

VIERA SCHEIBNEROVÁ¹**CRETACEOUS STRATIGRAPHY AND CRETACEOUS-TERTIARY
BOUNDARY IN THE KLIPPEN BELT OF WEST CARPATHIANS****BIOSTRATIGRAFIA KRIEDY A HRANICA KRIEDY A PALEOGÉNU
V BRADLOVOM PÁSME ZÁPADNÝCH KARPÁT***(Enclosure 2)*

Abstract. Review of the biostratigraphy in the Lower and Upper Cretaceous and the Cretaceous-Tertiary boundary in the klippen belt of West Carpathians in Slovakia on the basis of microfauna, macrofauna and microfacies.

Up to present the stratigraphy of the Lower Cretaceous of the klippen belt of West Carpathians in Slovakia was based only on macrofaunistic, resp. lithologic and microfacial data (D. Andrusov, 1959 a. o.). Foraminifera of the Lower Cretaceous were not studied. During the few last years the present author was dealing among others with collecting of samples from marly intercalations in limestones of the Lower Cretaceous (Valanginian to Aptian). At many places there were found very rich associations of Foraminifers. It was proved on the basis of these associations that it would be possible stratigraphically to divide and characterize many suites which up to present were not more detailed divided. The majority of material descends from marls and marly slates, from which the microfauna was collected by current methods. Part of the material descends directly from limestones from which the microfauna was gained by action of dilute solution of HCl. The first results of elaboration of the microfauna (Valanginian to Aptian) are presented in the first part of this contribution. More detailed results together with paleontological descriptions will be presented in the prepared larger publication.

Further we shall deal with biostratigraphy of the Middle and Upper Cretaceous and the special attention will be paid to the question of the Upper Turonian and Coniacian, which is in the present one of the most actual and important questions of the stratigraphy of Mesozoic of the klippen belt of West Carpathians in Slovakia as well as in the Alps-Carpathians system as a whole. The question of the Upper Turonian and Coniacian in this region is of extraordinary importance as it is in connection with important tectonic questions. During this time period there was an action of the most important tectonic movements, the folding of the Alps-Carpathians system.

During the last time we were dealing more intensively with this problem (V. Scheibnerová, 1962) and we pay an extraordinary attention also in this contribution.

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The questions of the occurrence of the Danian as well as the Cretaceous-Tertiary boundary are also very interesting and on the basis of up to present research we may design them as satisfactorily solved. During the last years it was found the Danian microfauna at many places in the klippen belt (E. Scheibner—V. Scheibnerová, 1961; J. Salaj, 1962; J. Salaj—O. Samuel, 1961), as well as in the eastern part of the klippen belt in Zakarpatská Ukrajina (O. S. Vjalov, N. V. Dabagjan, S. O. Kulčickij, 1960). Micropaleontological results gained by mentioned authors are identical or nearly identical with that gained in other regions of Europe.

Biostratigraphy of the Lower Cretaceous (Valanginian to Aptian)

In the klippen belt series the sedimentation of the Lower Cretaceous in the majority of series gradually passed from the Jurassic in deep-water facies. In some series (Czorsztyn, Haligovka-Klape, Manín series) there was an interruption of sedimentation of emersional character in various horizons of the Lower Cretaceous (partly in the Neocomian), the end of the Aptian and/or in the Lower Albian, after which began further transgression and continued sedimentation. Recently O. Jendrejáková and J. Salaj (1962) found in the bores made in the vicinity of Mikušovce the occurrence of the Neocomian microfauna (Valanginian to Hauterivian) which is regarded by the mentioned authors as belonging to the Czorsztyn series. This may testify that locally in the Czorsztyn series the sedimentation from the Jurassic to the Lower Cretaceous might continue without an interruption. However, this Neocomian probably belongs to the Pieniny series.

Most completely the Lower Cretaceous sequence is developed in the Kysuca series of the klippen belt and it was also more intensively studied (E. Scheibner—V. Scheibnerová, 1958). In the section of Rudina klippen occurs about 30 m thick suite of limestones of "biancone" type, slight grey coloured with rich Calpionellas and Lombardias (*Saccocoma*). These limestones gradually pass from the Tithonian limestones. They are often spotted and contain many cherts. Further increases a number of marly intercalations in which was found the Valanginian-Hauterivian microfauna. In the lower part of the suite was found: *Calpionella alpina* Lorenz, *C. elliptica* Cadisch, *C. undeloides* Colom, *Tintinnopsella carpathica* (Murgeanu et Filipescu, *T. oblonga* (Cadisch), *T. longa* (Colom), *T. cadischiana* Colom, *Calpionellites darderi* (Colom), *Stenosemellopsis hispanica* (Colom) and rarely *Globochaete alpina* Lombard. Frequently occurs *Nannoconus* sp. Sedimentation in this series continued without an interruption into the Aptian-Albian and further into the Cenomanian and Turonian. In the dark grey to black slates occurring between the beds of slight cherty limestones was found the microfauna of the Barremian-Aptian. The characteristic microfauna of the Barremian is composed of the species: *Tritaxia pyramidata* Reuss, *Lenticulina incurvata* (Reuss), *L. calliopsis* (Reuss), *L. subalata* Reuss, *L. slovenica* Scheibnerová, *Discorbis wassoewizzi* Djaffarova—Agalarova, *Gavelinella complanata* Reuss, *G. flandrini* Moullade, *G. flandrini inflata* Scheibnerová, *G. carpathica* Scheibnerová. In the Aptian was found the following microfauna: *Hyperamina gaultina* Ten Dam, *Reophax minutissimus* Plummer, *Glomospira charoides* (Jones et Parker), *Trochamminoides*

sp., *Haplophragmoides concavus* (Chapman), *Ammobaculites subcretaceus* Cushman et Alexander, *Lenticulina münsteri* (Roemer), *L. ouachensis* Sigal, *L. crepidularis* (Roemer), *Spirillina minima* Schacko, *Gavelinella barremiana* Bettenstaedt, *G. rudis* (Reuss), *Epistomina ornata* (Roemer), *E. reticulata* (Roemer), *E. caracolla* (Roemer), *E. caracolla* (Roemer), *Globigerinella duboisi* Chevalier, *G. gottisi* Chevalier, a. o.

In the Pieniny series s. s. we observe similar series of the Lower Cretaceous. In the lower part occurs a suite of light limestones of "biancone" type which passes into light grey thin-bedded marly limestones with cherts alternating with the dark grey slates. It is very typical for the mentioned suite. Above the marly limestones occurs a suite of black, frequently siliceous limestones alternating with black marly slates and green-black spotted limestones belonging to the Aptian-Albian with planctonic and benthonic microfauna quoted in the part dealing with the Middle Cretaceous.

In the Czorsztyn series locally sedimentation gradually continued from the Tithonian as well as in already mentioned series (O. Jendrejáková—J. Salaj, 1962), however, there were emersions, in consequence of which in various stages of the Lower Cretaceous sedimentation was interrupted. On the corroded surface of the older stages of the Mesozoic (Malm) transgressed a suite of grey spotted slates of the Albian (see D. Andrusov, E. Scheibner, V. Scheibnerová, J. Zelman, 1959). The Lower Cretaceous of the Czorsztyn series was described in the Pieniny klippen belt (K. Birkenmajer, 1957) and only locally at Považie and Orava. As Valanginian are regarded red and variegated slaty or nodular marly limestones and marls with many Globigerinas (about 70 per cent of the mass). Higher there were distinguished thin-bedded marly limestones with green and black cherts and green and black marls, frequently with little spots. They contain Radiolaria and Globigerinas (Globigerinas and Radiolarian beds, K. Birkenmajer, 1957; or Rudina beds, E. Scheibner, 1958). Facially these beds resemble cherty limestones of the other klippen belt series and stratigraphically they represent the Valanginian to Barremian. They pass into the Albian.

The Neocomian of the Niedzica series is very thin (2–3 m) and it is represented by cherty limestones. Higher there are black, green limestones and radiolarian cherts with plant fragments. Above these beds there are developed green spotted slaty marls with intercalations of black pyrite marls and marly limestones of 4 m thickness. Trehe was found in these beds *Aucelina* aff. *gryphaeoides* Sow., *Neohibolites minimus* (Lister), *Hamites* aff. *attenuatus* Sow., *H. aff. flexuosus* d'Orb., which belong already to the Albian.

In the Pruské series in the Váh valley the Neocomian is represented by a suite of light limestones (D. Andrusov, 1945). Near Medné (west of Púchov) on the Tithonian lies a limestone breccia. Fragments of the last are composed of white massive limestones with *Calpionella alpina* Lorenz, fragments of Crinoids, Aptychi and fish teeth. Cement of the breccias is of white limestone character with *Lamellaptychus seranonis* (Coqu.), *L. angulocostatus atlanticus* (Hennig). This suite belongs probably to the Neocomian (Berias-Hoterivian). The breccias represent an evidence of the transient emergence at the end of the Tithonian or beginning of the Neocomian, as well as in the Czorsztyn series.

Series of the Lower Cretaceous of the Manín series is analogous with the

Lower Cretaceous of the High Tatric series. The Lower Cretaceous gradually passes from the Jurassic (limestones with Calpionellas, M. Mišík, 1957) by dark grey limestones locally moderately marly with black cherts. The limestones frequently have pseudocolithic structure. Whole the character of the suite is deep-water, only in the upper parts are traces of shallowing—presence of glauconite and grains of SiO_2 . The macrofauna [*Neolissoceras grasi* (d'Orb.)] is also of the Valanginian-Hauterivian character. At other places this suite is developed in form of slight grey limestones and marls with *Lamellaptynchus seranonis* (Coqu.) and *Neocomites* aff. *neocomiansis* d'Orb. and higher in form of black, dark grey fine-grained to massive cherty bituminous limestones with irregularly straggled cherts. In the uppermost part of the Manín series occur massive limestones frequently organogenous with fragments of Rudists, Orbitolinas, Algae and reef-making organisms, which correspond with the Urgonian development of the Upper Neocomian (Barremian-Aptian). Between the Urgonian and Albian sedimentation was interrupted during the so-called Manín phase of emersional character (D. Andrusov, 1959).

At many places in the mentioned series of the klippen belt it was found rich microfauna of the Valanginian. It is composed of the species as follows: *Meandrosira washitensis* Loeblich et Tappan, *Ammodiscus tenuissimus* (Gümbel), *Tristix insignis* (Reuss), *Trochammia concava* (Chapman), *Lenticulina valanginiana* Bartenstein—Brand, *L. münsteri* (Roemer), *L. tricarinata* (Reuss), *L. robusta* (Reuss), *L. saxonica bifurcilla* Bartenstein—Brand, *L. ouachensis* (Sigal), *L. cultrata* (Montfort), *L. minutissima* Scheibnerová, *Pseudoglandulina gracilis* Scheibnerová, *Ellipsoglandulina nuda* Scheibnerová, *Globorotalites bartensteini intercedens* Bettenstaedt. In the marly intercalations between the Hauterivian limestones in various series was found this association of Foraminifera: *Glomospira pusilla* (Geinitz), *Textularia gramen* d'Orbigny, *Valvulina conica* Parker et Jones, *Ophthalmidium* cf. *longiscutum* (Terquem et Berthelin), *Lenticulina calliopsis* (Reuss), *L.* aff. *krzyzanowiensis* Sztejn, *L. münsteri* (Roemer), *L. striatocostata* (Reuss), *L. eichenbergi* Bartenstein—Brand, *Neodosaria sceptrum* Reuss, *Dentalina linearis* (Roemer), *Marginulina robusta* (Reuss), *Gavelinella complanata* Reuss, *G. intermedia* Berthelin, *Epistomina tenuicostata* Bartenstein—Brand, *E. caracolla* (Roemer), *E. dainae* Mjatljuk, *E. spinulifera* (Reuss).

Biostratigraphy of the Middle and Upper Cretaceous (Albian to Maestrichtian)

In the deep-water developments and series of the klippen belt sediments of the Albian-Cenomanian sequence develop gradually from the Neocomian-Aptian. The Albian is most frequently in the development of marly slates of grey colour, often spotted, with rich associations of planktonic Foraminifera: *Hedbergella trocoidea* (Gandolfi), *H. infracretacea* (Glaessner), *H. cretacea* (d'Orbigny), *Ticinella roberti* (Gandolfi), *Planogyrina gaultina* (Morosova), *Rotalipora ticinensis* (Gandolfi). Only sometimes occur red limestones (for instance in the Kysuca series at the right bank of river Kysuca near village Brodno). Locally, in the Czorsztyn series and Manín series we may observe in the Lower Cretaceous emersions, which were presented by an interruptions of sedimentation in various stages of the Lower Cretaceous. Therefore

the Albian is frequently transgressive, in form of green, grey slates and spotted marly limestones. In the cordillery series (Haligovka-Klape and Czorsztyn series) the Albian is frequently in the flysch development with rich associations of benthonic Foraminifera: *Dorothia conulus* (Reuss), *Gabonella minor* Scheibnerová, *Trochammina concava* (Chapman), *Haplophragmoides bulloides* (Beissel), *Ammobaculites subcretaceous* Cushman et Alexander, *Ammobaculoides whitneyi* Cushman et Alexander, *Quinqueloculina* sp., *Lenticulina prima* (d'Orbigny), *L. münsteri* (Roemer), *Ramulina spandeli* (Paalzow), *Dentalina subguttifera* Bartenstein, *Spirillina minima* Schacko, *Discorbis wassoewizzi planus* Scheibnerová, *Gavelinella rudis* (Reuss), *G. flandrini* Moullade, *G. complata* (Reuss), *G. robusta* Scheibnerová, *G. nosicensis* Scheibnerová, *Epistomina spinulifera* (Reuss), *E. cf. polonica* Sztejn, *E. hechti* Bartenstein, Bettenstaedt, Bolli, *Globigerinella carpathica* Scheibnerová.

The Cenomanian passes mostly gradually from the Albian. It is developed in form of marls, marly slates or fine to coarse grained sandstones with *Exogyra columba silicea* Lamarck (in the Klape series) with intercalations of slates. The last beds pass in the uppermost parts into the Upper Cenomanian and Lower Turonian with large types of *Exogyra columba*. These sandstones are represented by the so-called Orlové beds. In lower parts of the Cenomanian the most frequent is an association with *Rotalipora ticinensis* (Gandolfi), *Rotalipora appenninica* (Renz). In the middle parts of the Cenomanian disappears *Rotalipora ticinensis* (Gandolfi) and together with *Rotalipora appenninica* (Renz) occurs *Praeglobotruncana delrioensis* (Plummer). In the uppermost parts we find this association: *Rotalipora appenninica* (Renz), *R. cushmani* (Morrow), *R. deecke*i (Frank e), *Praeglobotruncana delrioensis* (Plummer), *P. delrioensis turbinata* (Reichel). Only occasionally in this association occurs *Praeglobotruncana helvetica* (Bolli) and *P. imbricata* (Mornod) and *P. oraviensis* Scheibnerová.

The Cenomanian in the klippen belt passes gradually into the Lower Turonian. It is built by marly slates and slaty marls of grey, green and red colours, often spotted, or by flysch beds with planctonic microfauna.

In the Kysuca series the Albian is represented by the so-called Rudina beds (E. Scheibner, 1958). It is a suite of marly bedded limestones of grey, dark-grey or brownish-grey colours, distinctly spotted. Between these limestones there is an intercalation of red limestone. Between the beds of limestone are intercalations of marly or siliceous slates of dark grey, green grey, black grey colours also spotted. In the upper parts the slates predominate. In the limestones are numerous pelagic microorganisms, *Nannoconus* sp., *Radiolarias*, *Hedbergella cretacea* d'Orbigny, *H. infracretacea* Glaessner, *Ticinella roberti* (Gandolfi). The last species occurs in the uppermost parts of the Rudina beds, which represent the Upper Albian. Higher predominate green grey, green, grey spotted slates with intercalations of massive spotted marls of the same colours. In the lower parts they contain *Ticinella roberti* (Gandolfi), *Rotalipora ticinensis* (Gandolfi) which represent the Upper Albian and higher in the Lower Cenomanian they contain *Rotalipora ticinensis* and *R. appenninica* (Renz). Above this transitional suite we may distinguish about 25 m thick suite of marls and marly slates of red, pink, grey colours often spotted with *Rotalipora appenninica* (Renz), *R. deecke*i (Frank e), *R. cush-*

mani (Morrow), *Praeglobotruncana delrioensis* (Plummer), *P. delrioensis turbinata* (Reichel) of the Upper Cenomanian age, which was called Lalinek beds (E. Scheibner, V. Scheibnerová, 1958). Above these beds lies a suite of red marly slates and marls which are alternated with grey calcareous sandstones. The thickness is about 15 m. They contain: *Praeglobotruncana helvetica* (Bolli), *P. delrioensis turbinata* (Reichel) and are of the Lower Turonian age. These beds were called the Kysuca beds (E. Scheibner, V. Scheibnerová, 1958). The uppermost suite of the Middle Cretaceous of the Kysuca series is a flysch suite composed of grey, dark grey marly or sandy slates, which are alternated with sandstones. On the stratification planes of the sandstones we observe many traces of Gastropods (*Paleobullia*). In the slates were found: *Globotruncana linneiana linneiana* (d'Orbigny). The thickness is about 200 m. It was called as Snežnica beds (E. Scheibner—V. Scheibnerová, 1958). All the Lower and Middle Cretaceous in the Kysuca series has a character of deep-water sediments. Only in the Turonian we observe a shallowing of the sea. As an evidence of it serves an essentiality of detritic sediments (flysch beds and conglomerates) and the microfauna is of another character as in other series as we shall see further.

In the Branisko series we may see the same sediments as in the Kysuca series.

The Middle Cretaceous sediments in the Pieniny series are of the similar character as in the Kysuca series, they differs only in some details and thickness of some beds.

In the Czorsztyn series the Albian is represented by thin-bedded marly limestones with green and black cherts and by green and black marls, often spotted, which contain numerous Globigerinas and Radiolarias, in upper parts with *Rotalipora ticinensis* (Gandolfi). Above the Albian lies the Cenomanian in form of the so-called Globotruncana beds—green, grey or red marls with *Rotalipora appenninica* (Renz). These beds gradually pass into the red marls of the Lower Turonian with *Globotruncana linneiana linneiana* (d'Orbigny). The upper part of the Lower Turonian is built by the flysch beds of the similar character as the Snežnica beds in the Kysuca series.

Very interesting is unusually little thickness of the older beds of the Cretaceous in this series, which represents a geanticlinal series. In the Turonian, however, we may observe the deepening of the sea and the development of the pelagic sediments with pelagic associations of Globotruncanas, which differ from that of the Pieniny series. More detailed dates about this microfauna see further.

In the Niedzica series in Pieniny the Albian is built by green spotted slaty marls with intercalations of black pyrite marly slates and marly limestones of 4 m thickness. In these beds was found *Rotalipora ticinensis* (Gandolfi), *Aucelina* aff. *gryphaeoides* Sow., *Neohibolites minimus* (List.), *Hamites* aff. *attenuatus* Sow., *H.* aff. *flexuosus* d'Orb. Above the Albian beds are developed beds of the Cenomanian-Turonian.

At Orava we may find very interesting suite of the Middle Cretaceous. Such suite occurs near Zemianská Dedina and Krásna Hôrka west of Tvrdosín, in which was found *Clavulina gaultina* Morosova, *Marssonella oxycona* (Reuss), *Hedbergella infracretacea* (Glaessner), *Ticinella roberti* (Gandolfi), *Planogyrina gaultina* (Morosova) and in thin (50 cm) intercalation

of red colour *Leymeriella tardefurcata* (Leym.) and other macrofossils of the tardefurcata zone. As these macrofossils were found only in the mentioned thin intercalation we may suppose all the suite as the Albian. Above this Albian suite are developed variegated marls of the Cenomanian age with *Glomospira charoides* (Jones et Parker), *Rotalipora appenninica* (Renz), *R. deecke* (Franken).

The Middle and Upper Cretaceous of the Pienidy series as a whole is characteristic by little thickness. The majority of sediments is of pelagic character and probably a deep-water. In higher parts is less deep-water mainly in the Cenomanian and Turonian.

The Middle Cretaceous of the Manin series lies transgressively on the Urgonian. It is of much more greater thickness and detritic development.

During the years 1960–1961 was distinguished a new series in the klippen belt of Považie (E. Scheibner, 1961), which represents a series of the klippen Klape. It is of geanticlinal character with shallow-water development of the Lias, Dogger and Cretaceous. In the Albian of this series deposited flysch like sediments with sphaerosiderites, the so-called sphaerosiderites beds. They represent a suite of grey marls which are alternated with thin beds of grey calcareous sandstones and compose a finerhythmic flysch. In these beds occurs a macrofauna: *Inoceramus* sp., *Neohibolites minimus* (Lister), *Phylloceras* sp., *Kosmatella* sp., *Hypacanthoplites milletianus* (d'Orb.), *Puzosia mayoriana* (d'Orb.), *P. sharpei* (Spath), *Turrilites* sp., *Lechites* sp. and problematical traces named as *Taonurus brianteus* Massalongo. This macrofauna is from various horizons of the Albian. Microfauna found in these beds is composed of the species (V. Kantorová et Andrusov, 1958): *Bigennerina complanata* (Reuss), *Lenticulina münsteri* (Roemer), *Epistomina spinulifera* (Reuss), *Rotalipora ticinensis* (Gandolfi) and others. Locally in connection with the sphaerosiderites beds we find 20 m thick beds of calcareous sandstones alternated with thin intercalations of marls. In these beds was found *Neohibolites minimus* (Lister) and *Glomospira charoides* (Jones et Parker), *Trochamminoides contortus* (Grzybowski), *Ammobaculites subcretaceous* Cushman et Alexander, *Clavulina gaultina* Morosova, *Lenticulina münsteri* (Roemer), *Epistomina spinulifera* (Reuss) and others.

In the Cenomanian it is developed a suite of the so-called Praznov beds (D. Štúr, 1860; E. et V. Scheibner, 1958) which represents a suite of fine-grained sandy slaty marls and marly slates of grey and greyish yellow colours locally with thin intercalations of sandstones. On the basis of microfauna: *Ammodiscus incertus* (d'Orbigny), *Marssonella oxycona* (Reuss), *Rotalipora appenninica* (Renz), *R. deecke* (Franken), *Praeglobotruncana delrioensis* (Plummer), *Hedbergella infracretacea* (Glaessner) we may regard them as of Cenomanian age. In the lower part of the Praznov beds are intercalations of conglomerates and sandstones with *Exogyra columba silicea* Lamarck, remains of Corals, Orbitolinas and Radiolites. In the belt between Považská Bystrica and Orlové the Cenomanian is developed in the detritic facies of the Orlové beds and sandstones with Orbitolinas. The Orlové beds are composed of grey sandy marls with Gastropods and grey sandstones with calcareous cement with the macrofauna: *Coelosmilium carpathicum* Kühn, *Exogyra columba silicea* Lamarck, *Neithea quinquecostata* Sow., *Protocardia hillana* (Sow.), *Acanthoceras rhotomagensis* (Defrance). In the uppermost

part of the Orlové sanstones were found great forms of *Exogyras* which are probably of the Lower Turonian age.

Near Považská Bystrica and Hrabové are developed the so-called Orbitolina sanstones with the Cenomanian types of this genus.

The Turonian of the klippen belt is built by red or grey marls with microfauna: *Praeglobotruncana helvetica* (Bolli), *P. delrioensis turbinata* (Reichel), *P. renzi* (Gandolfi), *P. oraviensis* Scheibnerová and *P. oraviensis trigona* Scheibnerová, *Globotruncana linneiana linneiana* (d'Orbigny) on the one hand and on the other one with microfauna: *Praeglobotruncana imbricata* (Mornod), *P. hagni* Scheibnerová, *Globotruncana sigali* Reichel, *Globotruncana schneegansi* Sigal, *Globotruncana linneiana linneiana* (d'Orbigny). To the last species in the Middle Turonian of the Czorsztyn series join some other species as *Praeglobotruncana klausii* Scheibnerová, *Globotruncana carpathica* Scheibnerová, *Palmula elliptica* Nilsson, *Stensiöina pokornyi* Scheibnerová

In the present time were found sediments of the Coniacian in the Czorsztyn series of the klippen belt, with which we shall deal in the next paper. The microfauna of the Coniacian, found by the author, is very typical for this stage and differs from that quoted by other authors working in West Carpathians as Coniacian. In the Upper Cretaceous we may observe many heteropic and heterotopic facies. Sedimentation begins locally directly in facies of marls and slaty marls of grey, green or red colours and flysch-like facies with microfauna composed of the species: *Globotruncana linneiana linneiana* (d'Orbigny), *Globotruncana linneiana tricarinata* (Quereau), *Globotruncana ventricosa* White, *Praeglobotruncana concavata* (Brotzen), *Stensiöina exsculpta* (Reuss), *Aragonia sotchica* (Keller), *Textularia subhaeringensis* Grzybowski and others.

Sedimentation of the Santonian at many places begins in the facies of exotic conglomerates, the so-called Upohlav conglomerates with intercalations of marls or sandy slates. In these marls and slates we often find redeposited microfauna of the Albian, Cenomanian and sometimes of the Turonian. Besides the conglomerates is developed flysch suite of the Santonian, locally named Upohlav beds, Pupov beds. Frequently occur also reefs with Hippurites, Corals and Algae.

Sedimentation of the Santonian continues gradually into the Campanian in various facies: marly or marly-slaty and flysch-like, in conglomerates facies and mainly in the facies of variegated *Globotruncana* marls. Microfauna of the Campanian is very distinct and is composed of the species: *Globotruncana linneiana linneiana* (d'Orbigny), *G. linneiana tricarinata* (Quereau), *Globotruncana arca* (Cushman), *G. elevata elevata* Dalbiez, *G. elevata stuartiformis* Dalbiez, *G. ventricosa* White; frequent are also *Stensiöinas*: *S. exsculpta* (Reuss), *S. dictyon* Pokorný, higher *S. pommerana* Brotzen, further *Textularia subhaeringensis* Grzybowski, *Reussella szajnochae* (Grzybowski), *Aragonia sotchica* (Keller), *Gümbelina globulosa* (Ehrenberg) and others. Together with this microfauna was found *Belemnitella mucronata* Schloeth.

As well as in the Campanian in the Maestrichtian we observe mainly marly facies, further flysch one and in the uppermost Maestrichtian near the Maestrichtian-Danian boundary also sandy-clayey facies of similar character as in the Danian. The microfauna is frequently rich and it is composed of species

as follows: *Globotruncana linneiana linneiana* (d'Orbigny), *Globotruncana linneiana tricarinata* (Quereau), *G. stuarti* (Lapparent), *G. conica* White, *G. contusa* (Cushman), *Praeglobotruncana havanensis* (Voorwijk), *P. mayroensis* (Bolli), *Globotruncana saratogaensis* Applin, *G. gansseri* Bolli, *Reussella szajnochae* (Grzybowski), *R. szajnochae elongata* Liebus et Schubert, *Neoflabellina rugosa* (d'Orbigny), *N. rugosa caesata* (Wedekind), *Stensiöina pommerana* Brotzen, *Pseudotextularia elegans* Rzehak, *P. acervulinoides* (Egger), *P. eggeri* (Cushman). In the sandy clayey facies we find an arenaceous microfauna composed of stratigraphically indistinct species: *Glomospira charoides* (Jones et Parker), *Trochamminoides contortus* (Grzybowski), *Dendrophrya* sp.

Biostratigraphy of the Danian and the question of the Cretaceous-Tertiary Boundary

To the question of the occurrence of the Danian in the klippen belt of Carpathians in Slovakia was paid an attention already in the past. As the Danian was regarded a suite of the so-called Zaskal breccias (D. Andrusov, 1945) which occurs in two sections in Orava (northern Slovakia): at the right bank of the river Orava near Mokrad and in new section near Kňažia. Both the sections were studied also from the micropaleontological point of view (E. Scheibner—V. Scheibnerová, 1961) and in fragments of breccias was found microfauna of almost all stages of the Middle and Upper Cretaceous and in cement the Santonian-Campanian microfauna composed of the species mentioned above. After deposition of the breccias continued the sedimentation of marls and marly slates with sandy intercalations of the Upper Campanian and Maestrichtian. Thus these sediments we cannot further regard as Danian, but as interformation breccias of Santonian-Campanian age.

Later, during the year 1958–1959, was found very interesting section near Stráža and Terchová (northern Slovakia, the vicinity of Žilina, see E. Scheibner—V. Scheibnerová, 1961) where occur the breccias-like clayey sediments and organogenous limestones with spines of Echinoids of the Danian. In the Maestrichtian beds we found typical Globotruncanas and other Foraminifers [*Globotruncana stuarti* (Lapparent), *Stensiöina pommerana* Brotzen, *Pseudotextularia elegans* Rzehak and others]. In the upper parts of the last stage increases a number of arenaceous Foraminifera [*Trochamminoides contortus* (Grzybowski), *Glomospira charoides* (Jones et Parker), *Dendrophrya* sp.]. Higher suddenly disappears microfauna of the Maestrichtian (mainly Globotruncanas) and together with mentioned arenaceous Foraminifera occurs *Globorotalia conicotruncata* Subbotina. In the mentioned sections sedimentation clearly ends after deposition of the Danian. The last stage is represented by its lower part, mainly. Upper parts of the Danian, resp. Montian, characterized mainly by three-chamber-Globigerinas is not developed in the mentioned sections. Similar conditions we may observe also at other places (see J. Salaj, 1962) where in the lower parts occur together with redeposited Cretaceous types (mainly Globotruncanas) *Globorotalia conicotruncata* Subbotina *Globigerina compressa* Plummer and *G. varianta* Subbotina.

If we compare the mentioned dates with that obtained in other sections of the Maestrichtian and Danian at one of the type localities in Denmark and

Sweden (see F. Brotzen, 1959 and W. A. Berggren, 1962) we see quite an extensive facial and paleontological conformity. Some differences in the microfaunas are caused mainly by much greater and complete outcrops in the type regions. The competent sections in the klippen belt of West Carpathians after an interruption of sedimentation were submitted to the erosion, to some degree. Further sedimentation, as shows the majority of the sections, continued perhaps without an interruption and developed the deposits of the Danian-Paleocene sequence, as in the Gosau facies of Brezovské pohorie.

Some notes to the microassociations of the Cretaceous

Microbiostratigraphical research of the Cretaceous during the few last years considerably succeeded so that in the present time it is possible to divide very exactly the Upper Cretaceous and as shows the present research of the author, also the Jurassic and Lower Cretaceous. However, in some stages of the Lower and Middle Cretaceous there are some difficulties caused mainly by insufficiently known microfauna of the competent stages all over the world. The difficulties are in the Aptian-Albian and Upper Turonian-Coniacian, which are to considerable degree complicated by facial variety, i. e. the variety of life conditions under which the pertinent microfaunas lived. Without respect to subjective interpretations of the important sections in northern Africa and in the sections where the results gained here were applied, there are some difficulties connected with the fact that there are associations with various planctonic species, but clearly of the same age.

In the Aptian-Albian the problem is in parallelisation of the benthonic and planctonic associations, essentially the question of the stratigraphical value of *Ticinella roberti* (Gandolfi). Investigations of many authors and the present author too show, that *Ticinella roberti* occurs only in the Upper Albian and not earlier and/or later.

In the Lower/Middle Turonian there is a question of parallelisation of two types of associations. On the one hand with *Praeglobotruncana helvetica* (Bolli), *P. delrioensis turbinata* (Reichel), *P. oraviensis* Scheibnerová, *P. oraviensis trigona* Scheibnerová, *Globotruncana linneiana linneiana* (d'Orbigny), *P. renzi* (Gandolfi) and on the other one with *Praeglobotruncana imbricata* (Mornod), *Globotruncana sigali* Reichel, *Globotruncana linneiana linneiana* (d'Orbigny). In current practice these two associations were regarded as of various stratigraphical value. The second association was regarded even as the Upper Turonian or Coniacian. More detailed studies showed that the first association with *Praeglobotruncana helvetica* (Bolli), *P. delrioensis turbinata* (Reichel), group of *P. oraviensis* Scheibnerová, *P. renzi* (Gandolfi) and *Globotruncana linneiana linneiana* (d'Orbigny) occurs inmostly in the Lower Turonian of the Pienidy series and developments, where in the Lower Turonian the district of sedimentation became shallower and the second association with *Praeglobotruncana imbricata* (Mornod), *P. hagni* Scheibnerová, *Globotruncana sigali* Reichel, *G. linneiana linneiana* (d'Orbigny) occurs in the Czorsztyn series (geanticlinal series as a whole), where sedimentation in the Lower Turonian was of pelagic character. Sedimentation in the series of such character as the Czorsztyn series continued into the Middle Turonian when appeared some new species such as *Globo-*

truncana schneegansi Sigal, *Globotruncana carpathica* Scheibnerová, *Praeglobotruncana klausii* Scheibnerová. In no profile these associations occur above each other, but in all profiles of the competent series always above the Upper Cenomanian. In both the types of the series the microfauna of the Upper Cenomanian is of the same character. In the Czorsztyn series some species of the second association pass into the Middle Turonian where occur with mentioned new, younger species. In the upper parts of the Lower Turonian in the Pieniny series the most characteristic is the association with *Globotruncana linneiana linneiana* (d'Orbigny), *G. linneiana tricarinata* (Queirau).

Except for the Turonian-Coniacian, where lithology is unsuitable for preservation of macrofossils, in the majority of stages of the Cretaceous was found macrofauna (Ammonites) together with microfauna, so that it was possible to compare the macrofauna and microfauna.

As the lithological character of the Neocomian is not suitable for preservation of microfauna (mostly limestones) only rarely we may parallel the macrofauna and microfauna. In the Kysuca series together with microfauna mentioned above was found *Crioceratites villersianum* (d'Orbigny), *Olcostephanus jeanotii jeanotii* (d'Orbigny), *Neolissoceras grasianum* (d'Orbigny), *Neocomites neocomiensis* (d'Orbigny), *Crioceratites duvali picteti* (Nolan).

In the Albian of the Manín series it was succeeded a parallelisation of the microfauna with macrofauna: *Puzosia communis* Spath, *Inoceramus concentricus* Parkinson, *Neohibolites minimus* (Lister).

In the Cenomanian was found together with mentioned microfauna *Acanthoceras rhotomagense* (Defrance), *Exogyra columba silicea* Lamarck, *E. columba minor* Jourdy.

At some places in the klippen belt it was found in connection with microfauna association of reef-making organisms: *Hippurites boehmi* Douvillé and corals *Agathelia esperella* Reuss, *Elephantaria linstroemi* Oppenheim, characteristic for the Santonian.

The microfauna of the Campanian was found in the beds with *Belemnitella mucronata* Schlotheim.

At the type locality of the Maestrichtian Gbelany beds together with the typical microfauna it was found *Inoceramus inconstans* Woods.

At many places was found a microfauna of the Cenomanian together with Orbitolinas: *Orbitolina concava* Lamarck, *O. mamillata* Archiac, *O. conica* Archiac. In the so called Orbitoids beds near Hrabové together with the Upper Campanian microfauna was found *Orbitoides media* d'Archiac, *O. apiculata* Schlumberger (E. Köhler, 1960).

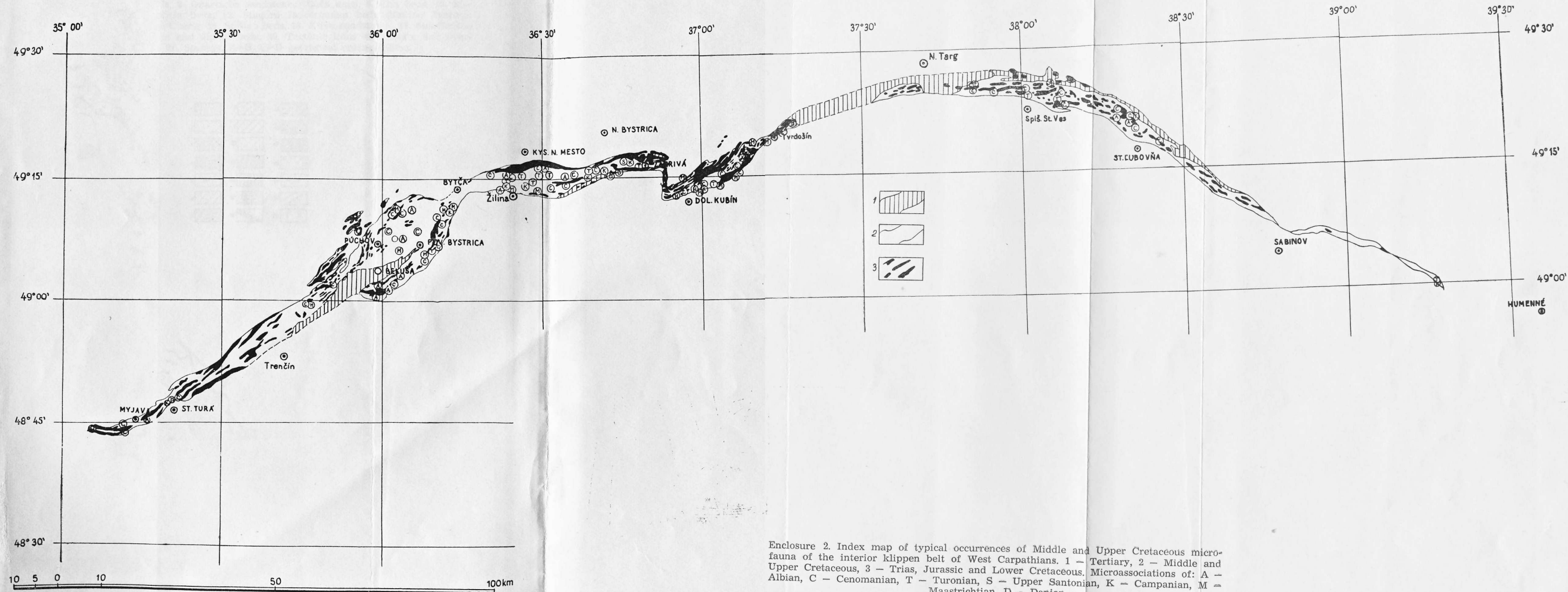
In the Danian beds with mentioned microfauna was found macrofauna of Echinoids, up to present undetermined, but resembling Echinoids from the type localities of the Danian stage (F. Brotzen, 1960). (Enclosure 2.)

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Review by V. Pokorný.



Enclosure 2. Index map of typical occurrences of Middle and Upper Cretaceous micro-fauna of the interior klippen belt of West Carpathians. 1 - Tertiary, 2 - Middle and Upper Cretaceous, 3 - Trias, Jurassic and Lower Cretaceous. Microassociations of: A - Albian, C - Cenomanian, T - Turonian, S - Upper Santonian, K - Campanian, M - Maastrichtian, D - Danian.