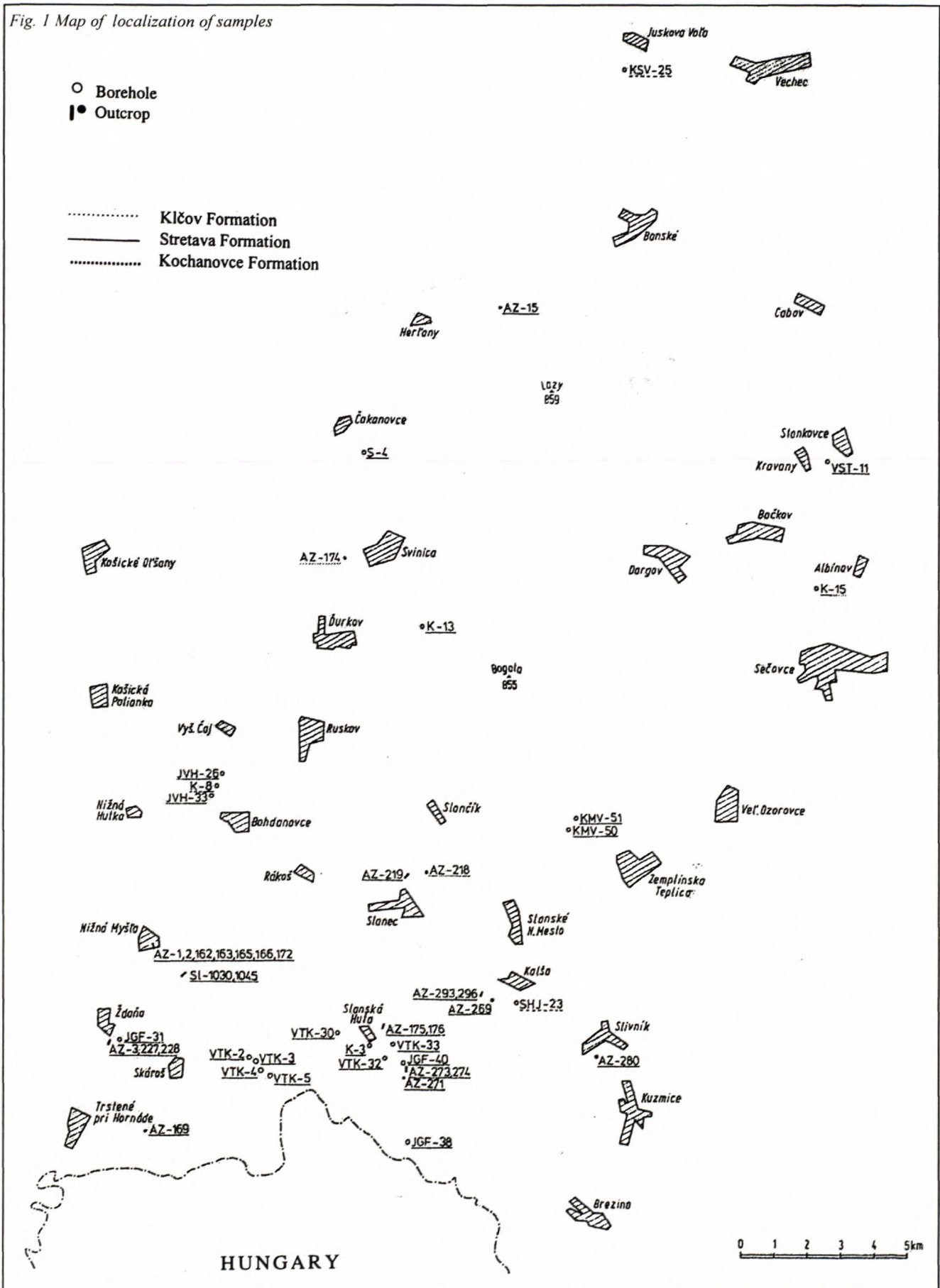
According to up to present knowledge we may establish the absolute age to 10-11 m.y. for the upper boundary and ± 14 m.y. for the lower boundary (Vass et al. 1974).

The denomination "Sarmatische Stufe" was published first by Suess in the year 1866. He designated so the beds, which are overlying the marine beds and underlying the Congeria Member, the latter were previously designated as the Cerithium Member (Ceritien-Schichten or Brakische Stufe) in the Vienna Basin.

Barbot de Margny (1867, 1869) mentioned under the denomination Sarmatian beds a similar brackish development in the Euxinian-Caspian region. Already originally a difference in the range of age of brackish beds in both regions was assumed. The range of age of the Sarmatian in the Vienna Basin is essentially less than the range of the Sarmatian in the Euxinian-Caspian region.

On the basis of the agreement of the Subcommission for Paratethys Stratigraphy at the "Committee of Medi-

Fig. 1 Map of localization of samples



terranean Neogene Stratigraphy" the question was solved provisionally in a way that "Suess Sarmatian" will be designated as s.s. whilst that of "Barbot" as s.l., the latter designation also includes the Volhynian, Bessarabian and Chersonian substages, established later (Simonescu, 1903, Papp-Marinescu-Seneš et al. 1974).

In the Eastern Paratethys where after the Sarmatian the Meotian stage follows, corresponding only to the uppermost Pannonian of the Central Paratethys, the Sarmatian is used in the sense of Barbot de Margny's definition.

The Sarmatian s.s. of Suess corresponds to the Volhynian and Lower Bessarabian, to the Sarmatian of the Central Paratethys (Tab.10).

The Upper Bessarabian, Chersonian and Meotian correspond in full extent to the Pannonian of the Central Paratethys.

The Sarmatian s.s. in the sense of Suess was divided on the basis of paleontological criteria in various ways in the Western Carpathians. Essential is in the first place the division of Grill (1941) according to foraminifers, of Papp (1954) according to molluscs and Jiříček (1972, 1983) according to ostracodes (Tab.10,11).

The lowermost Sarmatian is characterized in microfauna by brackish fauna with *Ammonia beccarii* (L.). In its higher part the so called lager elphidia appear, e.g. *Elphidium reginum* (Orb.), *E. aculeatum* (Orb.) (*Elphidium reginum* Zone, Grill, 1941).

The Middle Sarmatian belongs microfaunistically to the *Elphidium hauerinum* Zone (Grill, 1941).

The Upper Sarmatian belongs in microfauna to the *Nonion granosum* Zone (Grill, 1941) and is defined by the Pannonian base in the Central Paratethys. For the basal A Zone of the Pannonian s.s. onset of the foraminifer *Silicoplaentina hungarica* Koev. and onset of ostracode genera *Erpetocypris* and *Hungarocypris* and of the species *Hemicytheria loerentheyi* (Meh.) is characteristic.

The Sarmatian vertebrate fauna is of Miocene character. Only in the Pannonian younger elements of fauna occur as hipparions with developing autochthonous forms, for instance *Bunolophodon longirostris* (Kaup.) (Thenius, 1959).

The holostatotype of the Sarmatian is the locality Nexing in Lower Austria. As faciostratotype localities for the Sarmatian s.s. in the Western Carpathians of Slovakia were determined: Nižná Myšľa, Mochovce, Hontianska Vrbica and Močiar.

From the survey of up to present microbiostratigraphical investigations of the sarmatian in East

In the frame of the geological investigation of the Neogene in eastern Slovakia Bystrická (1954) evaluated

micropaleontologically several samples from the area east of the Slanské vrchy Mts. She found Lower Sarmatian sediments in the vicinity of the villages Veľaty, Byšta, Dvor Mária, Brezina (Kolbaš), Veľký Kazimír. In the upper part of the Lower Badenian she observed alternation of horizons of stenohaline fauna with brackish.

The Sarmatian with a typical brackish microassociation is mentioned by Bystrická (l.c.) from a brook near Kuzmice, from the right bank of the Olšava river, north of the village Olšovany, from the southern outskirts of Kalša, from the brook near Bohdanovce, from the brook Roňva between the farmstead Gender and the viaduct, west of Kuzmice, near Slivník and Slanská Huta, near the railway station in Slanec, east and northwest of the lake Izra.

From samples taken at the borehole Michaľany-1 from the depth of 140-283,7m Jendrejáková (1957) determined the Upper Badenian. At the profile of the borehole there is alternation of brackish and marine microfauna. With its comparison she has come to the conclusion that it mostly approaches foraminifer associations from the borehole near Veľaty.

The Sarmatian microfauna was studied by Bystrická (1959) from the vicinity of the villages Nižná Myšľa, Slanec, Nové Mesto Slančík, Skároš, Rákoš Trstené on Hornád, Kalša a Rankovce. According to predominating forms of foraminifers she delimited 5 types of associations.

Prokšová (1959, in Brodňan et al.(1959) evaluated micropaleontologically boreholes in the Podvihorlat coal basin. From the boreholes Hažín-1,2 and Blatné Revište-1 she determined the brackish Lower Sarmatian.

Sarmatian microfauna in eastern Slovakia was also dealt with by Kudláčková (1959, in Janáček, 1959).

Sarmatian sediments encountered in borehole Bočiar-1 were divided by Brestenská (1960), in Brestenská and Priečhodská, 1960) into 2 horizons: the lower - brackish and upper - freshwater horizons. From organic remnants in the freshwater Sarmatian root concretions and carbonized or pyritized remnants of plants are present only. Autochthonous foraminifers are absent. These 2 Sarmatian developments are distinguishable by heavy mineral associations (Priečhodská, 1960, in Brestenská and Priečhodská, 1960).

The beds of the Upper Badenian Bulimina-Bolivina Zone are overlain by a transgressively deposited brackish to freshwater formation, with was pursued by drillings near Sečovce, Albínov, between Sečovce and Michalovce and between Bidovce and Herľany. As to microfauna the formation was studied in detail mainly at the borehole Sečovce-1 by Zapletalová (1960). As it results from her investigations the 1 500m thick brackish Badenian formation is characterized by sedimentation in freshwater to brachyhaline environment with freshening

in overlying direction when sedimentation of the brackish Upper Badenian underlying the brackish Lower Sarmatian is terminated by beds with larger elphidia and Lower Sarmatian ostracodes.

Lower Sarmatian foraminifers of the zone of larger elphidia (*Elphidium reginum* Zone, Grill, 1941) from boreholes in the area of Belža, Trstené on Hornád, Nižná Myšľa, Ždaňa, Nižná Hutka and Nižný Čaj were investigated by Lehotayová (1960).

Cicha (1961) from microbiostratigraphical investigations near Brezina, Byšta, Veľký Kazimír, Michalany, Veľaty, Černocho, Veľká Trňa and in boreholes near Trebišov has not proved beds of the brackish Upper Badenian, transgressively overlying the Bulimina-Bolivina Zone in the Sečovce-Albínov area, on the general map sheet Trebišov.

Development of the brackish and freshwater Sarmatian in the East Slovakian Neogene region was studied by Cicha and Kheil (1962).

Microfaunistic analyses from borehole Klečenov -1, 2 were carried out by Zapletalová (1962).

From borehole R-16 (Ruskov, depth 50,6m) Gašparíková (1963) mentioned foraminifer associations of the highest part of the Lower Sarmatian, belonging in microfauna to the *Elphidium hauerinum* Zone (Grill, 1941).

In the frame of hydrogeological investigation of artesian aquifers in eastern Slovakia, in the area of Dargov-Zemplínska Teplica, micropaleontological analyses of drilling samples AV-1a and AV-2 were carried out. The sediments in the area of Zemplínska Teplica were assigned to the freshwater higher Sarmatian by Gašparíková (1964) on the basis of microassociations.

Biostratigraphy of the Sarmatian and Pannonian and the problem of their boundaries in eastern Slovakia were studied by Jiříček (1972).

A detailed study of foraminifers from lithostratigraphical units of the Sarmatian in the frame of regional geological investigation of the Košická kotlina depression and Slánske vrchy Mts. was performed by Zlinská (1984, 1986, 1987, 1988, 1989 a, b, 1990, 1990 a, 1991 a, b, 1992, 1992 a, b, 1993 a, b, c, 1994 a, b).

The correlation of the Sarmatian on the basis of foraminifers and molluscs may be found in the works by Zlinská and Fordinál (1988, 1989, 1995), Fordinál and Zlinská (1994) and Zlinská et al. 1996.

Correlation of sarmatian lithostratigraphic and biostratigraphical units in the Košická kotlina depression

In the frame of lithostratigraphical division of the Sarmatian in the Košická kotlina depression the units delimited by Vass and Čverčko (1985) for the Neogene of the East Slovakian Lowland were used. In biozonation

the scale elaborated by Grill (1941) in the Vienna Basin served as the basis (Tab. 12).

In this chapter the results of the works by Zlinská (1984, 1986, 1987, 1989 a, 1990 a, 1991 a, b, 1992), Zlinská and Fordinál (1988, 1989) and Zlinská et al. 1996 were used.

Klčov formation

In the Upper Badenian-Kosovian was differentiation of microfauna into marine, which is represented in the lower part of the substage, lithologically belonging to the Lastomír Formation and brackish, in the upper part of the substage, represented by Klčov Formation reaching stratigraphically the lowermost Sarmatian (Tab. 12).

From the mentioned formation together 31 samples were studied as to microfauna from boreholes: KSV-25 (Juskova Voľa, 1 sample from depth of 252,5-254m), K-8 (Nižný Čaj, 25 samples from depths of 294 - 648 m) and SHJ-23 (Kalša, 5 samples from depths of 75-100m) (Fig. 1).

As visible from the attached table (Tab. 1), the formation is characterized, besides redeposited marine microfauna, by mixed marine and marine-brackish foraminifers of the Bulimino-Bolivina and *Ammonia* biozones, of stratigraphic range Upper Badenian to lowermost Sarmatian. From the fauna of foraminifers mainly the genera were recorded: *Globigerina*, *Bulimina*, *Bolivina*, *Uvigerina* inclining to the Badenian and to the Sarmatian *Elphidium*, *Nonion*, miliolid forms (*Quinqueloculina*, *Triloculina*) and *Ammonia beccarii* (L.) as most abundant. The species *Elphidium flexuosum grilli* Papp is also known from the Lower Sarmatian of stratotype borehole Bč-1 (Bočiar) (Brestenská, 1974). Ostracodes are represented by diachronous species, only *Phlyctenophora farkasi* (Zal.) is bound to the Upper Badenian (NO-10 Zone, Jiříček, 1983).

The obtained foraminifer associations point to salinity and depth of the sedimentation area gradually decreasing from marine to brackish and from the neritic to sublittoral.

The sediments of this formation prevalently contained terrestrial gastropods (Zlinská et al. 1996) with prevalence of hydrophilous genera.

Stretava formation

From this formation 25 outcrop samples (AZ-1, 2, 3, AZ-15, 162, 163, 165, 166, 169, 172, 175, 176, 218, 219, 227, 228, 269, 271, 273, 274, 280, 293, 296, SI-1030, 1045 and 138 drilling samples were studied microfaunistically, coming from boreholes: S-4 (Čakanovce, 2 samples from depth of 17,9-26,5 m), JGF-31 (Ždaňa, 1 sample from depth of 14,2 m), VST-11

(Kravany, 10 samples from depths of 57,8-240,5m), KMV-50 (Zemplínska Teplica, 5 samples from depths of 21,5-49,6m), KMV-51 (Zemplínska Teplica, 12 samples from depths of 14,6-137,5m), VTK-2 (Skároš, 7 samples from depths of 24,2-48,2m), VTK-3 (Skároš, 5 samples from depths of 28,1-72,3m), VTK-4 (Skároš, 5 samples from depths of 17,2-46,5m), VTK-5 (Skároš, 4 samples from depths of 13,2-18,2m), JGF-38 (Izra, 1 sample from depth of 10,8m), JGF-40 (Slanská Huta, 1 sample from depth of 14,2m), VTK-30 (Slanská Huta, 2 samples from depths of 27-46,5m), VTK-32 (Slanská Huta, 4 samples from depths of 13,2-32,2m), VTK-33 (Slanská Huta, 4 samples from depths of 17,7-35,7m), JVH-26 (Nižný Čaj, 1 sample from depth of 19m), JVH-33 (Nižný Čaj, 1 sample from depth of 17m), K-3 (Slanská Huta, 29 samples from depths of 18-286m), K-8 (Nižný Čaj, 26 samples from depths of 7,3-242,5m), K-13 (Ďurkov, 8 samples from depths of 210,8-250m) and K-15 (Sečovce, 10 samples from depths of 236,4-275,2m) (Fig.1).

The formation contains shallow-water brackish foraminifers, according to up to present knowledge of the *Elphidium reginum* and *Elphidium hauerinum* biozones (Tab.12), or stratigraphically the Lower to Middle Sarmatian. The species *Elphidium hauerinum* (Orb.), which in basins of the Central Paratethys is found in the Middle Sarmatian, however, according to present-day results atypically appears already in the Lower Sarmatian in the Košická kotlina depression thus in the foraminiferal *Elphidium reginum* Zone (Grill, 1941).

To foraminifers characteristic of this formation (Tab. 2 - 8) mainly belong to the species: *Ammonia beccarii* (L.), *Elphidium reginum* (Orb.), *E. hauerinum* (Orb.), *E. ex gr. flexuosum* (Orb.), *E. macellum* (F.-M.), *E. aculeatum* (Orb.), *E. glabrum* Bystrická, *E. fichtelianum* (Orb.), *E. crispum* (L.), *E. microelegans* Serova, *Protelphidium bogdanowiczi* (Volosh.), *Elphidium granosum* (Orb.), the genera *Schackoinella*, *Nonion*, *Articulina* and other miliolid foraminifers. In the Košická kotlina depression, for instance, at the localities Nižná Myšľa and Skároš, in the Slanské vrchy Mts. in Slanská Huta and in the East Slovakian Lowland at the type locality of Kravany (borehole VST-11) the new species *Elphidium samueli* Zlinská (1993) was described in the Stretava Formation. It is a form transitional between *E. aculeatum* (Orb.) and *E. reginum* (Orb.).

The obtained foraminifers characterize the shallow-water brackish environment (Zlinská, 1992b).

From other organic remains Lower Sarmatian Bryozoa were found: *Schizoporella* sp. (Slanská Huta) and *Crisiella carnuntina* Bobies (Trstenné on Hornád, Kravany), algae (*Dasycladaceae*, *Chlorophyta*): *Chalmasia moreletii* Pokorný (Sečovce), described by Pokorný (1948) from the Sarmatian of Moravia (Podivín). Further

on, Sarmatian ostracodes were found, typical species of the NO-11 Zone (in the sense of Jiříček, 1983) (Tab.11). They are:

Aurila mehesi (Zal.) (Izra, Slanská Huta, Herľany, Sečovce, Nižná Myšľa, Čakanovce, Kravany, Zemplínska Teplica), *Senesia vadaszi* (Zal.) (Herľany, Kravany, Kalša), *Cytheridea hungarica* (Zal.) (Slanská Huta, Sečovce, Slanec, Herľany, Nižná Myšľa, Skároš, Izra, Nižný Čaj), *Loxococoncha hastata* (Rss.) (Herľany), *Hemicyprideis dacica* (Héjj.) (Ždaňa) and *Hemicytheria loerentheyi sarmatica* Jiř. (Zemplínska Teplica), which is described by Jiříček (1974) from the Lower Sarmatian (B Zone, Tab.10) of borehole 4 (Svinica, 35-40 m) in eastern Slovakia.

The studied formation contains gastropods, which permit to range it to Lower Sarmatian Rissoa beds in the sense Papp (1954) (Tab.10, Zlinská et al. 1996).

Kochanovce formation

The last studied lithostratigraphical unit of the Sarmatian is the Kochanovce Formation. A feature characteristic of this formation is the presence of freshwater molluscs and absence of brackish ones. In microfauna it corresponds to the *Elphidium hauerinum* and *Nonion granosum* biozones (Grill, 1941) (Tab.12) or to the stratigraphic range of the Middle to Upper Sarmatian.

From the Kochanovce Formation an outcrop sample from the locality Svinica (AZ-174) and 15 samples from borehole K-15 (Sečovce, from depths of 43,6-174,5m), were studied (Fig.1).

As it is a freshwater formation, it does not contain autochthonous associations of foraminifers (Tab. 9). Freshwater ostracodes were established only (Zlinská, 1992). The subspecies *Phlyctenophora farkasi sarmatica* Jiř. was described by its author from the Sarmatian D₃ Zone (Jiříček, 1974).

The sediments did not contain an autochthonous fauna of terrestrial gastropods and freshwater gastropods and bivalves (Zlinská et al. 1996).

Systematic part

Order FORAMINIFERIDA Eichwald 1830

Family HAUERINIDAE Schwager 1876

Genus *Cycloforina* Luczkowska 1972

Cycloforina hauerina (Orbigny 1846)

1846 *Quinqueloculina hauerina* Orbigny, p. 286, pl.17, fig. 25-27

1974 *Quinqueloculina hauerina* Orbigny - Brestenská, p. 249

1974 *Cycloforina hauerina* (Orbigny) - Luczkowska, p. 79, pl. 12, fig. 1a-c, text fig. 28/5

- 1985 *Cycloforina hauerina* (Orbigny) - Papp et Schmid, p. 97, pl. 91, fig. 5-8, textfig. 14/3

Remarks: The test is from outside similar to the species *Quinqueloculina akneriana* Orbigny. They are distinguished by cycloforine inner chambers.

Stratigraphic range: This form is found in the Badenian and Sarmatian in the Western Carpathians, mostly in association with elphidia and miliolids. In the East Slovakian basin it was established from the Kosovian to Lower Sarmatian.

Occurrences: In the Sarmatian of the Košická kotlina depression in samples: K-8 (Nižný Čaj), K-3 (Slanská Huta), VTK-4 (Skároš), VST-11 (Kravany).

Genus *Simuloculina* Luczkowska 1972

Sinuloculina consobrina (Orbigny 1846)

(Pl. I, Fig. 1)

- 1846 *Triloculina consobrina* Orbigny, p.277, pl.17, fig. 10-12
 1970 *Quinqueloculina consobrina consobrina* Orbigny-Didkovský et Satanovská, p.21, pl. 10, fig.2a-v
 1974 *Sinuloculina consobrina* (Orbigny) - Luczkowska, p.123, pl. 25, fig.5a-c,6, 7a-c, textfig.40
 1985 *Sinuloculina consobrina* (Orbigny) - Papp et Schmid, p.95, pl. 88, fig. 5-10, textfig. 14/2

Remarks: The initial chamber of this species is sinu-loculoid, enabling Luczkowska (1972) re-assignment to the genus *Sinuloculina*. *S.consobrina* is similar to *S.nitens* (Reuss). It is, however, more slender and has a more oval test. From the species *Triloculina gibba* Orb. it differs in a more slender test, more rounded cross section and insignificantly deepened sutures.

Stratigraphic range: In the East Slovakian Basin it was established from the Wieliczian to Lower Sarmatian.

Occurrences: In the Košická kotlina depression in samples: VTK-32,33,AZ-176, K-3 (Slanská Huta), AZ-169 (Trstené on Hornád), KMV-50 (Zemplínska Teplica), VTK-2,3,4 (Skároš), K-8 (Nižný Čaj), K-15 (Sečovce).

Genus *Articulina* Orbigny 1826

Articulina articulinoidea Gerke et Issaeva 1952

(Pl. I, Fig. 2)

- 1952 *Articulina articulinoidea* Gerke et Issaeva, p. 211, pl.33, fig.6-8 (in Bogdanowicz 1952)
 1974 *Articulina articulinoidea* Gerke et Issaeva - Brestenská, p. 253, pl. 2, fig. 4,6

Remarks: Similar to the species *A. sarmatica* (Karrer), which in the initial stage reaches less dimensions and in the uniserial part are chambers with smaller length than in *A. articulinoidea*. The initial part in both species is quinqueloculine.

Stratigraphic range: The species is endemic, bound in its occurrences with the Sarmatian of Paratethys.

Occurrences: In the Košická kotlina depression found in the Lower Sarmatian in samples: AZ-169 (Trstené on Hornád), VTK-32,33 (Slanská Huta).

Family *GLABRATELLIDAE* Loeblich et Tappan 1964

Genus *Schackoinella* Weinhandl 1958

Schackoinella imperatoria (Orbigny 1846)

- 1846 *Rosalina imperatoria* Orbigny, p.176, pl.10, fig.16-18
 1958 *Schackoinella sarmatica* Weinhandl, p. 141, textfig. 1 (nom.corr.)
 1974 *Glabratella imperatoria* (Orbigny) - Brestenská, p. 258, pl. 4, fig.1-3
 1985 *Schackoinella imperatoria* (Orbigny) - Papp et Schmid, p.66, pl. 60, fig. 1-5

Remarks: On the contrary to other species small spines on the dorsal side of chambers are typical of this species.

Ecology: The species belongs to representatives of the shallow neriticum. Murray (1973) mentions the lower boundary of extension of this species to 50m.

Stratigraphic range: In the central Paratethys found in the Early Sarmatian. In places it is prevalent in the zone of larger elphidia. In the eastern Paratethys it was already established in the Upper Badenian.

Occurrences: In the Košická kotlina depression it is found in the Lower Sarmatian in samples: VST-11 (Kravany) and AZ-169 (Trstené on Hornád).

Family *PARRELLOIDIDAE* Hofker 1956

Genus *Lobatula* Fleming 1828

Lobatula lobatula (Walker et Jacob 1798)

- 1798 *Nautilus lobatulus* Walker et Jacob, p.642, pl.14, fig.36
 1846 *Truncatulina lobatula* (Walker et Jacob) - Orbigny, p.168, pl.9, fig.18-23
 1846 *Anomalina variolata* Orbigny, p.170, pl. 9, fig. 27-29
 1960 *Cibicides lobatulus* (Walker et Jacob) - Cicha et Zapletalová, p.27, pl.7, fig.1-3
 1985 *Cibicides lobatulus* (Walker et Jacob) - Papp et Schmid, p. 64, pl. 56, fig.1-5
 1988 *Lobatula lobatula* (Walker et Jacob) - Loeblich et Tappan, p. 583, pl. 637, fig. 10-13

Remarks: Marks (1951) considers as synonym of this species the following species: *Truncatulina tuberculata* Orb., *Anomalina variolata* Orb., *Truncatulina communis* Reuss. As the variability of the studied taxon is considerably large, one may agree with his opinion.

Ecology: The species is a typical representative of shallow-neritic conditions.

Stratigraphic range: In the Tertiary of the central Paratethys it is common, in the Miocene abundant. In the East Slovakian Basin it was established from the Karpatian to Lower Sarmatian.

Occurrences: In the Košická kotlina depression in samples: AZ-69 (Trstené on Hornád), K-8, JVH-26 (Nižný Čaj), VTK-30, 32, 33 (Slanská Huta).

Family *NONIONIDAE* Schultze 1854

Genus *Nonion* de Montfort 1808

***Nonion commune* (Orbigny 1825)**

(Pl. I, Fig. 3)

- non 1791 *Nautilus scapha* Wulfen, p.242
 1798 *Nautilus scapha* Fichtel et Moll, p. 105, pl. 19, fig. d-f
 1825 *Nonionina communis* Orbigny, p.128, Nr. 20 (fide Ellis - Messina 1940)
 1846 *Nonionina communis* Orbigny, p. 106, pl. 5, fig. 7-8
 1939 *Nonion scaphum* (Fichtel et Moll) - Cushman, p. 20, pl. 5, fig. 18-21
 1967 *Florilus communis* (Orbigny) - Cicha et Zapletalová, p. 136
 1969 *Nonion scaphum* (Fichtel et Moll) - Roegl, p. 102, pl. 5, fig. 19a-b
 1984 *Nonion commune* (Orbigny) - Roegl et Hansen, p. 66, pl. 24, fig. 1-2,4-6
 1985 *Nonion commune* (Orbigny) - Papp et Schmid, p. 45, pl. 34, fig. 1-5

Remarks: According to revision of the original material of Orbigny by Papp and Schmid (1985) the species *Nonioni na Boueana* Orbigny is additionally ranged to the genus *Hanzawaia*. *Nonion commune* differs from the species *Hanzawaia boueana* mainly in less overlapping younger chambers and rounded periphery.

Stratigraphic range: In the Tertiary of the central Paratethys the species is common, in the Miocene abundant, bound to shallow-water facies. In the East Slovakian Basin it was established from the Karpatian to Lower Sarmatian.

Occurrence: In the Košická kotlina depression in samples: K-8, JVH-33 (Nižný Čaj), AZ-166 (Nižná Myšľa), K-13 (Ďurkov), K-3 (Slanská Huta), VTK-5 (Skároš), KMV-50 (Zemplínska Teplica).

Family *ROTALIIDAE* Ehrenberg 1839

Genus *Ammonia* Bruennich 1772

***Ammonia beccarii* (Linné 1758)**

(Pl. I, Fig. 4, 5)

- 1758 *Nautilus Beccarii* Linné, p. 710
 1846 *Rosalina vienensis* Orbigny, p. 177, pl. 10, fig. 22-24
 1857 *Rosalina vienensis* Orbigny - Egger, p. 277, pl. 8, fig. 11-13
 1959 *Rotalia beccarii* (Linné) - Dieci, p. 80, pl. 6, fig. 29a-c

- 1971 *Streblus beccarii* (Linné) - Hofker, p. 17, pl. 63, fig. 1-8, pl. 64, fig. 1-6
 1973 *Ammonia beccarii* (Linné) - Cicha et al., p. 312, pl. 6, fig. 32 a-b
 1985 *Ammonia beccarii* (Linné) - Papp et Schmid, p. 67, pl. 61, fig. 1-5
 1987 *Ammonia beccarii* (Linné) - Wenger, p. 303, pl. 14, fig. 13-16

Remarks: The species is characterized by great variability, which is depending on ecological factors.

Ecology: It is a form characteristic of shallow waters (Poag, 1981, Walton 1964). According to Phleger (1960) it is often found at depths of 10-50m. Reaches maximally 80m. Endures strong freshening.

Stratigraphic range: In the Miocene of the central Paratethys it is common. In the East Slovakian Basin it was established from the Eggenburgian to Middle Sarmatian.

Occurrences: In the Košická kotlina depression found in all the studied samples except AZ-271.

Family *ELPHIDIIDAE* Galloway 1933

Genus *Elphidium* de Montfort 1808

***Elphidium aculeatum* (Orbigny 1846)**

(Pl. I, Fig. 6)

- 1846 *Polystomella aculeata* Orbigny, p.131, pl. 6, fig. 27-28
 1932 *Elphidium aculeatum* (Orbigny) - Bogdanowicz et Fedorov, p. 14, textfig. 13-20, pl.1, fig. 4-7
 1985 *Elphidium aculeatum* (Orbigny) - Papp et Schmid, p. 53, pl. 43, fig. 4-7

Remarks: This species characteristic of the Sarmatian is distinguished by bent septa which are running out into spines.

Ecology: The genus *Elphidium* is generally considered as indicator of little water depths. In larger amount it is found at depths less than 80-100m (Boltovskoy-Wright 1976, Walton 1964, Poag 1981).

Stratigraphic range: In the central Paratethys the species is found from the Karpatian. We may observe typical *E. aculeatum* in the Early Sarmatian. In the East Slovakian Basin it was established from the Moravian to Lower Sarmatian.

Occurrences: In the Košická kotlina depression in samples: AZ-162, 166, Sl-1030, 1045 (Nižná Myšľa), AZ-176, 271, 274, VTK-32, 33, K-3 (Slanská Huta), AZ-227, 228, vz.3 (Ždaňa), JVH-26, K-8 (Nižný Čaj), VST-11 (Kravany), VTK-2, 3,4 (Skároš), K-15 (Sečovce).

***Elphidium crispum* (Linné 1758)**

- 1758 *Nautilus crispus* Linné, p. 709, No. 236
 1798 *Nautilus crispus* Linné - Fichtel et Moll, p. 40 (partim), pl. 5, fig. a-b
 1822 *Polystomella crispa* Lamarck, p. 624

- 1846 *Polystomella crispa* Lamarck - Orbigny, p. 125, pl. 6, fig. 9-14
 1932 *Elphidium crispum* (Linné) - Bogdanowicz et Fedorov, p. 12, pl. 1, fig.3, textfig. 11
 1971 *Elphidium crispum* (Linné) - Cicha et al., p. 270, pl. 17, fig. 6-8
 1985 *Elphidium crispum* (Linné) - Papp et Schmid, p. 50, pl. 40, fig.5-8

Remarks: From *E. rugosum* (Orbigny) it differs in a very clear central pillar. From *E. flexuosum* subtypicum Papp it differs in a higher number of chambers, larger test and clearly bordered considerably smooth pillar.

Stratigraphic range: In the central Paratethys Miocene a common species from the Eggerburgian. In the East Slovakian Basin established from the Karpathian to Lower Sarmatian.

Occurrences: In the Sarmatian of the Košická kotlina depression in samples: S-4 (Čakanovce), AZ-163 (Nižná Myšľa), AZ-2712 73 (Slanská Huta), KMV-50 (Zemplínska Teplica), VTK-4 (Skároš), K-15 (Sečovce).

***Elphidium fichtelianum* (Orbigny 1846)**

- 1846 *Polystomella fichtelliana* Orbigny, p. 125, pl.6, fig. 7-8
 1939 *Elphidium fichtellianum* (Orbigny) - Cushman, p. 42, pl.11, fig.12
 1960 *Elphidium fichtellianum* (Orbigny) - Krasheninnikov, p.34, pl.2, fig.2, pl.3, fig.1
 1985 *Elphidium fichtelianum* (Orbigny) - Papp et Schmid, p. 50, pl. 40, fig. 1-5

Remarks: From *E. ortenburgense* (Egger) it differs in flatter sharp, larger growth of chambers in the last whorl and more strongly bent septa. Both species are linked through transitional forms.

Stratigraphic range: *E. fichtelianum* (Orb.) is a species common in the central Paratethys, persisting from the Eggerburgian to the lower part of the Early Sarmatian where it is abundant in the zone of larger elphidia. In the East Slovakian Basin it was established from the Karpathian to Lower Sarmatian.

Occurrences: In the Košická kotlina depression in samples: K-8 (Nižný Čaj), AZ-163 (Nižná Myšľa), JGF-38 (Izra), K-3, VTK-32 (Slanská Huta), VTK-2, 4, 5 (Skároš), SHJ-23, AZ-269, 293, 296 (Kalša), AZ-219 (Slanec), K-15 (Sečovce).

***Elphidium flexuosum flexuosum* (Orbigny 1846)**

(Pl. I, Fig. 7)

- 1846 *Polystomella flexuosa* Orbigny, p.127, pl. 6, fig. 15-16
 1857 *Polystomella flexuosa* Orbigny - Egger, p. 303, pl. 10, fig. 21-22
 1963 *Elphidium flexuosum flexuosum* (Orbigny) - Papp, p. 271, pl. 12, fig. 5-6
 1985 *Elphidium flexuosum flexuosum* (Orbigny) - Papp et Schmid, p.51, pl. 41, fig.1-4

Remarks: Similar to the species *E. crispum* (L.). The latter, however has a larger number of chambers and a flatter form.

Stratigraphic range: In the Miocene of the central Paratethys wide-spread from the Eggerburgian to Sarmatian. In the East Slovakian Basin it was established from the Karpathian to Lower Sarmatian.

Occurrences: In the Košická kotlina depression in samples: K-8 (Nižný Čaj), K-15 (Sečovce), AZ-166 (Nižná Myšľa), AZ-228 (Ždaňa), AZ-280 (Slivník), AZ-293, 296 (Kalša), VTK-2,5 (Skároš).

***Elphidium (Porosonion) granosum* (Orbigny 1846)**

(Pl. I, Fig. 8)

- 1826 *Nonionina granosa* Nob.- Orbigny, p. 294 (nomen nudum)
 1846 *Nonionina granosa* Orbigny, p. 110, pl. 5, fig.19-20
 1857 *Nonionina subgranosa* n. sp. - Egger, p. 299, pl. 14, fig. 16-18
 1939 *Nonion granosum* (Orbigny) - Cushman, p. 11, pl. 2, fig. 17-18
 1985 *Elphidium (Porosonion) granosum* (Orbigny)-Papp et Schmid, p. 47, pl. 37, fig. 1-6

Remarks: From *Protelphidium roemeri* (Cushman) it differs in being flatter, having many mouths and thick perforation. *P. roemeri* is fine perforated.

Stratigraphic range: In the East Slovakian Basin established in the Moravian to Middle Sarmatian.

Occurrences: In the Košická kotlina depression in samples: AZ-175, VTK-33 (Slanská Huta), VTK-2, 3, 4, 5 (Skároš), K-8 (Nižný Čaj), AZ-162, vz.1, SI-1030 (Nižná Myšľa), AZ-219 (Slanec), KMV-51 (Zemplínska Teplica), K-15 (Sečovce).

***Elphidium hauerinum* (Orbigny 1846)**

(Pl. II, Fig.1, 2)

- 1846 *Polystomella hauerina* Orbigny, p.122, pl.6, fig. 1-2
Polystomella antonina Orbigny, p.128, pl. 6, fig. 17-18
Polystomella listeri Orbigny, p.128, pl. 6, fig. 19-22
 1932 *Elphidium hauerinum* (Orbigny) - Bogdanowicz et Fedorov, p. 21, pl. 1, fig. 19-21, textfig. 31-32
 1939 *Elphidium hauerinum* (Orbigny) - Cushman, p. 42, pl. 11, fig. 9
Elphidium antoninum (Orbigny) - Cushman, p. 43, pl. 11, fig.14
 1963 *Elphidium antoninum* (Orbigny) - Papp, p. 262, pl. 10, fig.3-5
Elphidium hauerinum (Orbigny) - Papp, p. 263, pl. 10, fig.6
Elphidium listeri (Orbigny) - Papp, p. 273, pl.12, fig. 9
 1985 *Elphidium hauerinum* (Orbigny) - Papp et Schmid, p. 49, 51, pl. 38, fig. 5-10, pl. 41, fig. 5-10, pl. 42, fig.1-4

Remarks: Similar to the species *E. obtusum* (Orbigny), which however, has finer sutural pits. Papp (1963) and Brestenská (1974) ranged *E. hauerinum* to primitive elphidia.

Stratigraphic range: In the central Paratethys the species is widespread in the Middle Sarmatian only. Relatively small tests with large pores are found in the Košická kotlina depression already in the upper part of the Lower Sarmatian.

Occurrences: In the Košická kotlina depression it was established in the higher part of the Lower and Middle Sarmatian in samples: S-4 (Čakanovce), AZ-15 (Herľany), VST-11 (Kravany), AZ-166 (Nižná Myšľa), AZ-227 (Ždaňa), VTK-2, 4, 5 (Skároš).

***Elphidium macellum* (Fichtel et Moll 1798)**

(Pl. II, Fig. 3, 4)

- 1798 *Nautilus macellus* var. beta - Fichtel et Moll, p.68, pl.10, fig. h-k
 1939 *Elphidium macellum* (Fichtel et Moll) - Cushman, p. 51, pl.15, fig.9-10
 1960 *Elphidium macellum* (Fichtel et Moll) - Krasheninnikov, p.32, pl.1, fig.2, pl.2, fig.1
 1974 *Elphidium macellum* (Fichtel et Moll) - Brestenská, p. 263, pl. 6, fig. 4
 1984 *Elphidium macellum* (Fichtel et Moll) - Roegl et Hansen, p. 50, textfig. 18B, pl. 14, fig. 2,5-6, pl. 15, fig.1-2

Remarks: From *E. fichtelianum* (Orbigny) it differs in wider form.

Stratigraphic range: In the Miocene of the central Paratethys it is found from the Egerian diachronously. In the East Slovakian Basin established from the Karpatian to Middle Sarmatian.

Occurrences: In the Košická kotlina depression it was established in the Sarmatian in samples: K-8 (Nižný Čaj), SHJ-23, AZ-269, 293, 296 (Kalša), AZ-15 (Herľany), VST-11(Kravany), AZ-227, 228, JGF-31 (Ždaňa), AZ-176, 271, 273, K-3, JGF-40, VTK-32, 33 (Slanská Huta), AZ-169 (Trstené on Hornád), AZ-218 (Slančík), AZ-162, 163, 166,172 (Nižná Myšľa), S-4 (Čakanovce), AZ-280 (Slivník), JGF-38 (Izra), KMV-50 (Zemplínska Teplica), VTK-2, 4, 5 (Skároš).

***Elphidium reginum* (Orbigny 1846)**

(Pl. II, Fig. 5, 6)

- 1846 *Polystomella regina* Orbigny, p.129, pl.6, fig. 23-24
 1960 *Elphidium regina* (Orbigny) - Krasheninnikov, p. 35, pl. 3, fig.3
 1985 *Elphidium reginum* (Orbigny) - Papp et Schmid, p. 52, pl. 42, fig. 5-9, pl. 43, fig. 8

Remarks: This index fossil of the Sarmatian is considered by Papp and Schmid (1985) as an endemic species for the Paratethys. Assignment to the genus *Parrelina* Thalmann 1951 is based on accidental resemblance.

Stratigraphic range: The species is very variable. Mainly the number, length and massiveness of projections are changing. In the central Paratethys it is bound to the zone of larger elphidia. In the S part of the USSR

it is still found in the Bessarabian. In the East Slovakian Basin it was established in the Lower Sarmatian.

Occurrences: In the Košická kotlina depression in samples: AZ-15 (Herľany), VST-11 (Kravany), K-8 (Nižný Čaj), AZ-163, SI-1030 (Nižná Myšľa), AZ-273, 274, VTK-32, 33, K-3 (Slanská Huta), K-15 (Sečovce).

***Elphidium samueli* Zlinská 1993**

(Pl. II, Fig. 7, 8)

- 1993 *Elphidium samueli* sp. n. - Zlinská, p. 85-87, pl. 19, fig. 4-9, pl. 20, fig. 1-8, pl. 21, fig. 1-8, pl. 22, fig. 1-8, pl. 23, fig. 2-9

Remarks: From *Elphidium aculeatum* (Orb.) it differs in a higher number of chambers, their shape, larger angle of sutures bending and irregular longer spines. From *Elphidium crispum* (L.) in less thickness. From *Elphidium reginum* (Orb.) in spines not overgrowing from the preceding whorl through the wall of the following whorl.

Stratigraphic range: The species was established in clayey-sandy facies of the lower brackish Sarmatian (*Elphidium reginum* Zone).

Occurrences: In the Košická kotlina depression in Lower Sarmatian samples: VST-11 (Kravany), VTK-3,5 (Skároš), AZ-165 (Nižná Myšľa), VTK-30, 32, K-3 (Slanská Huta), AZ-227 (Ždaňa), KMV-50 (Zemplínska Teplica).

Conclusion

The objective of the article was to find out the composition and character of foraminifer associations in the individual lithostratigraphical units of the Sarmatian in the Košická kotlina depression, their correlation with foraminifer biozones in the Vienna Basin and refinement of the taxonomy of foraminifers typical of the Sarmatian.

In the article the results of study of around 250 microfaunistic samples (foraminifers and ostracodes) are presented.

The Sarmatian is characterized by shallow-water forms of foraminifers, which are marked by a great variability of species. There are relatively few species having a narrow range of occurrence. Sometimes the stratigraphic assignment is very pretentious for the reasons of absence of these forms. Besides that the boundaries of litho- and biostratigraphical units are not equal. We place the microfaunistic boundary of the Klčov and Stretava Formations to the first occurrence of the species *Elphidium reginum* (Orb.), what represents as to microfauna the base of the equal-named zone and stratigraphically higher part of the Lower Sarmatian (Tab. 10). The boundary of the Stretava and Kochanovce Formations cannot be fixed microfaunistically because

no species of foraminifers exists, the first occurrence of which would be recorded above the Middle Sarmatian base. In general the Middle Sarmatian base in the Central Paratethys is characterized by onset of the species *Elphidium hauerinum* (Orb.). This however appears in the Košická kotlina depression untypically already in the uppermost part of the Lower Sarmatian (Stretava Formation), testifying to communication of this area with the Eastern Paratethys region. Equally in the Sarmatian of the Košická kotlina depression species are relatively largely represented, which were established first E of the East Slovakian Basin (Tab.2-8).

On the basis of the study of Sarmatian microfauna in the Košická kotlina depression it may be summarized briefly as follows:

1. In the Upper Badenian there was reduction of salinity and gradual shallowing of the sedimentation area. The Klčov Formation (Vass and Čverčko, 1985) (Upper Badenian to lowermost Sarmatian) contains a marine and marine-brackish microfauna with *Ammonia beccarii* (L.) and terrestrial gastropods with prevalence of hydrophilous genera. Only in one case the presence of brackish molluscs was established (Zlinská et al. 1996).

2. The Stretava Formation (Vass and Čverčko 1985) (Lower to Middle Sarmatian) is characterized by shallow-water brackish foraminifers (mainly of genus *Elphidium*) belonging as to microfauna to *Elphidium reginum* and *Elphidium hauerinum* Biozones (Grill 1941, Tab.12). In the area under study, however, *Elphidium hauerinum* (Orb.) appear untypically already in the Lower Sarmatian, indicating the possibility of restriction of this formation to the Lower Sarmatian. Gastropods of this formation correspond to the Lower Sarmatian Rissoa Member in the sense of division by Papp (1954, Tab.10), thus to the microfaunistic *Elphidium reginum* Zone (Zlinská et al. 1996).

3. The Kochanovce Formation contains from the original microfauna freshwater ostracode and fauna of terrestrial gastropods and freshwater gastropods and bivalves only (Zlinská et al. 1996).

The biostratigraphical contribution of the article consists in:

1. summarization of the character of foraminifer associations in the individual lithostratigraphical units of the Sarmatian Košická kotlina depression

2. their correlation with Sarmatian foraminifer (Grill, 1941), or ostracode (Jiříček, 1972, 1983) and mollusc (Papp, 1954) (Tabs.10,11).

3. refinement of taxonomy of the individual foraminifers and of their stratigraphic range in the East Slovakian Basin (Tab. 13).

4. paleogeographical reconstruction of the environment: on the basis of stratigraphic range of the species *Elphidium hauerinum* (Orb.) in the upper part of the

Lower Sarmatian in the East Slovakian Basin communication of this area with the Eastern Paratethys may be inferred.

5. refinement of the chronostratigraphical scale of the Sarmatian in the Central and Eastern Paratethys.

It results from the above mentioned that it will be necessary to pay longer-termed attention to these problems also in future mainly in connection with phylo- and ontogeny, taxonomy, extension of individual taxa and their correlation with other groups and with the Eastern Paratethys.

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LIST OF LOCALITIES AND USED SAMPLES

Kľčov Formation

Juskova Voľa : KSV-25
 Nižný Čaj : K-8
 Kalša : SHJ-23

Stretava Formation

Nižná Myšľa: AZ-1, 2, 162, 163, 165, 166, 172, Sl-1030, 1045
 Ždaňa: AZ-3, 227, 228, JGF-31
 Herľany: AZ-15
 Slanská Huta: AZ-175, 176, 271, 273, 274, JGF-40, VTK-30, 32, 33, K-3
 Slančík: AZ-218
 Slanec: AZ-219
 Kalša: AZ-269, 293, 296
 Slivník: AZ-280
 Kravany: VST-11
 Zemplínska Teplica: KMV-50, 51
 Skároš: VTK-2, 3, 4, 5
 Izra: JGF-38
 Nižný Čaj: JVH-26, JVH-33, K-8
 Ďurkov: K-13
 Trstené on Hornád: AZ-169
 Čakanovce: S-4
 Sečovce: K-15

Kochanovce Formation

Svinica : AZ-174
 Sečovce : K-15

EXPLANATION TO PHOTOGRAPHIC PLATES

Plate I

- Fig. 1 *Sinuloculina consobrina* (Orbigny), Slanská Huta
 Fig. 2 *Articulina articulinoidea* Gerke et Issaeva, Trstené on Hornád
 Fig. 3 *Nonion commune* (Orbigny), Kalša
 Fig. 4,5 *Ammonia beccarii* (Linné), 5 Skároš, 6 Kalša
 Fig. 6 *Elphidium aculeatum* (Orbigny), Skároš
 Fig. 7 *Elphidium flexuosum flexuosum* (Orbigny), Kalša
 Fig. 8 *Elphidium granosum* (Orb.), Kalša

Plate II

- Fig. 1,2 *Elphidium hauerinum* (Orbigny), Nižná Myšľa
 Fig. 3,4 *Elphidium macellum* (F.-M.), 3 Slivník, 4 Kalša
 Fig. 5,6 *Elphidium reginum* (Orbigny), 5 Ždaňa, 6 Nižný Čaj
 Fig. 7,8 *Elphidium samueli* Zlinská, Kravany

The photographs are made by elektron microscope JSM-840, operators J. Stankovič and K. Horák, the length of abscissa corresponds to 100 μ m.

