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LITHOFACIES, BIOFACIES AND SEDIMENTARY CONDITIONS IN THE CRETACEOUS BEDS OF THE FLYSCH ZONE IN THE CZECHOSLOVAK CARPATHIANS

LITOFACIES, BIOFACIES A PODMÍNKY SEDIMENTACE KŘÍDY VE FLYŠOVÉ ZÓNĚ ČESKOSLOVENSKÝCH KARPAT

(Enclosure 1)

Abstract. New definition of the flysch. Description of flysch-like and non-flysch deposits.

Cretaceous beds are represented in both the main neoid units of czechoslovak territory, i. e. in the Bohemian massif and the Carpathians. In the Bohemian massif, the Cretaceous sediments were closely connected with the development of the Cretaceous and Paleogene geosynclines in the peripheral part of the epivariscian platform, within which developed also the Bohemian massif.

In Czechoslovakia, the most thick and varied are the Cretaceous beds in the flysch zone of the Carpathians. This zone represents the Upper Paleogene and Lower Neogene mountain chain, which at present forms the tectonic and orographic axis of the northwestern and eastern Carpathians. It includes also earlier Mesozoic beds such as the Mesozoic of the interior klippen belt. The flysch zone of the Carpathians is built not only by beds of typical flysch. It contains also the "non-flysch" and "flysch-like" beds. On the other hand, outside the flysch zone there are in the Central Carpathians, for instance, Paleogene beds which from the lithological point of view are regarded as flysch.

In this paper we deal only with beds of Cretaceous age, since they are more variable and more extended in the wider foreland of the Carpathians. Definite general regularities are observable also in the Paleogene beds. We shall deal with the detailed analysis of the Paleogene in an other publication.

Objects, starting points and methods of investigation

The object of this work is further more detailed division of the flysch zone of Czechoslovak Carpathians on the basis of the regional stratigraphy and tectonic as they are up to present known.

Our study starts mainly from the facts gained during a few last years by the way of complete investigation of the flysch zone of Czechoslovak Carpathians. (Explanations to the geological map of ČSSR in scale 1 : 200 000, Tectonic

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development of Czechoslovakia, 1960—1961.) From the paleontological point of view we shall apreciate conclusions of the study of foraminiferal benthos and plankton in connection with lithology. From the lithological point of view we begin with analysis of pelites of the Subsilesia-Ždánice unit of the flysch zone which makes clear some relations of lithofacies (Z. R o t h, 1962). Elaboration and application of this analysis on wider region of whole the Czechoslovak Carpathian flysch zone ensues from summary work of I. G. W e e k s (1952), G. I. B u š i n s k i j (1954) and excellent, but unfortunately unpublished summary of V. S k o č e k (1962), which the author kindly permissed to use in our regional study. In some questions helped us the recent analysis of similar lithologic and lithogenetic questions of the Lower Paleozoic of Z. K u k a l (1960).

We accepted also a proposition of lithological definition of flysch elaborated on the basis of experience of Czechoslovak geologists and literature by F. P í c h a, M. E l i á š and Z. R o t h (1960). This definition we integrate in this paper above all in paleontological point and we define in with more precision.

At last, we accepted both our common works on the Cretaceous of the flysch zone (E. H a n z l í k o v á, Z. R o t h, 1962 a, b), which represent a stimulation for our present work and content criteria of the recent study.

Our method of work follows from the opinion that further progress in analysis of facts is a question of exact and objective criteria. On the basis of these criteria we divide a suite of the flysch zone of Czechoslovak Carpathians into typical flysch, flysch-like and non-flysch beds. In pelites which as we suppose are in general the common members of all three mentioned types we shall investigate affinities of facies with red pelites and facies with black-grey pelites. On the basis of the affinities of these types of pelites in the flysch beds and in beds of other character (studied mainly on the basis of foraminiferal benthos autochthonous also in the flysch beds), and of the importance of similar benthos in recent seas (if it is known) and lithological character of the sediments we shall attempt to define abiotic and biotic factors of original life conditions and means of sedimentation and diagenesis.

Stratigraphical and regional extension of the flysch, flysch-like and non-flysch beds in the Cretaceous of the Czechoslovak Carpathian flysch

The Cretaceous beds of Czechoslovak Carpathians in contrast to older beds of Mesozoic are mainly of the terrigenous character.

Among the Lower Cretaceous beds of lithologically typical flysch character is the Godula suite of the Silesia-Ždánice unit of Moravia-Beskid (Uppermost Albian to Cenomanian-Turonian). The typical flysch represents also the prevailing part of the Upper Cretaceous to Paleocene Istebná beds in the Silesia-Těšnovice unit, the Inoceramus beds of the region of the Dukla folds (in the Rača unit of the Magura group) in eastern Slovakia. In accordance with the lithological definition of the flysch (M. E l i á š, F. P í c h a, Z. R o t h, 1960) the Veřovice beds and the lower part of the Lhota beds do not belong to the flysch nor to the flysch-like beds, as they are exclusively of a claystone character.

The main part of the Cretaceous beds of Czechoslovak Carpathians is of the flysch-like character. The lithological affinity of the flysch-like beds is due mainly to presence of frequent interbeds of sandstones.

Also the typical flysch beds contain locally in the Cretaceous of Moravia-Silesian Beskid developments of non-flysch or flysch-like character, such as non-sandstone developments of variegated Godula beds in the vicinity of Staříč and Paskov. However, the Godula beds in western part of Moravia-Silesian Beskid have a flysch-like character especially in places where their thickness decreases (to 180 m).

The flysch-like character of the lower Těšín beds (which we regard as belonging to the Tithonian of the Silesia-Těšnovice unit) manifests itself in thin lens-like occurrences of sandstones and in presence of lens-like interbeds of organodetrital limestones. The flysch-like character of the Těšín limestones is in the distinct lens-like character of sandstones and conglomerate interbeds. The Baška beds lay at the boundary between flysch and flysch-like developments as they are of thickness of about 500 m and a little regional extension. Only the character of microfauna speaks about the flysch-like character of these beds (see below).

In the Subsilesia-Ždánice unit we may regard as flysch-like the Frýdek and Třinec beds because of the lense-like occurrence of sandstones. These beds lost the character of rhythmic alternation of psammites and pelites. "Flysch development" of part of the Upper Cretaceous (Turonian) of Pienidy series we cannot regard as flysch as whole the thickness of these "flysch beds" reaches by D. Andrusov (1958) only 70—200 m. Also the Lower Cretaceous of Central Carpathians does not represent a true flysch as it does not contain an important amount of psammites.

Typical flysch beds of the Cretaceous in the Czechoslovak Carpathians

As it was mentioned above, lithologically typical Cretaceous flysch is represented by the Godula beds of the Silesia-Těšnovice unit of Moravia-Silesian Beskid (Uppermost Albian to Cenomanian), Istebná beds of the Silesia-Těšnovice unit and Inoceramus beds of the Dukla folds unit and exterior marginal zones of the Rača unit in eastern Slovakia. Lithologically typical flysch, as we see, is in Czechoslovak Carpathians restricted into the flysch zone and practically does not extend beyond the sedimentary district of its exterior group (Krosno-menilite group). The Lower Cretaceous does not contain the typical flysch. In the Middle Cretaceous (as the Godula suite) it is restricted into the central section of the Silesia-Těšnovice unit between the Bečva and Skawa rivers. In the Upper Cretaceous flysch extends eastward as well as into the northern foreland of the Silesia-Těšnovice unit into the southern, more interior unit of the Dukla folds, and into the marginal Rača unit (Inoceramus beds). In the Paleogene suitable conditions for development of the flysch were in the Magura region, respectively in Central Carpathians.

Units of the exterior group of the flysch zone, however, in main are approximately in centre of the Cretaceous suites separated tectonically from their substratum. Therefore in the Subsilesia-Ždánice unit, in the Dukla folds unit and in the pre-Magura unit we do not know older beds than Upper Cretaceous. In the Silesia-Těšnovice unit we know (fragmentary) also the Jurassic. In spite of this it is not probable that in autochthonous remains of the mentioned units is the Lower Cretaceous and Middle Cretaceous flysch of many hundreds to thousands m in thickness, up to present unknown.

The main lithological phenomenon in development of flysch is secular, many times repeated, comparatively short epizodic deposition of sand to fine-grained gravel which "rhythmically" interrupted, a longtime deposition of claystone. We have many facts about the longtime "pedogenetic" development of clayey sea bottom during some periods of comparatively short acts of sedimentation of sand. Presence of non-sandy beds made up of claystones of similar character as that of the flysch of the same age in the Cretaceous of the flysch zone (for instance in the Godula suite) serves as evidence of independence both the pelitic and psammitic-psefitic members of beds building the typical flysch. As well as both the components are irregular in time of their deposition, they differ also in irregular position of their sources and conditions of transport. It is very probable, that while psammites (resp. psefites) descended as turbidity currents from elevated cordillery, fine mud descended in the geosyncline from much wider source region (bimodal sediments, see for instance J. D. Moody, M. J. Hill, 1956). Similar, but less concentrated source we may suppose in psammites and psefites of the flysch-like beds.

Occurrences of macrofauna in the beds of the typical flysch (also from our territory) are very rare. For explanation of conditions of development of the flysch beds of a greater importance are those which carry the traces of speed of sedimentation and features of environment. Such founds are for instance that of Stráník (1961) who found the ammonite in scree of the Godula beds. The cross-section of the core of this ammonite, which is composed of glauconite sandstone of the Godula type, showed that the shell has preserved only one, probably lower side. It is the very usual way of preservation of ammonite cores. Preserved (lower) part of the shell was protected by sediment into which the ammonite sunk, while the upper part of the core, which was rising, was subjected to corrosion in sea water. The core was not probably after its deposition transported as it laid parallely with planes of stratification of sandstone and corroded shell was filled up by sand from above. The lower part of the sandstone bed protected the shell from corrosion. It was deposited much earlier than the upper part of the last and filler of the core. However, it is not necessary to suppose discontinuous sedimentation, but it is probable. The core found by Stráník serves as evidence of comparatively slow or interrupted (discontinuous) sedimentation of competent sandstone bed as well as phenomena of particular destruction of Vermes buried in sand, described by M. Plička (1962) from the Paleogene flysch of Carpathians. We suppose that our conclusion is of wider acceptance for the Godula suite: portions of sandstones, which deposited in the flysch beds evidently during a few hours, may deposited elsewhere more slowly and even discontinuously. Of the same opinion is M. Plička (l. c.). Also the fauna in sandstones was not subjected to important secondary horizontal transport, before diagenesis of sandstones as is often suggested.

Frequent authigenic glauconite in cement of the sandstones of the Godula suite (R. Kühnel, 1958, M. Eliáš in Z. Roth et coll., 1962 b) shows that these sandstones deposited and developed in neutral to slightly oxydizing geochemical environment (V. Skoček, 1962), because the glauconite arises in oxydizing part of sea bottom (G. I. Bušinskij, 1954) and in depth lesser than 200 m (V. Skoček, 1962). In contrast to the last mentioned, the presence of pyrite in sandstones of the flysch Istebná beds and absence of glauconite

(Z. Roth et coll., 1962) confirms an origin in reducing geochemical environment of closed depression of sea bottom.

The pelites of beds of the typical flysch show the lithological affinity with pelites of non-flysch and flysch-like beds mainly in beds of the same age, and in the same sedimentary district. We may regard them in flysch, flysch-like and non-flysch beds either belonging to lithofacies with red pelites or with green-grey pelites which correspond in the main to Strachov's facies (N. M. Strachov and coll., 1959) (see Z. Roth, 1962). As well as the flysch, flysch-like and non-flysch character of beds is given by share and character of sandstone intercalations, the character of pelites is a criterion of regional-stratigraphical classification of beds (for instance variegated Godula beds).

Fauna of sandstones in both flysch and flysch-like beds is frequently regarded as redeposited. Fauna of pelites of the flysch beds is (as fauna of pelites of non-flysch and flysch-like ones) generally regarded as autochthonous. In despite it and mentioned lithological affinity with pelites of the non-flysch and flysch-like beds the pelites of the majority of the non-flysch and flysch-like beds differs by distinctly impoverished and uniform microfaunas. The microfauna of the Carpathian flysch beds is composed mainly of arenaceous benthonic Foraminifera (N. B. Vassoevič, 1958, our investigations). The plankton is composed mainly of Radiolaria and it is irrelevant.

As show investigations in recent marine basins (S. Ellison, 1951, F. Phleger, F. L. Parker, H. Schmidt, 1953), the benthonic microorganisms are good indicators of abiotic factors. We made an attempt to distinguish the abiotic factors such as temperature, depth, illumination and chemical character of water, as well as the biotic factors. Claystones of the flysch suites in Carpathians carry very impoverished benthos (in main 1—7 genera of Foraminifera with 1—12 species). Abundance of this benthos increases in the flysch beds of the Middle Cretaceous to Paleogene contemporaneously with variety of species. In the Middle Cretaceous Godula beds from Astrorhizidea are represented only genera Bathysiphon, Dendrophrya and Saccammina, rarely Rzehakina. In the Upper Cretaceous to Paleocene Inoceramus beds adhere to these genera Rhizammina, Kalamopsis, Reophax, Hormosina, Nodellum, Ammodiscus, Glomospira, Lituotuba, Rzehakina with many species and Rhabdammina. In the Eocene Beloveža and Zlin beds and in the upper part of the Paleogene of the White-Carpathians-Oravian unit which are also of the flysch character predominant is superfamily Lituolidea, in the Godula beds only sporadical, and disappear genera Rzehakina, Nodellum, Hormosina and Kalamopsis. Many genera are subjected to changes. The majority of species in the biotop of the flysch is represented by the only species and exclusively by more than one. Elsewhere, mainly in the Paleogene typical flysch, developed ecoforms dependent on lithological character of bottom (E. Hanzlíková, 1961, genus Dendrophrya).

Results of attempts to use the superfamily Astrorhizidea in reconstructing of features of sedimentary districts during geological periods are up to present very uncertain. In recent seas Astrorhizidea live in cold waters. In lower geographic latitude they live in considerable depth while in polar regions in shallow waters of shelf. During the Paleozoic they lived in shallow waters of higher temperature (V. Pokorný, 1958). Therefore we cannot the depth of recent extensions of family Astrorhizidae and temperature of environment studied for instance by R. D. Norton (1930) in sea near Florida and West Indies Islands (1100—5200 m, 1,8—7,6 °C) applicate to the flysch conditions in the Cretaceous seas. We cannot do it also, because by R. D. Norton studied recent associations, are composed mainly of calcareous foraminiferal benthos. Also recent arctic biotope and biotope of shallow-water seas of medium latitude contain besides the arenaceous Foraminifera always and in many places calcareous Foraminifera (A. R. Loeblich, H. Tappan, 1953 — northern Alaska; J. Cushman, 1944 — New England; J. Cushman, 1927 — 34—43° of northern latitude; J. Cushman, R. Todd, 1947 — Washington; K. Green, 1960 — north of Grant Land — 80° of northern latitude).

Exceptionaly were observed recent associations of arenaceous Foraminifera, to some degree resembling the flysch associations in Mediterranean sea, as mentioned below.

In non-flysch beds the Astrorhizidea are represented only by genera Reophax, Glomospira and Bathysiphon. By accompanying organisms in non-flysch Jurassic beds these genera appear as forms of shelf, warm sea. This is sure also for genera of superfamily Lituolidea (*Ammobaculites, Haplophragmium, Haplophragmoides, Frankeina*). In the Upper Cretaceous and Paleogene also in non-flysch beds we found both the types in associations without shallow-water elements together with calcareous benthos living at greater depth *(Bulimina, Pullenia, Chilostomella, Cassidulina)*.

Agglutinated Foramifera characteristic for beds of typical flysch contain locally the same, locally other species. They represent a component of stratigraphically equivalent associations from the flysch-like beds. For instance claystones of the flysch Godula beds are characterized by *Dendrophrya* sp., *Bathysiphon brosgei* Tappan, rarely *Trochammina rutherfordi* S. et W., very occasionally *Rzehakina? gaultina* (Reuss) and *Plectorecurvoides alternans* Noth. In neighbouring flysch-like part of the same sedimentary district, i. e. the Baška region the claystones of the Baška beds of the same age carry associations with numerous species with calcareous and arenaceous benthos of shallow shelf (*Ramulina, Lenticulina?, Gyroidina, Pernerina,* some species of *Trochammina, Ataxophragmium, Bigenerina* and rich *Globigerina-Globotruncana* plancton). Similar picture we obtain in non-flysch beds of the Pienidy, Hercynian or Subhercynian regions. Only some primitive genera and species of non-flysch associations are adapted to the conditions of sedimentation of typical flysch beds. Similar phenomena we see if we compare associations of non-flysch and flysch beds in the Upper Cretaceous and Paleogene. Therefore we suggest that biotope of the claystones of flysch beds is of endemic character.

As it was mentioned above, the monotonous, endemic, in many places represented by one genus, recent associations with predominant primitive arenaceous forms (Foraminifera), similar to that of the typical flysch beds of the Cretaceous and Paleogene of Czechoslovak Carpathians, were found only exclusively in warm and shallow waters of the Mediterranean sea in the vicinity of Monaco (E. Lacroix, 1929; J. Hofker, 1932). By H. Schmidt (1953) agglutinated Foraminifera occur here on muddy bottom of the depression Ammontatura in depth about 300 m and more. They occur together with Lagenid forms which are missing in the typical flysch. H. Schmidt gained from this depth by dredging oak leaves transported from dry land. This fact represents a great analogy with beds of the typical flysch in which the very characteristic components are carbonized fragments of plants, as it is possible establish, always of terrestrial origin (see also the Lower Carboniferous flysch — Culm). H. Schmidt compares depression of Ammontatura with waste hollow with nutritious substratum which entices fishes and Cephalopoda known in the Mediterranean sea living in a great depth. As an evidence of this serves a considerable amount of Ostracoda occuring with Foraminifera.

As is obvious from the mentioned data the biotop of the typical flysch beds shows many affinities to the endemic biotop of Ammontatura in the Mediterranean sea.

On the basis of the mentioned affinities and investigations we may amplify the lithological definition of flysch (M. Eliáš, F. Pícha, Z. Roth, 1960) by addition of new, micropaleontological sign. New definition of the flysch is as follows: as flysch we regard more than 500 m thick, fully detrital suite, at least to some degree gradally bedded, composed of rhythmically alternated beds of a) hardened or unhardened psammites (often with pelitic components), less frequently of psephites, b) hardened or unhardened silts and pelites.

Many of these beds have laterally very uniform lithological character in some hundreds to some thousands m. Coarse psammites have in direction of the sedimentary district very stable thickness. Do not occur evaporites, autochthonous coal and corals. The faunal content in general is very poor. Pelites without regard to the lithological character, manifested mainly in original colour, carry impoverished autochthonous associations of arenaceous Foraminifera of the endemic character.

In lower part of many beds of psammites (respectively psefites) is sharp boundary corresponding to short interruptions of sedimentation, frequently with organic or anorganic (biogenic or abiogenic) forms (hieroglyphs). The clastic material of rocks is in main of anorganic origin. Cement of the majority of rocks (including pelites) is from calcite, somewhere from other carbonates or SiO_2.

Share of psammites and pelites oscillates between prevalence of psammites or prevalence of pelites. Single beds of both the component are from some cm to some m in thickness.

Flysch-like and non-flysch beds

The majority of the Cretaceous beds of Czechoslovak Carpathians are of the flysch-like character. They show affinities to flysch, but some of the signs of the typical flysch are lacking. Micropaleontologically they represent wide and heterogenous group of biotopes with various biotic and abiotic factors. Besides associations which may live in deeper sea in pelites of the flysch-like beds there are in form of ingredient or in intercalations shallow-water associations. Only in some of these beds we may prove the connection with open sea (except for the Tithonian lower Těšín beds, such beds are: Těšín limestones, Baška beds, Pálkovice beds, Frýdek beds).

In contrast to the flysch beds in pelites of the flysch-like and non-flysch beds of the flysch zone of Czechoslovak Carpathians there is a greater biofacial variety caused by the character of pelites (claystones). Lithofacial character of pelites is most distinctly characterized by their original colour which is in accordance with geochemic environment and time of its action on developing pelite.

Further we shall deal with lithofacial division of pelites which mainly in the (claystones) flysch-like and non-flysch beds are closely allied to biofacial classification of beds.

Facies of pelites of the flysch-like, flysch and non-flysch Cretaceous beds

Flysch, flysch-like and non-flysch beds of the Cretaceous of Czechoslovak Carpathians contain as essential component pelites. The pelites we may divide predominantly into three lithofacies, which differ first of all in colour (see for instance N. M. Strachov and coll., 1959; Z. Roth, 1962). We name them as facies with red pelites, facies with green-grey, frequently spotted (chondritic) pelites and facies with black (black-grey) pelites. While in the facies with red pelites are interbeds of red pelites instead of quantitatively unessential element, as well as spotted pelites in the facies with green-grey spotted pelites, black (black-grey) pelites represent the only type in the facies with black (black-grey) pelites. Red pelites in the facies with spotted pelites do not occur as well as in the facies with red ones in general do not occur chondritic spotted pelites. In both these facies occur as common element greenish unspotted pelites. The mentioned three facies of pelites occur mostly in very typical forms of outcrops, i. e. one of them always predominates. Only exceptional are places where both these facies are alternated.

All mentioned three facies of pelites may be calcareous or to various degree calcareous and may pass into muddy limestones.

The facies with red pelites in our sense contain originally red portions in form of more or less thick or thin interbeds. Only rarely, in red pelites we may see secondary grey-green ones with blurs. Red beds are often alternated with beds or greenish pelites.

Microfauna of the facies with red pelites developes from associations of the lithofacies with green-grey spotted claystones (for instance associations of variegated Godula beds develope from those of the Lhota beds, variegated Subsilesian beds, Třinec and Frýdek beds). The microfauna is of more shallow-water character than that of the facies with spotted claystones. Here are lacking elements of poorly aerated environment (remains of fishes, pyritized cores of Foraminifera) and except for variegated Godula beds also elements which may be adapted to the brackish water (Trochamminoides, Ammobaculites). For the facies with red pelites (claystones) is typical communication with pelagic sea.

Already the Valanginian biotope of red calcareous claystones of the Kopřivnice limestone and breccias, which mantle the Štramberk limestone (E. Hanzlíková, 1960; Chapman F., 1900), carry mainly the shallow-water elements and many of them are of reefal character. As autochthonous foraminiferal benthos (Trocholina, Spirillina, Lenticulina, Neobulimina, Vaginulina) reaches here lesser size than that living in environment of bioherms, it seems, that it represents rather the benthos of clayey bottom of shallow litoral with conditions closely allied to those of bioherms. We may suppose that there was a communication with pelagic sea as here are Radiolaria and Tintinnids. Variegated benthos together with plankton testifies that it lived under conditions of well aerated sea.

The biofacies of claystones of variegated Godula beds develops from the biofacies of spotted claystones of the Lhota beds and passes into the biotope of arenaceous, very primitive Foraminifera — eurybionts, which represent the specific stenotype. In associations of the variegated Godula beds predominate *Haplophragmoides* and *Trochammina* (both genera are represented by 4 species and 30 per cent of specimens). Besides two mentioned genera there are *Dendrophrya, Bathysiphon, Glomospira, Dorothia, Ammobaculites, Verneuilinoides, Plectorecurvoides* which together with Radiolaria represent additional 10 per cent. In some portions predominates the only one species mostly of Dendrophrya or Bathysiphon.

The dwarfish growth of arenaceous Lituolid Foraminifera may serve as evidence of biotope with endemic microfauna as variegated Godula beds belong to the typical flysch elements of the Godula suite. Also an appearance of little Dendrophryas, evidently identical with forms known from clayey variegated beds of the lower Paleogene of the Magura group and later from the Zlín beds, show, that it represents the stenobiont, affected by abiotic factors, probably by the flysch sedimentation. Even if the shells of this *Dendrophrya* occur as disintegrated fragments, we need not be in doubt about their autochthonity. It is very interesting that in the vicinity of the British Islands J. Cushman (1918) describes from the lower boundary of tide zone, i. e. from the shallow interior neritic as very abundant two species of Dendrophrya closely allied to those of the biofacies of the typical flysch of Czechoslovak Carpathians. Their shells have walls composed of clayey material with single little grains of quartz. From other typical signs of the biotope of non calcareous Middle Cretaceous flysch Godula beds s. s. occur in variegated Godula beds irregularly coiled tests of Foraminifera and tests with irregular sizes of single chambers (mainly in last whorls). Such irregularities we may see in species *Haplophragmoides crickmanyi* S. et W., *Haplophragmoides spiritense* S. et W., *Haplophragmoides glomeratoformis* Zaspelova, *Glomospira gaultina* (Bielecka). Presence of *Trochammina rutherfordi* S. et W., *Trochammina nodosa* Zaspělova and less size of all species in contrast to forms of the Upper Cretaceous and the Lhota beds shows that associations of these forms represent thannatocoenosis of shallow neritic (partly euryhaline) with comparatively high temperature of water. In such environment live little arenaceous Foraminifera, mainly Astrorhizidea in the region of the Mediterranean sea, i. e. in the region geographically and genetically allied to Carpathian (V. Pokorný, 1953). Similar little Foraminifera were found also in warm waters of bathyal and abyssal parts of oceans. Coarse-grained walls of arenaceous Foraminifera may serve as an evidence of that they lived in shallower neritic as this sign is regarded as an evidence of shelf environment. Walls of arenaceous Foraminifera from claystones of the Lhota beds or facies with black—(black-grey) claystones. Also *Dorothia filiformis* (Berthelin) found in claystones of variegated Godula beds occurs mainly in shalow-water facies of epicontinental marine province.

Claystones of variegated Godula beds carry associations of Foraminifera of the flysch biotope with endemic signs and associations characteristic for the flysch-like and non-flysch beds. This corresponds with real conditions of variegated Godula beds in the flysch, flysch-like and non-flysch developments in the region of Moravia-Silesian Beskid. Both the types of associations in claystones of variegated Godula beds contain elements of Thannatocoenosis of very shallow, well aerated neritic connected with the pelagic sea, sometimes slightly brackish. As it is obvious from presence of sporadic Radiolaria and Globigerine plankton (Hedbergella, Globigerina) identic with thermophilic plankton of the Pienidy and Baška sedimentary districts, temperature of the upper parts of water was considerably high.

The facies with red calcareous claystones of the Upper Cretaceous (Gbelany beds — V. Kantorová, D. Andrusov, 1958; D. Andrusov, 1959, variegated beds of the Upper Cretaceous in the Těšnovice section of the Silesia-Těšnovice unit — A. Matějka, 1960, and pre-Magura unit — E. Hanzlíková, E. Menčík, V. Pesl, 1962) biofacially considerably differs from similar facies in the Middle Cretaceous. Rich, coarsely-faceted foraminiferal plankton testifies the subtropic to tropic sea. Locally this biofacies developes from biofacies of calcareous bottom (Pienidy type), locally from sandy biofacies (Frýdek type).

Paleoecologically both these types belong to two qualitatively different provinces. The Pienidy type (Gbelany beds) represents the distinctly mediterranean province, the Frýdek type (variegated beds of the Upper Cretaceous of pre-Magura and Silesia-Těšnovice units) the province transitional between mediterranean and epicontinental. By the character and variety of plankton the communication with pelagic sea was stable and thorough. The foraminiferal benthos—mainly by recent analogy composed of representatives of deeper neritic—is composed of closely allied or even identical species which occur in the facies of green-grey spotted claystones. It is composed of genera and species of arenaceous and calcareous Foraminifera as follows: *Gaudryina, Pseudogaudryinella, Pseudoclavulina, Marssonella, Dorothia, Ataxophragmium, Haplophragmoides, Spiroplectammina dentata, Textularia, Verneuilina, Reussella, Aragonia, Bolivinoides, Eponides, Pleurostomella, Stensiöina, Osangularia.*

Representatives of genus Reussella by F. B. Phleger (1954) occur in warm waters of the Atlantic ocean mostly in depth of 20—200 m. Some species of genus Osangularia and Eponides in contrast to the mentioned genus live in depth more than 100 m and by R. W. Crouch (1952) under temperature 3—6 °C. Species of Eponides occur mostly under temperature of 1,7—5 °C and in colder waters develope the ambonate forms with irregular sutures unknown from the Cretaceous beds. The majority of species is adapted to wider depth space. Pseudoparellas and Pulvinulinas which compose 10 per cent of the benthos of the Gbelany beds and other Upper Cretaceous beds with red claystones found in waters of 4—8 °C temperature. In colder waters they are very rare. Very similar results were obtained in study of *Cibicides, Anomalina* and *Planulina.* The majority of genera lives in depth of 270—600 m (by investigations of R. W. Crouch, 1952 from the region of California shore).

Ornamented species of the metioned genera found in the Upper Cretaceous variegated beds in Carpathians now live in less depth. Such are some Bolivinas, probably also Aragonellas, resembling *Bolivina* sp. 1 found in recent shallow-water microfauna near the Senegal shore (F. B. Phleger, F. L. Parker, J. Pierson, 1953). Pseudogaudryinas, Glomospiras, Haplophragmoides, Pseudoclavulina and Reophax are up to present eurybathyal as they are adapted to depth of 60 to more than 1000 m. In the Upper Cretaceous variegated beds very frequent form *Spiroplectammina (Textularia) dentata* by the analogy with similar form found in waters of Mexico gulf (F. B. Parker and F. L. Phleger, 1954) lived in depth 120—200 m. *Textularia agglutinans* and representatives of *Verneuilina* in the Mediterranean sea occur together with *Cibicides* in very shallow fythal zone. By O. Bandy (1954) coarse-grained arenaceous species of *Textularia* closely allied to the species found in red claystones are now extended in depth of 90—300 m.

Fossil Stensiöinas, very frequent mainly in the flysh-like facies of the Cretaceous Gbelany beds with red claystones lived by similar mode of life as recent *Cibicides*. Recent *Cibicides* are caught at swimming objects or, mainly in shallow sea, at sea grasses (the Neapol bay) (H. Schmidt, 1953). Catching at such objects are frequently taken into the pelagic sea.

On the basis of our analysis the benthos of variegated beds of the Upper Cretaceous is composed mainly of forms living now in neritic zone with permanent temperature between 3—8 °C. It is a biotope closely allied to that of the facies of spotted claystones. During the Paleogene the interior parts of the Magura sedimentary district and in the region of the Subsilesian unit became deepening and developed beds with red claystone. Benthos is here lacking while the plankton is a main component of the *Globigerine* and *Globorotalia* muds. Scarce Dorothias and Gaudryinas which represent foraminiferal benthos are comparatively coarse-arenaceous so that (because the species are identical with species of variegated Paleogene beds of the Magura flysch) it is not out of question that the sea was considerably shallow.

The facies of spotted claystone is characterized by green-grey colours of pelites. Typical are chondritic mainly dark or brown-grey spots (probably traces of organisms living in muddy ground). Spots (fucoides, chondrites) have a diameter of some cm and frequently are concentrated in some more thick portions. If the pelites are dark-grey the spots are (but rarely) light. In greenish interbeds of the facies with red pelites chondritic spots are lacking.

Biotope of the facies of green-grey spotted pelites from the micropaleontological standpoint represents the main initial biotope of the Cretaceous beds of Czechoslovak Carpathians. From associations of this biotope are derived associations of other biotopes, mainly of the biotope with black-grey claystones and that of the facies with red claystones. It is natural, as lithologically the facies of grey-green spotted pelites is the only facies which in time and space continuously occurs in the Cretaceous of Czechoslovak Carpathians, while the facies of black-grey and variegated claystones occurs only in originally, in time and space, isolated parts of the Cretaceous of Czechoslovak Carpathians (Lower Valanginian, Albian-Eocene).

In general the biotope of the facies with spotted claystones represents an environment of deeper, well aerated neritic with good conditions of development of both the benthos and plankton and of development of thannatocenosis as the water was in unremitting movement, the sea was in communication with the pelagic sea and it was very well illuminated throughout.

The plankton of this biotope is mostly rich, thermophilic *(Radiolaria, Foraminifera, Infusoria, Flagellata)*. Also rich benthos may serve as evidence of favourable biotic and abiotic factors of development of calcareous and arenaceous forms. Accumulation of sand affected as well as in other facies of claystones an abundance of benthos (for instance the flysch beds of the Middle Cretaceous of the Silesia-Těšnovice unit).

In the Cretaceous of Czechoslovak Carpathians this biofacies we may observe already from the Valanginian. The oldest pelites of the spotted facies represent in the flysch zone of Czechoslovak Carpathians the Těšín limestones. In thannatocoenosis of the Těšín limestones occur about 70 species of benthonic

Foraminifera mostly distinctly ornamented which show affinities to marine shallow-water associations of the Lower Cretaceous of the north-western Germany and on the other hand to marine developments of the Malm of the Central Poland. Very rich are Ostracoda (about 20 species). Material of washed samples of thannatocoenosis is composed of 50 per cent remains of Echinoidea, Sponges, Holothuroidea. All these signs correspond to the shallow neritic zone (inner neritic zone of S. Ellison, 1951) with calcareous organic detrit deposited between distant bioherms. Numerous Spirillinas in recent seas live in depth 80–200 m (J. Cushman, 1915). Radiolarian plankton (*Trochammina, Ammobaculites, Haplophragmoides* and *Epistomina*) eliminates relevance of pelites of the spotted facies in the Těšín limestone to the litoral zone. So that the Těšín limestones were deposited in greater depth of exterior parts of inner to outer neritic (about 50–250 m).

Biotope of claystones of the spotted facies of the Lhota beds (Albian) is different. It shows affinities to biotope of the claystones of the spotted facies of the Třinec beds (Maastrichtian). The plankton composed of Radiolaria and Foraminifera occurs only in the upper parts of the Lhota beds near Mikuszovice cherty sandstones. It is possible that here was a communication with the pelagic sea and later also with the Baška sedimentary district. Bathymetrically this biofacies does not differ, as it seems, from the biofacies of black-grey claystones of the Veřovice beds. In some parts of the Lhota beds there occur also calcareous Anomalinas, Gavelinopsis, Gyroidinas, common in the warm, neritic biotopes of the Baška beds. Therefore it is probable, that there was communication, from time to time, between the sedimentary districts of the Baška and Lhota beds, also in the deeper parts of the districts.

Presence of Bathysiphon may serve in associations of the Lhota beds as evidence of neritic well illuminated zone. The majority of species has siliceous shells or shells with a considerable amount of siliceous cement joining the grains of quartz. Usually organisms with such shells live in cold water.

In the Lhota beds very common is Haplophragmoides nonioninoides (Reuss) which was described from shelf thannatocoenoses of the Gault and Upper Neocomian of western Europe (E. A. Reuss, 1863 from the so-called Flammenmergeln) and from the thannatocoenoses of the Aptian and Albian of the Central Povolžie and Obščij Syrt, from the valley of Emba — E. Mjatljuk, 1939 composed of shallow-water Foraminifera (*Marginulina, Cristellaria* and *Trochammina*), Ostreas, Aucellas and Inocerami (*Inoceramus aucella* Tr.). Very abundant is also Bathysiphon from the Lhota beds. Recent representatives of this genus live in various depth. From the Marocco coast Bathysiphon is quoted from the depth of 370 m, from the vicinity of Corsica from 727 m, from Irish coast 20–400 m. The majority of representatives of Bathysiphon live in the depth of between 160–2000 m in the Atlantic ocean (J. Cushman, 1918 — *Bathysiphon filiformis* and *B. rufus*). It seems that this genus is stenothermal, living in cold water.

We suppose that the facies of the spotted claystones of the Lhota beds developed bathymetrically between the facies of red Godula beds and the facies with black pelites of the Veřovice beds since part of the benthos is closely allied in both facies.

The biotopes of claystones of the spotted facies in the Baška and Pálkovice beds show many affinities. By quality of benthos and accumulation of thermophilic plankton (Radiolaria and Foraminifera) mainly in some periods they resemble shelf deposits of the epicontinental Middle Cretaceous and Upper Cretaceous seas.

Indicators of warm and comparatively shallow conditions are representatives of Ramulina recently found near Phillipines in the depth about 190 m, near Japan in the depth of 200 m (J. Cushman, 1913), further the representatives of *Gavelinopsis, Gyroidina, Anomalina, Cibicides* quoted mostly from the depth of 50—1000 m (F. B. Phleger, F. L. Parker, 1954). Also the arenaceous benthos does not live at a greater depth (mostly species with calcareous cement: *Pernerina, Gaudryina, Dorothia, Bigenerina* and *Bifarina*). Scarce Bigenerinas and Bifarinas are quoted from warm waters mostly from depth lesser than 200 m as well as sporadic *Ataxophragmium*. Considerable amount of *Cibicides, Anomalina* and further genera in the Lower Senonian of the Pálkovice beds (E. Hanzlíková, 1954) serves as an evidence of shallowing of the biotope.

The facies of green-grey (partly) spotted claystones of the typical flysch beds of Godula development (s. s.) carry the flysch type microfauna probably endemic (see above). Paleoecological conditions of development of their associations was affected by abiotic factors, i. e. the flysch sedimentation which changed the normal character of biotope and refused the normal development of the biofacies of spotted claystones.

The same may be said about the biotope of the Inoceramus beds in the region of the Dukla folds unit, which shows affinities with species of the biotope of the facies with black-grey claystones. Presence of Radiolarian plankton in the Paleocene and Globotruncana plankton in the Upper Cretaceous of the Inoceramus beds speaks for communication of this region with the sedimentary district of exterior group as well as that of the Magura group. Foraminiferal benthos of the Inoceramus beds by M. Dylażanka (1921), E. Hanzlíková (1960) and V. Kantorová (1956) enriched by elements with calcareous cement (*Marssonella, Eggerella, Spiroplectammina*). Certain proportion of *Rhabdammina* which occurs together in thannatocoenosis of the arenaceous autochthonous Foraminifera shows that the enviroment was not so infested as in the case of the facies with black-grey claystones.

Species of *Rhabdammina* which represent the esential members of thannatocoenosis of the spotted facies of the Třinec beds of the Subsilesia-Ždánice unit were found recently together with smooth Hyperamminas in the Atlantic ocean in depth between 160—2000 m, mostly between 400—800 m. Other species reach the depth greater than 3000 m. Many coarse-arenaceous Reophax and Saccaminas live in the Atlantic and Pacific ocean in the same depth and thermal conditions as the mentioned Rhabdamminas. A great extension of *Trochamminoides, Haplophragmoides* and numerous irregularities in coilling of the test and sizes of chambers do not exclude the possibility of endemic character of microfauna in the biotop of comparatively colder waters and possibly greater depth of exterior neritic to bathyal zone. In such case may take a part transport of necrocoenosis into greater depth and development of autochthonous thannatocoenosis or frequently of allochthonous thannatocoenosis.

The spotted facies of the Třinec beds gives a very good picture about the task of abiotic factors in development of thannatocoenosis. Considerable accumulation of plankton during sedimentation of these beds indicates an intensive movement of water. The benthos in the older beds is very monotonous, exclusively siliceous and arenaceous composed only of the genera: Glomospira, Rhabdammina, Ammodiscus, Gaudryina, Thalmannammina and coarse-arenaceous Trochammina which on the basis of recent analogy lived at a depth of 200—100 m and more. Presence of Cyclammina in the Middle Eocene indicates probably a greater depth although scarcely were found in the depth of 160 m. We may suppose also lesser depths if we compare associations of the spotted facies of the Třinec beds with that found in warm seas of lower geographical latitude (Bay Bahia de Todos Santos near California, W. Walton, 1955). Living species of genus *Ammodiscus* occur here in the maximum depth of 100 m, coarse-grained Proteoinas (closely allied to the Paleogene Saccamminas) at a depth of 15—200 m, species of Recurvoides mostly between 50—150 m. Similar extension have also many species of Reophax. In a greater depth considerably decreases an amount of the mentioned species (lesser than 1 per cent). Trochamminas, typical fossils of claystones of the spotted facies occur in the California bay in the depth of 20—40 m. In this facies varies the grain size of the walls of arenaceous Foraminifera which may be in connection with near dry land.

The facies of black (black-grey, black-brown) pelites does not contain both greenish and red pelitic interbeds. It contains in general only layers of psammites and pelocarbonates of various thicknesses.

Black-grey claystones represent very special biofacies composed almost exclusively of small benthonic Foraminifera with arenaceous walls and sphaerical (planktonic) Radiolaria generaly pyritized. These associations qualitatively and quantitatively vary very little and by their generic composition show affinities to the flysch biofacies. The typical flysch beds, however, contain claystones typical for other lithologic facies (variegated, spotted). In despite of this in each case biofacies of claystones of the flysch beds is very similar to that of the black-grey claystones. From the mentioned facts it is obvious that the biofacial identity of the flysch-like and non-flysch claystones of black-grey facies and other facies of claystones of the typical flysch beds follows from the identity of biotic factors as abiotic factors affecting the lithofacies of claystones of the typical flysch beds are evidently different from the abiotic factors of black-grey claystones. Only a number of microfauna in black-grey claystones of the flysch-like and non-flysch beds is higher and in the profile of the facies of black-grey claystones does not vary. Approximately 20 per cent steril samples comes on 100 studied samples while in the typical flysch beds comes 80 per cent steril samples on 100 studied ones.

In the Beskid section of the Silesia-Těšnovice unit developed thannatocoenosis of the facies with black-grey claystones of the Těšín—Hradiště suite from rich calcareous associations of spotted pelites of the Těšín limestones by the way of descrease to disappearance of shallow-water in general in reefal detritus living Miliolid Foraminifera *(Trocholina, Cornuspira),* by development of Lenticulinas without an ornamentation and by the increase of primitive arenaceous Foraminifera mainly from superfamily Lituolidea *(Haplophragmoides, Ammobaculites, Haplophragmium, Bigenerina, Trochammina, Verneuilinoides, Gaudryinella)* and Astrorhizidea *(Reophax, Glomospira, Hyperamminoides).* These changes are analogic with those of the biofacial deepening of the sea. In the lower part of the Těšín—Hradiště suite in which became this change is not yet developed such arenaceous microfauna in younger beds characteristic for the facies of black-grey claystones this indicates a very shallow sedimentary district with associations resembling recent associations of shallow brackish basins. In the upper part of the Těšín—Hradiště suite (i. e. in the Hradiště beds) to this shallow-water conditions correspond numerous species (*Verneuilinoides neocomiensis* Mjatljuk, *Ammobaculites* ex gr. *agglutinans* d'Orb., *Reophax neominutissimus* Bartenstein and Brand, *Haplophragmoides barremicus* Mjatljuk, *Haplophragmoides cushmani* Chapman, *Verneuilinoides subtiliformis* Bartenstein, *Trochammina neocomiana* Mjatljuk and some primitive Bigenerinas). They made up one component of the necrocoenosis of the Hradiště beds. Such benthos the character of which is emphasized also by the development of irregularly coiled Trochamminas (typical for instance for the brackish conditions of Maracas bay in Trinidad — J. B. Saunders, 1957) is typical for some portions of the facies with black-grey claystones.

In the Hradiště beds all the studied species reach 0.6 mm. In contrast to recent representatives of superfamily Lituolidea (and Astrorhizidea, too) from arctic basins are once to twice as smaller. By generalized conclusions (see C. R. Stelck, J. H. Wall, W. G. Bahan, L. J. Martin, 1956) indicates the coming of such primitive microfauna (arenaceous) is related to the transgression caused by deeping of the bottom. That coming was accompanied by an ingression of pelagic plankton which indicates the vicinity of the pelagic sea. Also the claystones of the Hradiště beds carry pyritized Radiolaria. In this period we may postulate a progressive transgression into the district of the Baška development, and perhaps into the Frenštát district of the Godula development.

The presence of some species of Trochammina allows us to compare associations of the Hradiště beds with very similar recent associations living in swamps bordering a shore (F. Phleger, 1954, 1958; F. L. Parker, W. D. Athearn, 1959). Also some further species of *Haplophragmoides* and *Ammobaculites* quoted in associations without calcareous microfauna from shallower facies of the Jurassic (G. F. Lutze, 1960) of the northern Germany (Lower Cretaceous, H. Bartenstein and E. Brand, 1951), the Hradiště beds of Emba (E. Mjatljuk, 1939) indicate the immediate proximity of dry land and shallow sea. The majority of the mentioned species was adapted even to brackish conditions. Associations of very fine-arenaceous Foraminifera (mainly *Reophax*, *Haplophragmoides)* show that they lived under conditions of more close sea basin with the depth of a few tens m. Also sporomorphs and Dinophlagellata found by M. Dvořáková (1962, in press) near Štramberk indicate a compararatively shallow sea with a tendency to freshening of the water.

We cannot compare the biotope of the facies with black-grey claystones with recent arctic biotopes. Even in the arctic shallow-water associations there are smaller primitive arenaceous Foraminifera (A. R. Loeblich, H. Tappan, 1953; J. Cushman, 1944) all the arctic associations contain predominantly calcareous Foraminifera (benthonic Miliolidea, Rotaliidea, Peneroplides). An accumulation of fish teeth in some parts of the Hradiště and Hluk beds of the White Carpathians-Oravian particular unit in the Magura group testifies the local development of conditions similar to those in the recent Black Sea. In the upper parts of the Hradiště beds (which were often regarded as the Veřovice beds) we have to suppose the normal salinity as there are frequent finds of Ammonites.

At the transition between the Hradiště and Veřovice beds ends or retards the accumulation of clastics. As is obvious from lack of Radiolarian plancton, it is not out of question that in extensive region between Valašské Meziříčí and Sanok during a short period was interrupted the connection with the pelagic sea.

The biotope of black-grey claystones of the Veřovice beds carry exclusively the arenaceous foraminiferal benthos. Among Foraminifera there are many eurybionts which pass from the older beds (the Hradiště beds) (*Verneuilinoides, Ammobaculites, Haplophragmoides*). We may say about the ecological factors of the Veřovice beds almost the same as about those of the Hradiště beds. Recently appears here Haplophragmoides spissum Stelck and Wall which is quoted from associations of sea with normal salinity and with depth about 30 m. Comparatively lesser depth are indicated also by numerous opal microfauna resembling the Ophthalmidiidal Foraminifera of shallow sea. Also primitive Saccamminas resemble the recent shallow-water genus *Leptodermella* (J. Cushman, P. Bronnimann, 1948). The primitive tubular Astrorhizidean Foraminifera of the Veřovice beds are lacking.

Conditions of sedimentation, life and diagenesis of the Cretaceous districts of the flysch zone in the Czechoslovak Carpathians

Studying the Subsilesia-Ždánice unit (Z. Roth, 1962) we came to the conclusion that red claystones of the variegated Subsilesian beds represented originally the red mud transported from dry land to sea in which the upper parts of the bottom had not reducing conditions. Secundary grey-green and green-grey spots which occur locally in red pelites show that they developed in oxidizing conditions where the boundary with $Eh = 0$ lies in the sediment in a depth of some to 30 cm (G. I. Bušinskij, 1954).

The facies of spotted pelites of the Třinec beds developed (Z. Roth, 1962) from the same red mud as red pelites developed by reduction of the red pigment to green one (see M. Eliáš – F. Čech, 1957). In the sense of Teodorovič's clasification conditions here were neutral or slightly reducing where the boundary of reduction and oxidation ($Eh = 0$) runs on the surface of sediment or at a very shallow depth.

The facies with black-grey claystones rich in pyrite locally with lenses of pelosiderites corresponds to reduced conditions. Similar conclusions in many aspects moding by Z. Kukal (1959). By classification of L. G. Weeks (1952) and G. I. Bušinskij (1954) the facies with red and spotted pelites developed in the depth where waves and currents obstructed a constant deposition of organic mud on the bottom, respectively where the benthos and aerob bacteria quickly consumed the organic mud. The facies with black (black-grey) pelites deposited in contrast to the mentioned sediments in zone laying below the usual effective base of waves and currents transporting the organic mud (L. G. Weeks, 1952), where live almost exclusively anaerob bacteria (or poverished benthos if water was not infested by H_2S). Therefore the facies of spotted pelites carries traces of lumbricoidal organisms in form of chondritic canals while the facies of black (black-grey) pelites such traces do not occur (Z. Roth, 1962). The facies with black pelites contains only remains of plankton and fish teeth and Ammonites (L. G. Weeks, 1952).

The facies with red pelites carries frequently chondrites but exclusively in layers of green-grey pelites. We explain this by local alternation with the facies of spotted pelites.

In general the distinctly stratified character of the red pelitic layers shows that red pelites were deposited in zone of rapid accumulation of red mud transported from dry land and deposited under oxidizing conditions. The facies of spotted pelites developed approximately within the effective base of waves and currents (L. G. W e e k s, 1952, 2116).

We must note that the effective wave and current base (L. G. W e e k s, 1952) by which we understand the maximum depth in which waves and currents move a sediment (so that at lesser depth cannot be deposited any stable sediments) is different for sands, inorganic muds and organic muds and varies in connection with time and in certain periods also with place. The effective base of wave is (for organic muds) in pelagic sea some feet and more, in separated parts of sea it is a few feet only and in protected lagunas or basins only some feet or inches (L. G. W e e k s, 1952, 2105—2107).

From the mentioned it is obvious that all three facies of clayey bottom may develop either in through illuminated or non-illuminated zone of the water. Thus the facies of black (black-grey) pelites deposited in through illuminated part of sea was found in the Třinec beds of Subsilesia-Ždánice unit (E. H a n z- l í k o v á, 1955).

The facies with black-grey and black pelites, frequently with sulfids in general may serve as an evidence of closed depressions of sea bottom unaffected by waves and currents and somewhere infested by H_2S. Such closed depressions developed mostly by tectonical way (in consequence of tectonical movements) so that the sulphide medium we regard as mainly in tectonically active regions as tectonic facies of sediments deposited in closed depressions of the bottom (G. I. B u š i n s k i j, 1954, 403). It was proved on the one hand that the organic materials (wastes) accumulate intensively in isolated or nearly isolated basins and on the other hand there is a direct dependence between content of organic C and S in recent sediments (Z. K u k a l, 1960, 94—95).

From connection between mentioned three in essentiality geochemical facies of pelites it is clear that they represent preserved ground types of clayey sea bottom with genetic affinities and with a connection with conditions of origin. In the Subsilesia-Ždánice unit the sediments of which deposited in comparatively narrow marine space not too distantly of shore laterally and vertically substitue these facies. Their vertical series in general shows shallowing and deepening of the sedimentary district proved by other paleogeographical conclusions. The series of facies from which stratigraphically oldest is the facies of black-grey claystones indicates the change similar to shallowing and opposite series indicates a deepening (Z. R o t h, 1962). We speak about changes similar to shallowing or deepening because in other cases the reasons for the changes may be different. For instance in the Subsilesia-Ždánice unit on the basis of various criteria the change of geochemical facies of clayey bottom is expressed mainly in the depth changes. These facies are results of combination of conditions of various character under which deposited sediments and of conditions of diagenesis. Under such conditions there may develope various geochemical facies of clayey bottom in the same depth and similar ones in different depth.

The three mentioned main facies of clayey bottom resulting from oxidizing-reducing conditions (expressed mainly in colour of pelite) in closed connections repeated in the Carpathian beds of various geological age and their series and extension represents a basis of lithostratigraphical and regional-geological division. They are locally modified by a varying content of $CaCO_3$ which indicates the alcalicity of medium (L. G. W e e k s, 1952; G. I. B u š i n s k i j, 1954). These facies are distinct in the Upper Trias or in the Lower Jurassic. Here we shall deal with them mainly in regard to the Cretaceous of the Czechoslovak Carpathians.

The mentioned facies of clayey sea bottom (besides the Subsilesia-Ždánice unit) we may observe in multiple alternation and superposition and partly in lateral changes in the Silesian unit of Moravia-Silesian Beskid (mainly in the Godula development).

The facies change was in the Valanginian to Middle Aptian in the sense of change similar to deepening and the development of closed bottom depressions, respectively closed basins. The older Valanginian is characterized by intensively calcareous facies of spotted claystones (the Těšín limestones) and by younger beds (up to the Middle Aptian) in the lower parts calcareous and higher non-calcareous facies of black-grey claystones (the Těšín—Hradiště suite and the Veřovice beds).

In the Uppermost Aptian there was a change into (mostly non-calcareous) spotted claystones (the Lhota beds), i. e. in the sense of changes similar to shallowing. This tendency culminated in the Albian with a non-calcareous facies of red claystones (in the typical Godula development) — the variegated Godula beds. In axial part of the Godula sedimentary district in the eastern part of Moravia-Silesian Beskid the variegated facies is lacking (for instance E. M e n č í k, 1960).

In the Uppermost Albian we may see change comparable to deepening. Deposited here claystones of the Godula beds s. s. which by colour and locally by distinct chondritic spots belong to the facies of non-calcareous spotted claystones. The tendency of "deepening" to development of closed depressions continued further during the sedimentation of the Istebná beds (non-calcareous facies of black-grey claystones) into the Paleocene.

In the Lhota beds and in the Godula suite of the Silesian unit we observe also lateral change of the geochemical medium of the clayey sea bottom. East of the valley of the stream Ráztoka in the eastern part of the Moravia-Silesian Beskid disappear primary in the southern zone of the Silesian unit the variegated Godula beds (A. M a t ě j k a, Z. R o t h, 1949) while in the northern zone as show fragments near Nýdek they occur (E. M e n č í k, 1960). Contemporaneously in the southern zone of the Silesian unit in the Lhota beds becomes predominate the facies of black-grey claystones and thickness of the Godula beds s. s. reaches the maximum. Mainly the last circumstance shows that we are near the axial parts of that deepening Silesian sedimentary district and the geochemical changes indicate the "deep" series of facies as it was made in the Subsilesia-Ždánice unit.

This very interesting to compare the stratigraphical and regional change of the calcareous character of claystones in various parts of the Silesian and Subsilesia-Ždánice unit. Thus, in the Lhota beds (facies of spotted claystones) and in the variegated Godula beds calcareous claystones accumulate (concentrate) near the exterior margin of the unit, mainly in non-sandstone development now occuring in the vicinity of Staříč and Paskov. Also the non-calcareous facies of black-grey claystones in the Uppermost Cretaceous and Palaeocene of the Silesian unit (the Istebné beds) corresponds locally to the calcareous development of black-grey claystones of the Třinec beds of the Beskid section of the Subsilesia-Ždánice unit. The fact that for non-calcareous pelites we may find here a stratigraphical equivalent of calcareous character indicates that non-calcareous development of claystones is not a result of regional affects of clima, but rather of fall of pH which are as a rule in deeper parts of the sea.

In general the calcareous character of deposits is connected with the alkalinity of water (pH) which in open basins is higher than in closed parts of the sea. Under conditions similar to those in the Black sea it even changes somewhere into acidity. It mainly depends on the content of CO_2 in water. However, also in alkaline medium there are unfavourable conditions for deposition of $CaCO_3$ namely in open shallow shelfcor high parts of the bottom, so that also if in shallower sea were favourable conditions for deposition of limestones, in depressions developed non-calcareous Lhota and Godula beds of the same age or between partly calcareous black-grey claystones of the Třinec beds and fully non-calcarecus claystones of the Istebná beds. On the basis of lime-content even within the same geochemical facies of clayey sea bottom we may on the regional scale observe a tendency towards the change resembling deepening and shallowing. Such tendency, however, though not so surely, we may pursue stratigraphically if we compare lime-content of claystones of similar facies but of various age. Thus, the facies of spotted claystones of the Middle Cretaceous Lhota and Godula beds (s. s.) is lesser calcareous that similar facies of the Upper Cretaceous and Upper Eocene Třinec beds and less than the Lower Cretaceous facies of the Těšín limestones. In these changes, however, take a part also changes paleoclimatic and topofacial ones. Similarity of the Facies of the variegated Godula beds in their flysch development with the variegated Godula beds in non-sandstone development of the same age (now occurring near Staříč and Paskov) as well as comparision of the upper flysch Lhota and Mikuszowice beds with the spotted claystones of non-sandstone development of the Lhota beds of the same age shows that episodic deposition of numerous interlayers of sandstones between layers of claystones did not influenced the character of the facies and geochemical conditions.

Comparision of the character of the flysch and non-sandstone development of the variegated Godula beds shows that the primary character and speed of sedimentation of clay by episodic deposition of sandstones in the flysch sedimentation is not affected. This and also a regional relationship of non-sandy and flysch developments confirm the bimodal character of the flysch Godula beds, i. e. that the claystones of this suite developed mainly from the mud transported from the foreland of the Carpathians while the sandstones from detritus of an "exotic" ridge (see Z. R o t h, 1962).

Eastwards in Poland the geochemical facies of claystones of whole not too thick Godula suite contain red interbeds while at Czechoslovak territory the claystones of very thick Godula beds s. s. pass with regard to the older variegated Godula beds into "deeper" facies of green-grey, partly spotted claystones and relatively "deeper" facies reached the claystones of younger Istebná beds (facies of black-grey claystones). From this we may suppose that the change of the facies of variegated claystones into the facies of spotted claystones in the Godula suite and then in the facies of black-grey claystones of the Istebná beds (deposited in closed tectonic depression of sea bottom) was caused by tectonic subsidence of the bottom and the intensive episodic accumulation of sand was not by fall sufficiently compensed. The above-mentioned changes of the facies in the eastern part of the Moravia-Silesian Beskid, i. e. disappearance of variegated Godula beds, essential extension of the facies of black-grey claystones of the Lhota beds and a great regional increase of thickness of the Godula beds s. s. may serve as an evidence of the correctness of this conclusions. The beginning of fall was at the end of the Aptian.

The presence of abundant authigenic glauconite in sandstones of the Godula beds which testifies not a great depth of development (also the passing of the Krosno beds into the Silesian unit after menilite beds) marks that sedimentation was stimulated by intensive accumulation of sand and this might under certain conditions compensate the tectonic subsidence of the bottom.

As is obvious from facies of claystones of the Godula suite episodic accumulation of sand layers was in considerable time distances which did not impede to pedogenetic ripeness of lithofacies and locally to distinct development of burrowing benthos in layers of clays.

In despite of the fact that the typical flysch lithologically is made up only by interbeds of sandstones (as the clays are facially almost identical in the flysch, flysch-like and non-flysch beds), the microfauna of clays (in general regarded as autochthonous in contrast to fauna in sandstones) in the flysch beds differs from the microfauna of other beds, it is poverished and endemic. It is surprising, as one may suppose that also in the flysch basins in prevailing part of time deposited pelites, because the lithofacies of pelites might diagenetically ripen in both the flysch and non-flysch beds. Abundance and non-flysch character of the microfauna in pelites of the Baška development which in their lithological character show the most affinities to the typical flysch, marks that differences between flysch and non-flysch basins were not only in different geological profile of sea bottom (which was in the sedimentary district of the flysch Baška and Godula beds very similar to the typical flysch), but also in the biological development. Even if the physico-chemical conditions of sea bottom in periods between pelitic sedimentation and accumulation of sand were very quickly compensated, evidently did not appear on the bottom benthos burried under layer of sand suddenly deposited on a great part of the bottom. Immigration and development of foraminiferal benthos began evidently from the beginning. New ground afforded at the beginning probably very poor food and character of ground was very quickly changed by increasing amount of pelites. Therefore the associations remained very primitive until a new accumulation of sand. Only in marginal parts of the flysch basins as it was in the Baška beds was immigration easier, the benthonic associations developed after burying more quickly and the beds lost the biofacial character of the flysch. Thus probably we may explain the endemic character and poorness of microfauna of the flysch beds and their similarity with benthos of the facies (both the flysch and non-flysch) of black-grey claystones which also stifled development of benthonic associations of Foraminifera though rather by unfavourable environment than by the character of sedimentation.

The Baška beds of the Silesian unit represent the flysch-like beds as they are of lesser thickness and because of character of the microfauna. In the character of the claystones they correspond to the lithofacial character of the spotted claystones, which in the Baška sedimentary district are deposited before the facies of black-grey claystones of the Těšín-Hradiště suite (Chlebovice development). Also the upper part of the Pálkovice beds (Z. Roth and coll., 1962) and in the eastern Slovakia the Inoceramus beds of the Upper Cretaceous to Paleogene of the Dukla folds zone and the Magura unit (H. Świdziński, 1947) contain claystones of the spotted facies.

The Frýdek beds, the lower part of the Pálkovice beds (Tithonian) and lower Těšín beds we cannot on the basis of claystones to place in order. They contain rather dust-stones than claystones. They are very little sorted and the geochemical facies of clayey bottom is not developed. They correspond most probably to Week's (l. c., p. 2107) "dumped deposits" which deposited too quickly, mostly under the effective base of waves and currents, but also above it. Some features show that in our case they developed rather under conditions of the facies of black (black-grey) pelites. In the lower Těšín beds confirmed this for instance abundant resins.

Division of the Cretaceous beds of the Czechoslovak flysch on the basis of conditions of the clayey bottom (expressed in colour of the claystones) allows to clear some questions of stratigraphical hiatus and lithological changes known in the Silesian unit. Local hiatuses in the Valanginian near reefs of the Štramberk limestone was after deposition of calcareous pelites of the facies of spotted and variegated claystones (inclusively the Kopřivnice type of limestone, V. Houša, 1961) and is overlain by the Těšín—Hradiště suite of the black-grey claystones which locally directly transgressed on to the older substratum (Z. Roth and coll., 1962 a). Also the stratigraphical equivalent of this hiatus in the Godula development of the Silesian unit separating the muddy facies of the Těšín limestones and the younger detrital facies (E. Menčík, 1960) was at the boundary of the older lithofacies of spotted pelites and the younger lithofacies of black-grey claystones. Both these facts together with the micropaleontological content of the menilite beds of the Subsilesia-Ždánice unit in the Beskids (E. Hanzlíková, 1960) show that as is mentioned by G. I. Bušinskij (1954) sedimentation affected by rich organic material runs not only in to deep-water depressions of the sea, but also in the depressions and shallow-water parts (Z. Kukal, 1960). Lithofacies of black-grey claystones therefore must regarded as a product of environment without access of 0 which developes mostly in depressions of sea bottom at various depths. In the sedimentary districts with intensive accumulation of sediment such depressions have the tectonic origin, so that the facies of black-grey claystones may serve as an evidence of tectonic movements.

Rush assembling of detrital (and dark clayey) sedimentation in the upper part of the Těšín limestones we may regard as an evidence of lithological change caused without interruption by tectonical movements. Similar sudden change in character of sedimentation of layers of sandstone and clay we may see also at the boundary of the Istebná beds (and Godula). Locally as in the Pálkovice beds of the same age (see Z. Roth and coll., 1962 a) we may distinguish on the basis of the Istebná beds quite a distinct discordance and hiatus (in the vicinity of Rožnov pod Radh., B. Zahálka, J. Koutek, 1927; A. Matějka, Z. Roth, 1949; in the vicinity of Jablunkov — E. Menčík, 1960). We may suppose that in the Upper Turonian and Lower Senonian sedimentation in the region of development of the Godula beds of the Silesian unit was interrupted. In the Upper Turonian and especially in Maastrichtian sedimentation was restored in a shallow closed depression of the bottom which quite a quickly deepened and allowed the accumulation of thick typically flysch Istebná beds with black-grey pelites. Relatively more slowly was deepened. The bottom in the north-west, where deposited the Pálkovice beds of the Baška development (with green pelites and probably lesser original thickness) and in the east where the Istebné beds are non-flysch, almost exclusively of sandstone development and considerable lesser thickness (in the vicinity of Jablunkov).

Conclusions

1. In this work is presented revision and completed by characteristic of the specific biotop the lithologic definition of the flysch as it was originally proposed by F. Pícha, M. Eliáš, Z. Roth (1956). The definition are applicated as criterion for division of the Cretaceous beds of the Czechoslovak Carpathians.

2. The Lower Cretaceous restricted on Czechoslovak territory to the region of Carpathians does not content the typical flysch beds. The Middle and Upper Cretaceous (D. Andrusov, 1959) on Czechoslovak territory occurs in various extension in both the main neoid units, i. e. either in Bohemian massive, either in the Carpathians. The typically flysch character have only the beds of the exterior (Krosno-menilite) group of the Carpathian flysch zone.

3. The majority of the Cretaceous beds of the Carpathian flysch zone are made up of flysch-like beds (i. e. beds similar to the flysch, which lack at least one of the essential character of the typical flysch).

4. The typical flysch on Czechoslovak territory is represented by the Middle Cretaceous Godula suite in the Silesia-Těšnovice unit (except for lesser extended marginal non-sandstone development north of Nový Jičín and Frýdek-Místek), by the Upper Cretaceous to Paleoceneous Istebná beds of the same unit [except for a non-clayey development of little thickness between the hill Burkov (1031 m), Bystřice nad Olší and Czechoslovakia-Poland state boundary] and by the Upper Cretaceous to Paleocene Inoceramus beds in the Dukla folds unit. As non-flysch beds we regard in the flysch zone of Czechoslovak Carpathians the Cretaceous non-sandstone or non-clayey beds for instance the Veřovice beds of the Godula development in the Silesia-Těšnovice unit and the non-sandstone facies of the Lhota beds and the Godula suite. Other Cretaceous beds of the flysch zone we may regard as flysch-like ones.

5. The typical flysch is missing in the Cretaceous of Central Carpathians, interior klippen belt and whole the flysch zone south-west of Valašské Meziříčí.

6. A regional extension of the typical flysch beds during the Cretaceous period was from the west to east within exterior, Krosno-menilite group of the flysch zone.

7. While the psammites of the typical flysch beds were transported from an elevated fault adge which bordered the sedimentary district, fine mud was transported from a much wider region. The main source of the psammites in the Cretaceous beds of the flysch zone of Czechoslovak Carpathians was represented by fault edge which bordered the geosyncline of the exterior group of the flysch zone to the south (west in the tectonic expression), northern border of the Maleník exotic block; in the paleogeographical expression the northern slope of the peninsula of silesian reefs.

8. All layers of psammites (locally psephitic) in the typical flysch beds of the Cretaceous of the Czechoslovak Carpathians probably did not develope by a short-time sedimentation from single turbidity currents. The portion of beds developed by other way than by turbidity currents up to present was not in the typical beds of the Czechoslovak Carpathians estimated.

9. Abundant authigenic glauconite in the cement of sandstones of some beds of the typical flysch first of all of thick typically flysch Godula suite of the Middle Cretaceous (studied among others by R. Kühnel, 1958) marks that these sandstones were diagenetically formed in a not too cold sea, with a depth of a few hundreds m (V. Skoček, 1962).

10. Pelites of the flysch, flysch-like and non-flysch beds in the Cretaceous of the Czechoslovak Carpathians we may distinguish into lithofacies with red pelites (in lesser extension in the Valanginian, Upper Albian to Senonian), lithofacies with green-grey locally dark-grey chondritic spotted pelites (Valanginian and Aptian to Senonian), lithofacies with black-grey (black) pelites (upper part of the Valanginian to Albian and Upper Senonian). These facies are stratigraphically and laterally alternated.

11. Lithofacies of mentioned three types correspond to three specific biotops of microfauna. However, the claystones of all three types represent one homogeneous biotope.

12. Biotope of the facies with green-grey (spotted) pelites in the non-flysch and flysch-like beds represents the main, initial biotop from the micropaleontological point of view. It is a biotop of deeper, well aerated-neritic zone from which we may derive biotopes of other lithofacies of claystones of the Cretaceous beds of the flysch zone.

13. Interlayers of red pelites in the Cretaceous beds of the studied flysch zone developed by accumulation of red mud transported from dry land. Under suitable conditions this mud changed into greenish-grey to black mud.

14. Comparatively most abundant intercalations of red pelites in the Cretaceous marine sediments of Czechoslovak Carpathians are in the Albian and Upper Senonian. The sources of this red mud were in north-western foreland of Carpathians and in penninsula of the Silesian reefs. The region of most stable accumulation of red terrigenous mud was the Pienidy sedimentary district extending on the southern slope of the penninsula of the Silesian reefs (the Maleník exotic block).

15. On the basis of ecological comparision of autochthonous foraminiferal benthos of the Cretaceous of the flysch zone with recent one we may suppose that the clayey bottom of sedimentary districts of the flysch zone was of middle (or lesser) depth.

16. On the basis of the important role of terrigeneous mud, the character of the lithofacies of pelites and calcareous character we may suppose that the sedimentary district of Czechoslovak Carpathians extended in the zone of semi-arid warm clima. The biotope of the facies with red pelites testifies the connection with the pelagic sea, and the seasonal character of flows transporting the mud.

17. While the facies with red pelites and facies with green-grey (spotted) pelites represent the facies of a muddy sea bottom within the effective wave and current base (I. G. Weeks, 1952), the facies with black-grey (black) pelites (without regard to the depth) represents the facies of closed depressions

of bottom with stagnant water. Also the claystones of the black-grey facies may developed in the illuminated zone (E. H a n z l í k o v á, 1955) and in lesser depth.

18. Closed depressions on the sea floor with the facies of black-grey (black) pelites developed in deepening sedimentary districts of the Cretaceous of the Czechoslovak Carpathians.

19. Pelites of the same lithofacies deposited contemporaneously in the beds of typical flysch and in the non-flysch beds [for instance in the non-sandstone variegated Godula beds and variegated flysch Godula beds (Albian), black-grey Třinec beds and the Istebná beds in the Uppermost Senonian to Paleocene] may serve as an evidence of constant chemical character of environment of clayey sea bottom during periods of pelitic sedimentation.

20. Despite the geochemical similarity of environment of development of pelites and lithological similarity, the pelites of the typical flysch beds differ from that of non-flysch and flysch-like beds by monotonous and poverished microfauna with predominant agglutinated foraminiferal benthos. Such microfauna may be found only in the facies of black-grey pelites.

21. The biofacies of black-grey pelites in the beds of non-flysch character and flysch-like character differs from that of all the types of pelites in the flysch beds in its microfauna which is much more abundant.

22. The affinities of the biofacies of the typical flysch beds and the biofacies with black-grey (black) pelites of non-flysch and flysch-like beds follow from similar biotic factors.

23. The biotope of claystones of the typical flysch beds is of an endemic character.

24. The endemic biotope of the typical flysch beds of the Cretaceous of the Czechoslovak Carpathians is very similar to that of the recent hollow Ammontatura in the Mediterranean sea (H. S c h m i d t, 1953).

25. The Upper Cretaceous of the facies with red pelites in the pre-Magura unit and in the Těšnovice section of the Silesia-Těšnovice unit carries foraminiferal benthos of the Frýdek type which developed from associations living under conditions of sandy bottom. The Upper Cretaceous beds with red pelites in the Magura unit (interior klippen belt and Hluk region) carry foraminiferal benthos of the Pienidy type which may be derived from associations living under conditions of calcareous bottom.

26. A short-time epizodic accumulation of sand (sandstone) during sedimentation of the typical flysch beds was at sufficient intervals during which ripened chemically the lithofacies of the clayey sea bottom as well as in regions of deposition of non-flysch or flysch-like beds. During the periods of episodic accumulation of sand the benthos was exterminated. Associations immigrating into such regions remained to the next accumulation very primitive like associations living under conditions similar to that in the Blach sea [i. e. conditions of the facies with black-grey (black) pelites].

27. The microfauna of the pelites of the flysch, flysch-like and non-flysch beds of the Cretaceous of the Czechoslovak Carpathians contains exclusively elements of shallow sea. Lithology of the claystones and sandstones of these beds is not of a deep-water character.

28. Abundant authigenic glauconite in the sandstones, the character of the

claystones and their microfauna may serve as evidence of development of the flysch beds in a not deep sea.

Translated by V. S c h e i b n e r o v á.

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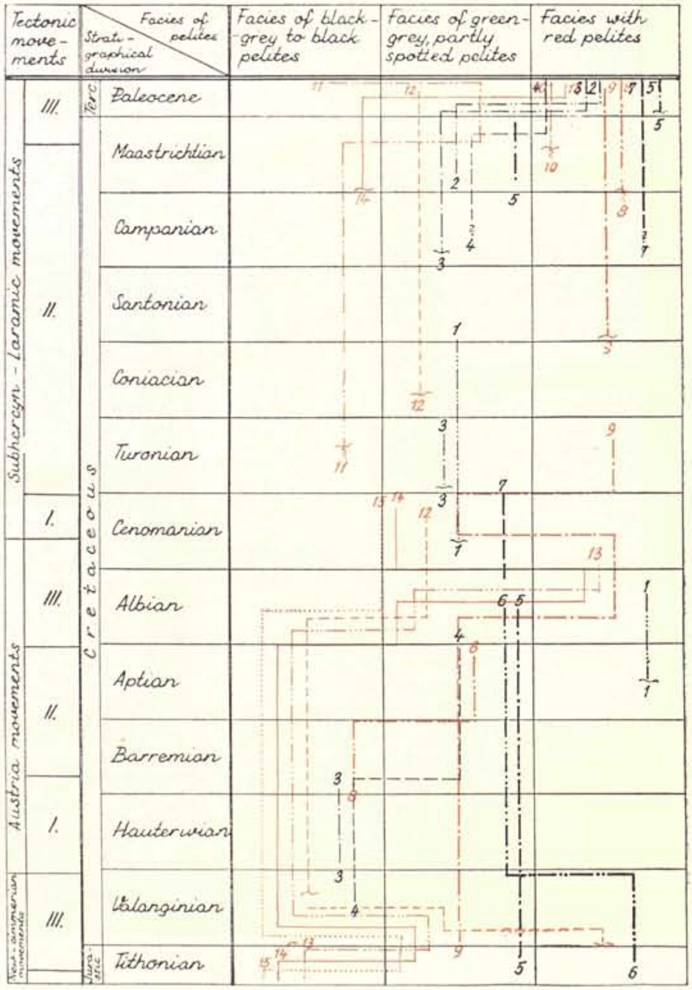

Enclosure 1. Fig. 1. Scheme of development of pelitic facies in the Cretaceous beds of the flysch zone of Czechoslovak Carpathians. Sedimentary district of the Maleník block and more southern ones of the Bohemian massif. 1 — platform development, sedimentary district of the Subsilesia-Ždánice unit. 2 — Ždánice section. 3 — Pavlovské kopce—Waschberg section; sedimentary district of the Silesia-Těšnovice unit. 4 — Těšnovice section (Partim Zdounky—Kurovice section); sedimentary district of the exotic block, 5 — Cetechovice sedimentary district (Kurovice partim). 6 — subpieniny sedimentary district. 7 — pre-Magura sedimentary district; depression sedimentary district. 8 — Hluk region. 9. pieniny region; sedimentary district of the Silesia-subsilesia depression, Subsilesia-Ždánice sedimentary district. 10 — paraautochthonous development. 11 — normal development of the Beskid section; sedimentary district of the Silesia-Těšnovice unit. 12 — Baška development. 13 — Godula development (non-sandstone, Frenštát—Těšín region, Nýdek region); I — period of more intensive movements of bottom, II — period of slow movements of bottom, III — period of origin of closed depressions of sea bottom.

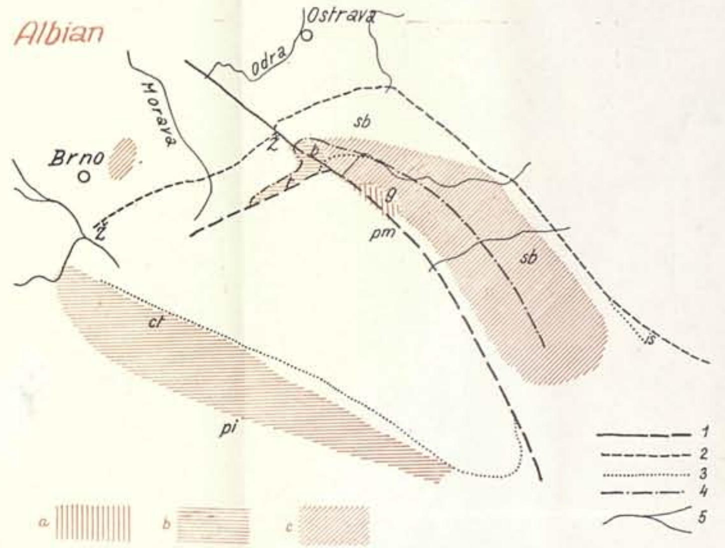

Fig. 2. Paleogeographical scheme showing a distribution of various facies of clays in the Cretaceous of the flysch zone of Czechoslovak Carpathians (with regard to R o t h, 1960, 1962; K s i ą ż k i e w i c z, 1960; S c h e f f e r, 1960; S t i l l e, 1953). Black line: facial development of pelites in elevated parts of the sedimentary districts, coloured line: facial development of pelites in depressions. 1 — fault margins of blocks of pre-Permian substratum of the flysch zone sedimentary district. Now these blocks are thrust under the block of Central Carpathians. 2 — exterior margin of the flysch zone sedimentary district. 3 — northern margin of the Cretaceous sedimentary district of the Magura group of the flysch zone (including the interior klippen belt). 4 — exterior (northern) margin of the Silesia-Těšnovice sedimentary district. 5 — recent rivers. ž — Ždánice sedimentary district. sb — subsilesian and Bachowice sedimentary districts. is — Skol sedimentary district. t — Těšnov sedimentary district. b — Baška sedimentary district s. s. g — Godula sedimentary district. pm — pre-Magura sedimentary district. ct — Cetechovice sedimentary district. pi — Pieniny sedimentary district. a — facies of black-grey pelites. b — facies of green-grey, partly spotted pelites. c — facies of red pelites.

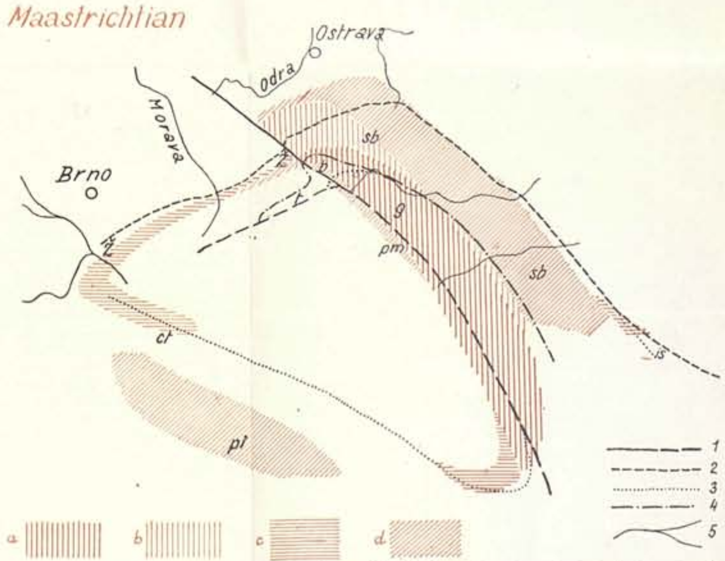

Fig. 3. Paleogeographical scheme showing a distribution of various facies of clays in the Cretaceous of the flysch zone of Czechoslovak Carpathians. 1 — fault margins of blocks of pre-Permian substratum of the flysch sedimentary district. Now these blocks are thrust under the block of Central West Carpathians. 2 — exterior margin of the flysch sedimentary district. 3 — northern margin of the flysch zone (including the interior klippen belt.) 4 — exterior (northern) margin of the Silesia-Těšnovice sedimentary district. 5 — recent rivers. a — facies of black-grey pelites. b — facies of grey pelites. c — facies of green-grey, partly spotted pelites. d — facies of red pelites.