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CONTRIBUTION TO THE STRATIGRAPHY OF CRETACEOUS OF THE KLIPPEN BELT AND CENTRAL WEST CARPATHIANS

PRÍSPEVOK K STRATIGRAFII KRIEDY BRADLOVÉHO PÁSMA A CENTRÁLNYCH ZÁPADNÝCH KARPÁT

(Plate I–II)

A b s t r a c t. In the present work, the authors submit the stratigraphy of the Central Belt Cretaceous, of the Klippen belt, the Manín series and of the Myjavská pahorkatina.

I. STRATIGRAPHY OF THE CRETACEOUS OF THE CENTRAL ZONE

In the Central zones of the West-Carpathians appear sediments of the Lower Middle Cretaceous. Cenomanian flysch sediments are the youngest proved (V. K a n t o r o v á and D. A n d r u s o v, 1958) and most probably by them ended the sedimentation in the Central belt. According to M. M a h e ľ (1959), characteristic feature of this zone are frequent stratigraphic hiatuses, occuring mainly in the Mantle series of individual core mountains. Their stratigraphy was discribed in the work of the above mentioned author. We shall deal in details only with the stratigraphy of the Krížna or the Zliechov M. M a h e ľ (1961) series, characterized by continuous sedimentation. Microbiostratigraphy of the individual members of the series is given completely for the whole Central zone of the West-Carpathians. From the facial standpoint, the Lower Cretaceous is represented mainly by two types of facies. The Neocomian is represented predominantly by light-grey and dark grey, often spotted, thin and thick-bedded, immasive, muddy limestones sometimes with cherts. The Aptian is formed by organodentritic fine-grained, frequently cherty Orbitolina limestones. The Middle Cretaceous represented by the Albian-Cenomanian sediments, is formed in the lower part by marls with sporadic interbeddings of sandstones, increasing in number toward the top, so that the Upper Aptian and the Cenomanian are regarded as a flysch complex. The presence of Turonian has not been proved in Central Carpathians, till now. The age of individual facies fluctuates remarkably, concerning especially facies of organodendritic limestones, observed already in the Hauterivian (M. M a h e ľ, 1960). The age of individual facies has been proved by microfauna and by macrofauna as well.

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Valangian

Valangian sediments, developping slowly from Tithonian limestones, are being formed by light-grey to dark-grey limestones, with occassional spots. In these sporadic intercalations of marls appear often rich microfauna. It is necessary to point out that not always they contain microfauna. For instance, in southern parts of the Central belt, especially in the vicinity of Banská Bystrica, Harmanec, Ľubietová, the Neocomian — including the Valangian — is strongly folded, in some places even slightly metamorphosed. The Valangian together with upper members of the Neocomian is rich in microfauna, mainly in the Zliechov series, in the vicinity of Trstie, Podskalie, Rajecká Lesná, Zbyňov, Fačkov, Lietava, Lietavská Lúčka, Babkov, Turie.

The contact between the Tithonian and the Neocomian has been determined mainly on the ground of Calpionella microassociations, studied by D. Andrusov (1945) and A. Kullmanová (1961).

The Tithonian-Berriasian is characterized by the following species: *Globochaete alpina* (Lombard), *Calpionella alpina* Lorenz, *Calpionella elliptica* (Cadisch); in the uppermost part of the succession, belonging to the Berriasian by *Calpionella undelloides* (Colom), *Tintinopsella carpatica* (Murgeanu et Filipescu) and *Nannoconnus steimanni* (Campter) occur.

The following species are characteristic for the Valangian to Hauterivian: *Calpionellites darderi* (Colom), *Stenosemellopis hispanica* (Colom) and *Tintinopsella oblonga* (Cadisch).

From among the Foraminifera in the Valangian the following species occur: *Ammodiscus tenuissimus* (Gümbel), *Glomospira gaultina* (Berthelin), *Glomospira* cf. *gordialis* (Jones et Parker), *Trochammina inflata* (Montagu), *Lenticulina (Lenticulina) ouachensis* (Sigal), *Lanticulina (Lenticulina) guttata* ten Dam, *Lenticulina (Lenticulina)* aff. *münsteri* (Roemer), *Lenticulina (Lenticulina)* aff. *nodosa* (Reuss), *Vaginulina semiornata* Reuss, *Citharina* aff. *pseudostriatula* Bartenstein et Brand, *Flabellinella didyma* (Berthelin), *Frondicularia loryii* Berthelin and *Epistomina ornata* (Roemer).

Hauterivian

The Valangian passes into the Hauterivian of the similar facies. In some places dark-grey organodetritic limestones are developed, whose age within the Hauterivian has been proved by microfauna (M. Maheľ, 1961) from the vicinity of Zliechov. Organodentritic limestones in the Neocomian are well exposed to investigation in the big quarry in the scarp of the road to Lietava. From the paleogeographic standpoint it is obvious, that the shallowing of the sea in Zliechov series which passes into the Manín series started somewhat earlier. In several localities Hauterivian macrofauna has been found, represented especially by Ammonites, from among the following species have been determined by J. Pevný: *Oosterella cultrata* (d'Orbigny), *Crioceretites duvali* Leveille, *Saynella* cf. *clypeiformis* (d'Orbigny) and *Pseudothurmannia* sp. The localities to be mentioned are mainly Trstie and Podskalie (quarry near the church.).

In the area mentioned, as well as in other areas (Malá Fatra and Nízke Tatry) there is abundant microfauna, containing first representatives of

plankton. Generally, Hauterivian microfauna is represented by the following species: *Glomospira gaultina* (Berthelin), *Ammodiscus tenuissimus* (Gümbel) *Haplophragmoides nana* (d'Orbigny), *Trochammina inflata* (Montagu), *Verneuilina* cf. *neocomiensis* Mjatljuk, *Marssonella* cf. *oxycona* (Reuss), *Vaginulina gaultina* Berthelin, *Vaginulina recta* Reuss, *Lenticulina (Lenticulina) guttata* ten Dam, *L. (Lenticulina) ouachensis* (Sigal), *L. (Lenticulina) cultrata* (Monfort), *L. (Lenticulina) münsteri* (Roemer), *L. (Lenticulina) roemeri* Reuss, *L. (Lenticulina) nuda* (Reuss), *Lenticulina (Marginulinopsis) djaffaensis* (Sigal), *Dentalina communis* d'Orbigny, *Lagena apiculata* Reuss, *Frondicularia* aff. *inversa* Reuss, *Planomalina (Globigerinelloides) typica* (Gandolfi), *Biticinella breggiensis* (Sigal), *Hedbergella infracretacea* (Glaessner), *Hedbergella trocoidea* (Gandolfi), *Cibicides djaffaensis* Sigal, *Anomalina (Gavalinella) barremiana* (Bettenstaedt), *Cytherella* aff. *steringi* Van Veen, *Ostracoda* div. sp.

Barremian

In the Barremian, besides the above described marly grey-green limestones, facies of black-grey marlstones with intercalations of Orbitolina limestones may be also observed. They occure first of all near Fačkov, Zbyňov (D. Andrusov, 1959), in Veľká Fatra and in Strážovská hornatina (Trstie, Podskalie, Horný Moštenec).

The abundant microfauna is represented predominantly by the following species.

Miliammina cf. valdensis Barthenstein et Brand. *Lenticulina (Marginulinopsis) djaffaensis* (Sigal), *Epistomina spinulifera* (Reuss), *Hedbergella infracretacea* (Glaessner), *Hedbergella trocoidea* (Gandolfi), *Anomalina (Gavellinella) barremiana* (Bettenstaedt), *Protocythere hechti* Triebel, *Protocythere triplicata* Triebel.

Aptian

It is facially formed mainly by bluish marlstones with interbeddings of bluish to dark-grey limestones. In some places limestones are predominant.

Microbiostratigraphically the Aptian of the Central Carpathians is divided into three biozones (J. Salaj, 1962).

1. Zone with *Planomalina (Planomalina) cheniourensis* (Sigal), *Planomalina (Globigerinelloides) algeriana* (Cushman et ten Dam) and *Planomalina (Globigerinelloides) typica* (Gandolfi).
2. Zone with *Anomalina djaffarovi* Agalarova.
3. Zone with *Epistomina charlotae* Vieaux.

In the first biozone the foraminifera association is formed by species: *Planomalina (Globigerinelloides) typica* (Gandolfi), *Planomalina (Globigerinelloides) algeriana* (Cushman et ten Dam), *Planomalina (Planomalina) cheniourensis* (Sigal), *Biglobigerinella barri* Bolli, Loeblich et Tappan (syn: *Biglobigerinella sigali* Chevalier), *Schackoina cabri* Sigal, *Hedbergella trocoidea* (Gandolfi), *Globigerinella escheri* Kaufman, *Biticinella breggiensis* (Gandolfi) (syn: *Biticinella ferreolensis* Moulade), *Globigeri-*

nella duboisi Chevalier, *Bigenerina complanata* (Reuss), *Anomalina (Gavelinalla) flandrini* Moulade, *Anomalina (Gavellinella) barremiana* Bettenstaedt. (Table 1.)

In the second biozone benthosic species predominate: *Anomalina (Anomalina) djaffarovi* Agalarova, *Discorbis wassoewizi* Djaffarov et Agalarova, *Anomalina (Gavelinella) complanata* Reuss, *Bigenerina complanata* (Reuss) and *Epistomina spinulifera* (Reuss).

In the last biozone Epistomina have the maximum representation: *Epistomina charlotae* Vieaux (syn: *Epistomina limbata* Tappan, 1943, *Epistomina cretosa* Ten Dam, 1947, *Epistomina juliae* Mjatljuk, 1949), *Epistomina spinulifera* (Reuss), *Epistomina spinulifera polypioides* (Eichenberg).

In connection with general biostratigraphic classification of the Aptian it is necessary to mention, that also in higher strata of the Aptian planktonic microfauna were observed, though rather rarely. *Hedbergella roberti* (Gandolfi), [*Ticinella roberti* Reichel, 1950 = *Ticinella multiloculata* (Morow)] occur through the whole Aptian. Consequently, we may agree with J. Sigal (1955) suposing that varieties of the species *Ticinella roberti* (Gandolfi), occuring in the Aptian of the Clansay zone of Kel Amara ben Ali are really identic with the species *Ticinella roberti* (Gandolfi) [= *Hedbergella roberti* (Gandolfi)]. Besides, as a synonym must be regarded also the species *Praeglobotruncana rohri* Bolli forming an important biozone in the sense of H. M. Bolli (1960) characteristic for the Upper Aptian and Lower Albian.

Because of the underestimation of the stratigraphic distribution of the species *Hedbergella roberti* (Gandolfi) and the synonyma connected with this, V. Scheibnerová (1962) — the sense of older criteria — objected stratigraphic occurence of the species *Hedbergella roberti* (in V. Scheibnerová's sense — *Rotalipora roberti*). The author relied upon stratigraphic results of the investigation of the locality Medziholské sedlo pod Rozsutcom in Malá Fatra. The locality has been studied by J. Salaj together with O. Jendrejáková. Zone of dark-grey marls with concretions of about 5 m thick, light-grey Neocomian limestones with Ammonites, belong to the Barremian. It is proved by Ammonites and by microfauna, represented by planktonic species, belonging mainly to the species *Hedbergella infracetacea* (Glaessner). Facies of grey-green to bluish Aptian marls with layers of bluish limestones rich in microfauna, indicating to the Aptian. It has been already presented in detail by O. Jendrejáková (1961), later on by V. Scheibnerová (1962), therefore we appeal to their works. Besides Aptian Epistomina and Biglobigerinella occurs here although sporadically — the species *Hedbergella roberti* (Gandolfi).

The important species to be mentioned is *Epistomina spinulifera* (Reuss), generaly known from the Lower Albian. In the Carpathians it occurs from the Barremian to the Aptian, with the maximum distribution in the Upper Aptian. Wider stratigraphic occurence of the species has been noticed by several authors (W. Eichenberg, 1933; E. F. Hecht, 1938; E. V. Mjatljuk, 1949).

Albian

Albian sediments, either in the facies of grey-green marls or in the flysch facies, are widely distributed in the Central belt. Important is the M. Mahel' (1959) recognition of the occurence of dark limestones (similar to the Aptian

Table 1. Microbiostratigraphy of Cretaceous sediments of Manín-series at the contact with the Subtatric nappe in the surroundings of the villages Podskalie and Moštenec

Horizont	Thick.	Lithofacial character	Faunal character
Base of Maastrichtian	20 m	Marls with sandstone layers	*Aragonia velascoensis*
Upper Campanian	80 m	Marls with frequent sandstone layers, sometimes in flysch facies	*Aragonia solchica, Globotruncana arca*
Lower Campanian	60 m	Grey-green marls, rarely red marls with individual sandstone layers	*Aragonia solchica, Planoglobulina bipartita, Planoglobulina alpina, Globotruncana arca*
Santonian	400 m	Flysch sequence, towards Zemiansky Kvašov passing into marl facies	*Globotruncana stuartiformis, Globotruncana elevata, Globotruncana fornicata, Globotruncana subspinosa, Globotruncana linneiana tricarinata, Gublerina decoratissima*
			Sigalia deflaensis, Sigalia carpatica, Buliminella reussi
Coniacian			*Globotruncana linneiana linneiana, Globotruncana linneiana marginata, Globotruncana angusticarinata*
Turonian	200 m	Flysch sequence	*Globotruncana linneiana linneiana, Globotruncana imbricata*
Middle and Upper Cenomanian	250 m	Grey-green marls with sandstone layers and limestone conglomerates intercalations	*Rotalipora cushmani, Thalmanninella reicheli, Praeglobotruncana oraviensis trigona, Thalmanninella appenninica, Rotalipora montsalvensis*
Lower Cenomanian	200 m	Conglomerate limestones, sandy limestones with marl layers	*Thalmanninella evoluta, Thalmanninella brotzeni, Exogyra columba silicea*
Upper Albian	200 m	Flysch sequence → Marls	*Thalmanninella evoluta, Thalmanninella licinensis Planomalina buxtorfi*
Barremian and Lower Albian	400 m	Augitites Blue-grey marly limestones and marls sometimes black–grey limestone of Urgonian type black-grey marls and limestones of Urgonian type	*Epistomina charlotae, Epistomina spinulifera, Hedbergella roberti Discorbis wassoewizi, Anomalina (Anomalina) djaffarovi Planomalina (Globigerinelloides) cheniourensis Hedbergella infracretacea, Anomalina (Gavelinella) barremiana*
Valanginian Hauterivian	100 m	Light-grey limestones and spotted marls	*Planomalina (Globigerinelloides) typica, Bilicinella breggiensis Lenticulina ouachaensis, Lenticulina gutlala, Conorbis valendisensis*

ones) in the Albian. The Albian is microbiostratigraphically divided into the lower and upper parts.

The Lower Albian is characterized by the following foraminiferal association: *Haplophragmoides nonioninoides* (Reuss), *Epistomina spinulifera* (Reuss), *Epistomina spinulifera polypioides* (Eichenberg), *Hedbergela roberti* (Gandolfi), *Anomalina (Gavelinella) complanata* Reuss, *Arenobulimina torula* Tappan, *Arenobulimina paynei* Tappan, *Valvulineria fusca* Wiliamsom, *Discorbis wassoewizi* Djaffarov et Agalarova, *Pleurostomella obtusa* Berthelin, *Pleurostomella barroisi* Berthelin, *Pleurostomella reussi* Berthelin, *Hedbergella globigerinellinoides* (Subbotina) and *Hedbergella* sp.

The Upper Albian contains distinct foraminiferal association represented mainly by species: *Thalmanninella ticinensis* (Gandolfi), *Ticinella multiloculata* (Morrow), *Planomalina (Planomalina) buxtorfi* (Gandolfi), *Rotundina stephani* (Gandolfi) and *Arenobulimina* cf. *brevicona* (Perner).

Cenomanian

Cenomanian sediments have not been preserved in all series in the complete stratigraphic sequence. They may be studied near the Smolenice castle and Škarbák, where complete Cenomanian has been preserved, marls predominating. Generally, association of foraminiferes of the Lower Cenomanian has been represented by species: *Thalmanninella evoluta* (Sigal), *Thalmanninella appenninica* (Renz), *Thalmanninella ticinensis* (Gandolfi), *Rotudina stephani* (Gandolfi), *Glavulina gaultina* (Morozova), *Anomalina (Gavelinella) complanata* (Reuss).

Middle-Cenomanian foraminiferal association has been represented by species: *Thalmanninella appenninica* (Renz), *Thalmanninella reicheli* (Mornod) and *Globigerinella* sp.

The Upper Cenomanian of the Central Carpathians is represented by species: *Ammodiscus tenuissimus* (Gümbel), *Glomospira gaultina* (Berthelin), *Marssonella oxycona* (Reuss), *Thalmanninella reicheli* (Mornod) and *Rotalipora cushmani* (Morrow).

II. MANÍN SERIES

Geographically it covers 6—10 km wide, in some places narrower, belt, beginning near Trenčianská Teplá, continuing to Ilava, Ladce, Košeca, Belušská Slatina, Dolný and Horný Lieskov, Dolný Moštenec, Považská Teplá, Hrabová and disappearing in the northern vicinity of Žilina. However, in the area from Hrabová to Žilina in the Senonian also variegated marls have been developed, giving the Cretaceous of Manín the character, more or less resembling the Cretaceous of the Klippen belt.

Opinions on the position of the Manín series were different. We shall mention just two of them here. D. Andrusov (1945, 1959) regarded the Manín series (included by D. Andrusov and E. Scheibner 1960 into the Vysoké Tatry series) as a member of the Klippen belt, while M. Maheľ (1960) included the series in the Central belt of the West-Carpathians, i. e. to the group of the West-Carpathian series.

Reasons, leading the mentioned authors to such diverse opinions were based upon tectonic criteria (partly klippen style of the tectonic structure of the Manín series), facial criteria as well as stratigraphic (facial concordance of some stratigraphic members with the Klippen ones as well as with the West-Carpathian members and occurrence of stratigraphic hiatuses, acknowledged till now).

Although the Manín series has many common features either with the Kysuca or the Zliechov series, we incline to the opinion, that it has the character of an independent unit, however, not in the tectonic sense — as understood by D. Andrusov, E. Scheibner (1960). The Manín series is connected with the Zliechov series (the "Subtatric") and with the Kysuca series by means of gradual facial transition. Therefore also the boundaries among particular series are rather a question of convention.

Besides that, detailed biostratigraphic works proved connection of the Flysch Albian of the Manín type with the underlying Lower Cretaceous of the Kysuca series, in several places (A. Began 1962; J. Salaj 1961) (Tables 2, 3).

Cretaceous sediments of the Manín series are characterized by remarkable diversity of the facies in both vertical and horizontal directions. Greatest variety of the facies may be observed in the section across the Manín series, i. e. from the "Zliechov" series to the Klippen belt. The age of individual facies is strongly variable, most probably because of different bathymetric conditions.

The Neocomian is characterized by grey-green marly spotted limestones and marls. On the stratigraphic tables the variable extent of the facies is evident. From the lithologic standpoint, the Neocomian of the Manín series besides the Manín and Butkov klippens is identical with that of the Choč and the Krížna series as well as with that of the Kysuca series. Facial differenciation started only at the end of the Neocomian e. g. at the contact of the Neocomian of the Choč and the Krížna series the Barremian — Lower Albian is developed in the same facies, common to both Neocomian sequences. It consists of black-grey, here and there green marls, and dark, cherty fine-crystalline limestones. In some places, especially in the upper part of the sequences, beds of sandstones, occur sporadically.

In the Manín series, in the Barremian-Aptian several types of facies may be observed. First of all there are limestones of the Urgonian type. Further there are marls with sporadic intercalations of sandstones, belonging to the Aptian. This type of facies may be studied near the cemetery in Považská Bystrica around the elevation of Kalvária. Besides that the marls, belonging to the so-called spherosiderite beds, may be observed in wider vicinity of Lednické Rovné. They have been developed from the Neocomian of the Kysuca series (J. Salaj, 1961). Their age diapason covers the Aptian-Albian, in some places even the Lower Cenomanian. Toward the top they pass into variegated marls of the Kysuca series. Variegated marls with the Aptian microfauna (*Globigerinelloides algeriana, Globigerinelloides typica, Planomalia cheniourensis, Hedbergella roberti, Biglobigerinella barri* and others) may be found in the scarp of the field road to the village Uhry. The marls are about 3 m thick. They pass into the Flysch Upper-Aptian to Lower-Albian sediments.

Important is the fact, that the above Aptian sediments gradually pass into the Albian without any interruption. It is completely proved by recent biostratigraphic results as well as by new field mapping throughout the Manín series. The Krížna development of the Aptian-Lower Albian passes gradually

Table 2. Microbiostratigraphy of Cretaceous of the Manín-series and Paleogene of the Klippen belt in the surroundings of Považská Bystrica, Orlové, Plevník and Udiča

Horizonts	Thick.	Lithofacial character	Faunal character
Paleocene	50 m	Light-grey sandy to conglomerate limestones with reef alg—coral limestones	*Discocyclina* aff. *seunessi*
Maastrichtian	50—80	Orbitoid limestones	*Orbitoides* sp. *Pseudotextularia elegans, Globotruncana falsostuarti*
Campanian	100—150 m	Flysch sequence	*Globotruncana arca, Globotruncana caliciformis*
Santonian		Variegated marls	*Globotruncana fornicata, Epistomina favosoides*
Coniacian	500 m	"Orloé" beds facies	*Globotruncana linneiana coronata, Globotruncana linneiana linneiana* *Globotruncana angusticarinata*
Turonian			*Globotruncana linneiana linneiana, Globotruncana imbricata* *Exogyra columba maior*
Cenomanian			*Exogyra columba silicea*
	10 m	Orbitoline sandstones and marls	*Orbitolina conica, Orbitolina mammillata, Orbitolina plana*
Albian	300 m	Flysch sequence with thick layers of exotic conglomerates	*Thalmanninella licinensis*
Aptian	500—600 m	Flysch sequence with marls prevailing in bottom parts	*Discorbis wassoewizi, Epistomina spinulifera, Epistomina charlotae, Hedbergella globigerinellinoides*
	6 m	Variegated marls	*Hedberg. roberti, Globigerinelloides typica, Globiger. cheniourensis*
Valanginian—Barrémian	50 m	Grey-green marly, spotted limestones and marls	*Hedbergella infracretacea, Gavelinella barremiana, Lenticulina ouachensis*

Table 3. Microbiostratigraphy of Cretaceous of the Manin series and of the basal Paleogene of Central Carpathians in the surroundings of Dolný Moštenec, Manin, SW surroundings of Pov. Bystrica and Rybárikovo

Horizones	Thick.	Lithofacial characteristics	Faunal character
Lower and Middle Paleocene	100 m	Fine-grained, conglomeratic, sandy, organogene limestones fine-grained conglomerates with layers of organogene corall—algal limestones	*Discocyclina seunessi*, primitive Nummulites
Danian (= Lower Paleocene)	20 m	Sandy to conglomeratic limestones, fine-grained conglomerates with beds of Hippurites limestones	Hippurites and — ? primitive Nummulites
Maastrichtian	250 m	Grey-green marls with sandstone layers	*Reussella szajnochae, Gublerina acuta robusta, Globotruncana falsostuarti*
Campanian			*Globotruncana arca* *Gublerina bipartita*
Santonian	200 m	Flysch sequence	*Globotruncana elevata, Globotruncana fornicata* *Planoglobulina decoratissima*
Coniacian	200 m		*Sigalia deflaensis*
			Globotruncana angusticarinata, Stensiöina bohemica
Turonian	200 m		*Globotruncana imbricata, Globotruncana linneiana linneiana*
Cenomanian	200—250 m	Grey-green Flysch sequence, sometimes in the facies of "Orlové" beds	*Rotalipora cushmani, Thalmanninella reicheli, Praeglobotruncana oraviensis, Rotalipora montsalvensis* *Exogyra columba silicea* *Thalmanninella brotzeni, Thalmanninella appenninica*
Albian	200 m	Marls augitites, tuffites	*Thalmanninella evoluta* *Thalmanninella ticinensis* *Hedbergella roberti*
Urgonian	100—150 m	Black-grey, sometimes cherty limestones. At Skalica also as conglomerats	*Clavihedbergella subcretacea, Anomalina agalarovae, Anomalina djaffarovi* *Orbitolina bulgarica, Orbitolina paronai, Orbitolina conoidea, Orbitolina discoidea*
Valanginian—Hauterivian	120 m	Light-grey marly limestones and marls	Tintinidae, *Neolissoceras grassi*

into the Manín Flysch Albian. Possibility for the transition from the Krížna Aptian to the Manín Albian in the vicinity of Trstie and Horný Moštenec has been recorded by M. Maheľ (1955) and affirmed by later investigations (M. Maheľ, A. Kullmanová, 1961; J. Salaj, 1962).

Microfauna has proved that the Barremian-Aptian in the facies of the Urgonian limestones passes gradually into marls of the Upper Aptian-Lower Albian (e. g. near H. Moštenec, Záskalie) as well as into marly limestones and marls of the Albian (in the quarry near Horné Ladce). In some places, between the Urgonian limestones and Upper-Albian marls occure the igneous rocks (augitites) and tuffites (near Praznov, H. Moštenec).

Grey-green and variegated Aptian marls from the vicinity of Lednické Rovné and Uhry pass into the Flysch sediments connected with the overlying exotic conglomerates of the so-called Upohlav beds. The latter bear intercalations of sandstones and marls with the Upper-Albian microfauna. Sporadic beds of these conglomerates appear also in the Orlov beds, their age diapason being Cenomanian-Lower Santonian. The study of exotic conglomerates has been carried out during the field works of 1959–1961 by A. Began (in: J. Salaj, 1961) and J. Salaj – A. Began (in press). The authors point out that the material of exotic conglomerates originated from a ridge extending at the boundary of the Manín and the Kysuca series. The ridge in the vicinity of P. Bystrica existed from the Upper Albian to the lower Santonian and the in vicinity of Žilina – from the Upper Turonian to the Upper Coniacian. The ridge has been mentioned also by E. Scheibner (1962), though, in another sense. It is necessary to add, that the conglomerates in question (the scarp of the road near Orlové and adjacent vicinity) represent a marginal facies, surrounding the ridge, emerged already from the Upper Albian, and not evidence of the Upper-Cretaceous transgression.

Cenomanian

Besides the above mentioned facies of the Orlové sandstones (cropping out mainly in the large syncline between Orlové, Pov. Podhradie, Vrtižer, with one limb having the reversed bed sequence near Pov. Podhradie) in the Lower Cenomanian occur the flysch Orbitolina beds (Pov. Bystrica, Hrabové) and beds of organogenous conglomeratic limestones and conglomerates with *Exogyra columba silicea* Lam. In the Lower Cenomanian in the scarp of the field road to Slopná developed the conglomerates. The Middle and Upper Cenomanian have been developed in the facies of marls that may be studied mainly near Horné and Dolné Lieskové and Slopná.

The Turonian – Santonian of the Manín series is represented by the flysch sediments. At some places marls may be found. The Lower Cenomanian is represented by grey-green marls with sandstone beds and variegated marls. The mentioned beds together with the uppermost Santonian developed also in the facies of variegated marls, appear above the Orlové beds exposed near Udiča.

The Upper Campanian-Lower Maastrichtian has been developed also in the flysch facies and in the facies of variegated marls. The flysch sediments crop out mainly near Hrabová, Dolný and Horný Moštenec, while the variegated marls – at the contact of the Manín series with the Klippen belt.

Near Rybárikovo the Upper Maastrichtian in the facies of green marls with sandstone beds in connected with overlying Paleocene organogeneous conglomeratic limestones with *Discocyclina seunesi* Douville. The facies southwards becomes transgressive and younger.

Variety of facies as well as their various age changing from place to place, emerging of the elevation at the boundary of the Manín series and the Klippen belt, existence of conglomerates with exotic material in various horizons of the Cretaceous, all this indicates synsedimentary tectonic movements, beginning already at the end of Neocomian, continuing during the entire Cretaceous, with intensity changing from place to place.

III. THE CRETACEOUS MICROBIOSTRATIGRAPHY OF THE KLIPPEN BELT

Several authors devoted remarkable attention to the Lower and Middle Cretaceous of the Klippen belt of particular series (the Pieniny, Kysuca, Pruské and Czorsztyn series). Earlier works, concerning the problems have been evaluted in D. Andrusov's (1945, 1959) works. In the last years, particular series in various areas of the Klippen belt have been studied first of all microbiostratigraphically, resulting in valuable contributions to the knowledge of facial conditions of individual series. Such are especially works of the following authors: V. Kantorová—A. Began (1958); E. Scheibner—V. Scheibnerová (1958 a, b); V. Scheibnerová (1958 a, b, 1961 a, b); D. Andrusov—E. Scheibner (1960); B. Leško—O. Samuel (1960); A. Began—V. Kantorová 1961; J. Salaj (1961); J. Salaj—O. Samuel (1963); J. Salaj—A. Began (1963); J. Salaj—O. Jendrejáková (1962).

Important contribution to the stratigraphy of the Lower and Upper Cretaceous is the recognition of K. Birkenmajer (1957) about the uninterrupted sedimentation between the Lower and Middle Cretaceous, admitted till the present in the Pieniny, Kysuca and Pruská series, while in the Czorsztyn series stratigraphic hiatus has been admitted (D. Andrusov, 1959), due to the geanticlinal structure of the Czorsztyn series in the course of the Neocomian. As a ground for this opinion serves the lack of the Neocomian in the series and transgression of the Middle Cretaceous on the Tithonian-Berriasian. By closer study of the problem it may be found that Middle Cretaceous sediments which should be transgressive, have been developed always in the facies of variegated marls, without detrital admixture, considered as purely pelagic in the rest of the series of the Klippen belt.

The Upper Neocomian and the Aptian have been developed in the marly facies in all the series of the Klippen belt. The lack of these sediments in the Czorsztyn series may be explained not only by the primary absence, it may also be secondary due to submarine erosion (as admitted e. g. by K. Birkenmajer, 1957).

It cannot be said unambiguously, however, that the interruption of sedimentation in some parts of the Klippen belt in the Czorsztyn series would be impossible, but the recent facts so far are not sufficient proof of the stratigraphic hiatus in the whole extension of the series. The question of the hiatus in the Czorsztyn series examined O. Jendrejáková—J. Salaj (1962) when studying the vicinity of Mikušovce and microbiostratigraphically evaluating

the boreholes with complete section of the Lower and part of the Middle Cretaceous.

The Lower and Middle Cretaceous of the Klippen belt have been microbiostratigraphically evaluated in the Kysuca series of Pieniny (V. Kantorová in J. Srnánek, 1956). Later on in the vicinity of Žilina near Brodno (E. Scheibner—V. Scheibnerová, 1958). Facies described here, may be observed also in other series of the Klippen belt. The Neocomian-Aptian has been developed in the facies of marls and limestones. The above mentioned authors call the Albian developed in the facies of spotted marls as Rudiná beds, the Cenomanian variegated marls — as Lalinek beds, variegated marls of the Lower Turonian with sandstone interbeddings — as Kysuca beds, and the overlying Flysch sequence, considered as the Lower Turonian, the Snežnica beds. According to E. Scheibner and V. Scheibnerová (l. c.) these beds terminated the sedimentation of the Middle Cretaceous in the Kysuca series. Interruption of sedimentation is recognized also in the other series of the Klippen belt (D. Andrusov, E. Scheibner, 1960).

It is difficult, however, to distinguish among the particular series of the Klipen belt in the field without micropaleontologic data whether the marls of the Albian, Cenomanian or Turonian are concerned. The less possible it is then to call them by apropriate names. Besides that, spotted marls determined as the Rudin beds contain not only the Albian, but also the Aptian and the Barremian. In this case it is then better to use older term Globigerina-Radiolaria beds, introduced by K. Birkenmajer (1957).

The sandstone strata in the Lower-Turonian variegated marls are not always developed, and besides that, the Flysch sequence of the Lower Turonian has in the majority of cases larger stratigraphic diapason even to the Coniacian; consequently, as to the age diapason—the Snežnica beds may correspond also to the Polish Sromowiec beds determined by K. Birkenmajer (1959), which on the ground of macrofauna (K. Birkenmajer—B. Kokoszyńska, 1958) and microfauna (M. Książkiewicz, 1958) have been included in the Upper Turonian to Lower Emscherian.

The above reasons, and the fact, that stratigraphic diapason of facies is changing much within the series, lead us to coclusion, that it is more correct not to use the above mentioned terms in the lithological-stratigraphical sense.

Till the present, the Senonian sediments of the Klippen belt have been stratigraphically considered as one sedimentation cycle, which—after the Subhercynian folding—started the transgression by the Santonian sediments. The Danian-Paleocene variegated marls have been considered as the youngest sequence (K. Birkenmajer, 1954; V. Kantorová—A. Began, 1958; J. Salaj, 1961; D. Andrusov—E. Scheibner, 1960).

Since we incline to the opinion about continuous sedimentation between the Middle and Upper Cretaceous, for better understanding of the stratigraphy of the Cretaceous the stratigraphic analysis of the so-called Upohlav conglomerates is going to be presented, too. The sequence so far has been included in Santonian. However, the following facts oppose the opinion:

1. Were the conglomerates really Santonian and transgressive, inevitably there should be a transgressive surface they would lie upon. However, any transgressive beds of the so-called Upohlav conglomerates have not been found throughout the Klippen belt (cf. D. Andrusov, 1945).

2. Detail studies have indicated (J. S a l a j, 1961) that conglomerate sequences (without organogenous limestones) belong to various stratigraphic levels.

a) Conglomerate sequence in the belt between Dolný Moštenec and Zemiansky Kvašov belongs to the Cenomanian. It is proved by Exogyra, represented by species *Exogyra columba silicea* L a m., Coralls and by microfauna represented mainly by Rotalipora.

b) Conglomerate sequences, forming intercalations in the Flysch sequence near Považská Bystrica (Kukučínova street) belong to the Upper Albian. It is proved by their position. They are found in below the Orbitolina Lower-Cenomanian sequence with abundant Exogyra, represented also by the species *Exogyra columba silicea* L a m. Direct superposition of the conglomerates is proved by abundant hieroglyphs in sandstone beds.

c) Exotic conglomerates—as the integral part of the Flysch sequence—developed in wider vicinity of Nosice, Upohlav, Milochov, belong to the Upper Albian (A. B e g a n in J. S a l a j, 1961), while underlying Flysch sequence (here and there marls are predominating) belong to the Aptian—Middle Albian.

d) The so-called Upohlav conglomerates near Brodno are to be regarded as the integral part of the Flysch sequence with age diapason covering the Turonian—Lower Coniacian. The sequence develops from the Lower Turonian—Lower Conician variegated marls, passing into variegated marls of the Upper Coniacian.

e) In Orava near Dlhá and Krivá there are the Upohlav conglomerates of the Coniacian-Santonian age, slowly developing from the Upper Turonian Flysch sequence. In contrast to the conglomerates of Upohlav the conglomerates which are exosed in the scarp of the road leading to Krivá belong to Upper Maastrichtian. Rich orbitoid Foraminifera appearing within the fine calcareous arenaceous cement are represented by the following species: *Orbitoides gensacicus* (L e y m e r i e), *Orbitoides apiculata apiculata* S c h l u m b e r g e r, *Orbitoides apiculata grünbachensis* P a p p, *Orbitoides apiculata plana* K ö h l e r, *Orbitoides gensacicus* (L e y m e r i e) and *Siderolites calcitrapoides* L a m a r c k.

The facies just described in the wider enviroment of the discused locality is reaching up to Paleocene.

f) In wider vicinity of Púchov there are conglomerates belonging to the Maastrichtian-Paleocene, resting either conformably over the variegated Campanian-Lower Maastrichtian marls, or they are transgressive (A. B e g a n—J. S a l a j, 1962).

g) In the East Slovakia, conglomerates of the Upohlav type in the Klippen belt are completely absent.

3. Special attention has been devoted to the Hippurites limestones, occurring with the reef corall-Algae limestones in the conglomerate sequence, in the belt between Kočkovce and Považská Bystrica. On the ground of paleontological data (Nummulites, Discocyclinas, Distichoplaxes) the sequence with all occurrences of organogenous limestones (except the Hippurites reef from the locality Pod Húšťom) belongs to the Paleocene. Facies of the organogenous Hippurites limestones is formed by grey-brown limestones, in some places sandy. On the elevation point Rašov, primitive Nummulites have been found in the limestones with fragments of Hippurites.

In limestones filled by complete Hippurites no Nummulites have been found. An objection may arise, however, that Hippurites fragments may have been

resedimented from older deposits. Although the possibility is not excluded, we should like to add, that fragments of Hippurites forming the breccia, may be observed also in the cement matter, among well-preserved Hippurites forming the Hippurites limestones. From the standpoint of ecology, this fact is obvious, since the organogenous limestones have been formed in shallow-water of the coastal zone and there many individuals have been broken with other reef forming organisms.

In the thin-section of the Hippurites limestones from the locality Pod Húšťom strongly recrystallized section across a large Foraminifera has been found, reminding the primitive Nummulites.

These facts convinced us to include the above sequence with Hippurites limestones from localities Rašov and Pod Húšťom into the Danian or to the uppermost Maastrichtian.

Since Hippurites determined by O. Kühn, D. Andrusov (1937, 1942) are believed to be of Santonian age, it is necessary to carry out a revision of all so far recovered Hippurites and thus to help solving the problem. In fact, it is possible, that in the localities occur Hippurites which by their stratigraphic position are bound only to the uppermost Maastrichtian to Danian, as it is known from other world localities (E. Neaverson, 1955).

The reef-forming activity has been bound to the period of Lower Paleocene-Yppresian. Reefs occur usually as lenses in conglomerate sequences, or as rounded blocks and boulders. Paleocene age of the organogenous limestones is proved by Discocyclina, represented mainly by the species *Discocyclina seunesi* Douvillé. Besides that there are abundant organisms of predominantly plant origin, indicating the Paleogene age (M. Mišík and J. Zelman, 1959). In conglomerate sequences Nummulites occur, especially near P. Bystrica and at Kravárikov.

4. It has been supposed, that before the transgression of the Senonian (D. Andrusov, E. Scheibner, 1960) the surface of the Klippen belt were uneven, the depressions were filled with conglomerates. Overlying marls rest transgressionally upon higher strata, i. e. upon the particular klippens. Variegated marls with particular klippens are always in tectonic contact.

After proving that the so-called Upohlav conglomerates are of variable age and that variegated Senonian marls are mainly of Campanian age passing into Orbitoides beds, the use of terms Jarmut and Rašov developments of the Senonian is further unfounded.

It should be remarked to the problem of the age of variegated Gbelany marls and Jarmuta beds, that in the majority of cases the Jarmuta beds are resting normally over the variegated marls. In some places, where the Senonian sea has been deeper the age diapason of variegated marls is from Campanian to the Maastrichtian, and thus in these cases the Jarmuta beds have not been developed. Consequently, in this case we may speak of isopic character of the above facies in the sense of D. Andrusov. It should be added, that in some places, facies of Jarmuta beds in the Klippen belt continues to the lower members of Paleogene, without the development of variegated Danian-Paleocene marls. Besides that, we are going to deal with the stratigraphy of the Turonian of the Klippen belt its existence as a complete stratigraphic unit in connection with continuous sedimentation between the Middle and Upper Cretaceous. Therefore it is necessary to give its brief microbiostratigraphic characteristic.

The uppermost Cenomanian, found in the Klippen belt in the facies of variegated marls, contains Foraminifera associations formed by the following species: *Rotalipora cushmani* (Morrow), *Rotalipora turonica* Brotzen, *Rotalipora turonica thomei* Hagn et Zeil, *Rotalipora turonica expanza* Carbonier, *Praeglobotruncana delrioensis* (Plummer), *Praeglobotruncana gibba* Klaus, *Praeglobotruncana marginaculeata* (Loeblich et Tappan), *Thalmannilla reicheli* (Mornod), *Hedbergella planispira* (Tappan), *Hedbergella portsdownensis* (Williams et Mitchell).

Foraminifera association, formed by species: *Rotalipora* ex. gr. *cushmani* (Morrow), *Thalmanninella reicheli* (Mornod), *Praeglobotruncana oraviensis* (Scheibnerová) it is probably the syn. of the species *Praeglobotruncana oumalensis* (Sigal), *Praeglobotruncana oraviensis trigona* Scheibnerová, *Globotruncana imbricata* Mornod, *Globotruncana helvetica* Bolli, is till now considered as transitional biozone of the boundary of the Cenomanian and the Turonian, since on one hand—according to reference data, *Rotalipora cushmani* (Morrow) and *Rotalipora turonica* Brotzen (Morrow, 1934; Brotzen, 1942) occur in the Lower Turonian, and on the other hand, *Globotruncana imbricata* Mornod and *Globotruncana helvetica* Bolli—in the uppermost Cenomanian (Gandolfi, 1955). When it will be proved that *Globotruncana helvetica* Bolli occurs only in the Turonian, then we shall be obliged to regard the zone as Lower Turonian.

The Lower-Turonian Foraminifera association (association of upper part of the Lower Turonian) is formed by species: *Globotruncana imbricata* Mornod, *Globotruncana turonica* Samuel et Salaj, *Praeglobotruncana oraviensis trigona* Scheibnerová, *Praeglobotruncana oraviensis* Scheibnerová. It is interesting, that the species *Globotruncana helvetica* Bolli has not been found in the Foraminifera association. It has been found in the following Foraminifera association: *Globotruncana renzi* Gandolfi, *Globotruncana coldriensis* Gandolfi, *Globotruncana imbricata* Mornod, *Praeglobotruncana oraviensis* Scheibnerová, *Praeglobotruncana oraviensis trigona* Scheibnerová.

The following Foraminifera association is considered partly as the lower, but mainly as the middle and lower part of the Upper Turonian: *Globotruncana helvetica* Bolli, *Globotruncana imbricata* Mornod, *Globotruncana renzi* Gandolfi, *Globotruncana sigali* Mornod, *Globotruncana biconvexa biconvexa* Samuel et Salaj, *Globotruncana biconvexa gigantea* Samuel et Salaj, *Praeglobotruncana oraviensis* Scheibnerová, *Praeglobotruncana oraviensis trigona* Scheibnerová.

The Upper-Turonian association of Foraminifera is represented by species: *Globotruncana sigali* Mornod, *Globotruncana linneiana linneiana* (d'Orbigny), *Globotruncana linneiana coronata* Bolli, *Globotruncana linneiana marginata* (Reuss), *Globotruncana renzi* Gandolfi.

IV. CENTRAL CARPATHIAN SENONIAN (GOSAU CRETACEOUS)

Sediments of the so-called Gosau Cretaceous crop out in the Myjavská pahorkatina highlands. We are not going to deal with its stratigraphy here, since it has been presented in previous works [J. Salaj 1960, 1962; O. Sa-

muel—J. Salaj 1961; J. Salaj—O. Samuel (in press), J. Salaj—A. Began (in press)].

We are going introduce briefly some data, generally characterizing the sediments of Myjavská pahorkatina highlands:

1. Stratigraphic diapason of the sediments reaches from the Coniacian to the Upper Eocene.

2. Paleogene sediments according to their development in the southern part of the Myjavská pahorkatina highlands belong to the Central-Carpathian Paleogene, while in the northern part, adjacent to the Klippen belt—to the southern development of the Paleogene of the Klippen belt.

3. The Senonian of the Myjavská pahorkatina highlands is facially very similar to the Senonian of the Klippen belt, differring from it by transgressive character of the Coniacian sediments and by their clastic development.

4. Characteristic feature of the Central-Carpathian Senonian is the fact, that it has been developed from the Pienidy geosyncline. In the Coniacian the sea advanced from the geosyncline to the South upon folded series of the Central belt.

5. Sediments of the Myjavská pahorkatina highlands were in direct contact with the Paleogene of the Klippen belt and the Magura belt.

6. Folding of the Coniacian-Upper-Eocene sediments took place as late as in the Oligocene.

Detailed Cretaceous stratigraphy of particular areas of the West-Carpathians has been presented by the authors (J. Salaj, O. Samuel) elsewhere (in press).

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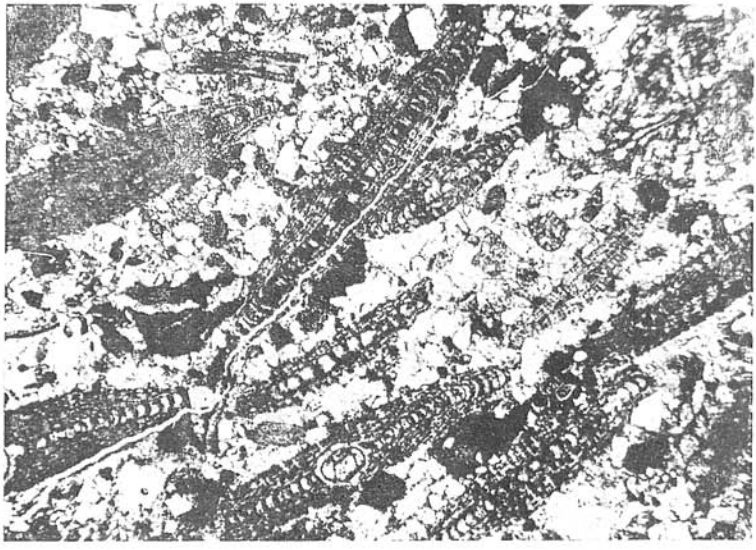
Review by V. Pokorný.



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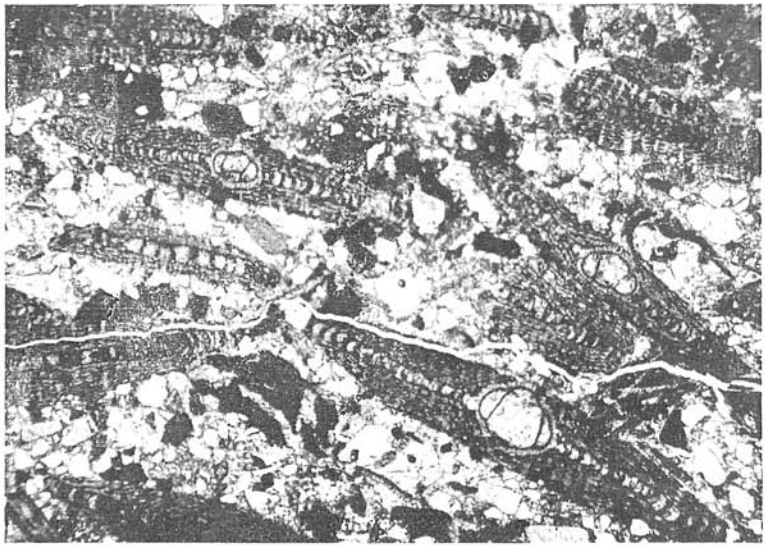

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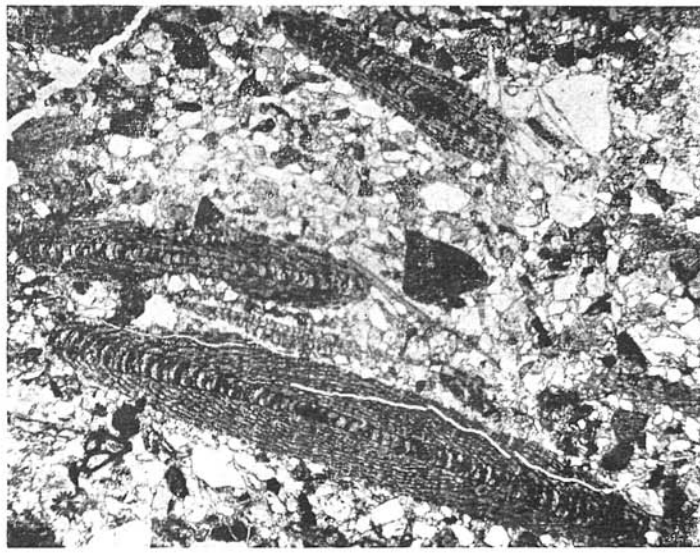
Fig. 1. *Orbitoides apiculata grünbachensis* Papp, *Siderolites calcitrapoides* Lamarck and *Orbitoides apiculata plana* Köhler. — Fig. 2. *Orbitoides apiculata plana* Köhler, *Orbitoides apiculata grünbachensis* Papp. 13.



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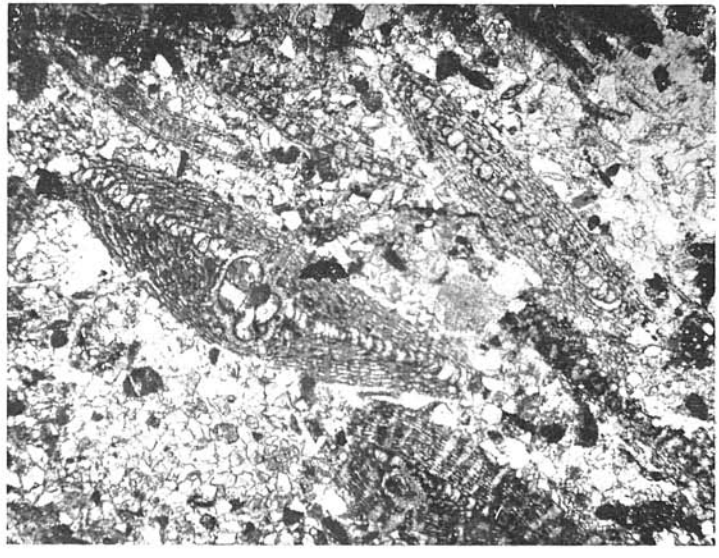

2

Fig. 1. *Orbitoides apiculata plana* K ö h l e r. — Fig. 2. *Orbitoides apiculata plana* K ö h l e r, *Orbitoides gensacicus praevius* K ö h l e r.
All from the same thin-section. X 13. Cement of the Upohlav Conglomerats. Locality: The escarpment of the road SW Krivá. Middle Maastrichtian.