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# DISTRIBUTION OF THE TOARCIAN LITHOFACIES IN THE CENTRAL ZONE OF WEST CARPATHIANS

## PRIESTOROVÉ ROZLOŽENIE LITOFÁCIÍ V TOARKU CENTRÁLNEHO PÁSMA ZÁPADNÝCH KARPÁT

*(Textfigs. 1–4)*

A b s t r a c t. Five lithofacial types are distinguished, characterized by the presence of Ammonites, Brachiopoda, Bivalvia and Crinoidea.

On the basis of the present knowledge of the Toarcian lithofacies of the Central zone of West Carpathians five lithofacial types may be distinguished, viz.:

a) lithofacies of arenaceous crinoidal limestones,
b) lithofacies of crinoidal limestones,
c) lithofacies of red nodular limestones,
d) lithofacies of Fleckenmergel; spotted marls,
e) lithofacies of dark shales.

Lithofacies are characterized by distinct features differing from each other. Differences among the above lithofacial types have been conditioned by the position of sedimentation area of the given lithofacies in the geosyncline in the course of sedimentation. Such dependence occurs not only in the stadium under question, but also in the preceding and following stadii. Consequently, the position influences not only the character of the whole series, it simultaneously determines the degree of relations among individual lithofacies and series.

### Sedimentary-Petrographic and Biofacial Characteristic of the Individual Lithofacial Types

L i t h o f a c i e s o f a r e n a c e o u s - c r i n o i d a l l i m e s t o n e s. This lithofacies is characterized by a great amount of clastic material, mainly quartz. The main rock component is formed by crinoidal limestones with various amount of the clastic component. According to the contents of clastic material several lithotypes may be distinguished here. Most frequent are the arenaceous-crinoidal limestones, red or grey, sometimes (in red types) containing thin beds of sedimentary Fe-oxide "ores" (e. g. Kadlubek, Klape).

The lithofacies is biofacially characterized by the presence of Ammonites,

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Brachiopodes, Bivalves and Crinoids. The lithofacies is rather closely related to the lithofacies of crinoidal limestones, differing from it by great amount of clastic admixture. Beds forming the lithofacies, were deposited near the shore (in the littoral zone and in the shallow neritic). The lithofacial type may be found first of all in the so called "Mantle series" and in a number of series, introduced by M. Maheľ (1959) as the West-Carpathian series. The lithofacies has been developed in the following series: Kadlubka development, Beckov series, Manín series, Klape development, eastern part of Šipruň series, Donovaly series, Red Magura series, High-tatric series, Čierna Hora series and Tribeč series.

Lithofacies of crinoidal limestones. Characteristic feature of the lithofacies is the occurence of ferruginous oxidic sediments. In the sense of sedimentary petrography they may be regarded as ferruginous sediments of hematite character. Orientational analyses show 6,8 % $Fe_2O_3$. In the majority of cases they have been developed in the form of thin (average 30 cm) lenses of ferruginous sediments in limestones. Alternation and transitions of limestones is very frequent. Adjacent limestones are usually crinoidal or massive. Occurence of clastic quartz is occasional (loc. Prístodolok). The texture is usually crusty with slight lamination. In some cases (loc. Prístodolok and Strážov) appear also oolites.

From the biofacial standpoint the lithofacies is characterized by abundant occurences of Ammonites (mainly representatives of Ammonitina), Crinoids, Brachiopods and Bivalves. Nautiloidea are very rare. All the above mentioned groups of organisms require shallow, well oxidized environment of the neritic zone.

Distribution of this lithofacial type is relatively considerable throughout the central zone. The typical development of this lithofacies occurs first of all in the Choč overthrust at the following localities: Hrušové in Nedzovské pohorie, and on the southeastern slopes of Strážov. In the Krížna overthrust such typical locality is regarded the Prístodolok and Vývrat.

Lithofacies of red nodular limestones. It is characterized by development of red nodular limestones and marly shales. There are no crusty ferruginous sediments, but Fe is dispersed in the rocks. Only the cement of nodules in some cases bears evidence of forming the ferruginous crust. There ist no further transport of clastic material. In top parts at the contact with Dogger Radiolarites occure concretional forms. Frequently green stains may be observed, caused by bivalent Fe. Usually they are the Ammonites molds.

From the biofacial point of the view, the lithofacies is characterized first of all by abundance of Cenoceras (Nautiloidea) representatives of Phylloceratina and Lytoceratina orders. Ammonitina are less frequent while Belemnoidea are rather abundant. Benthos is represented by sporadic occurences of Brachiopods, Bivalves and Crinoids.

Sediments, included in this lithofacies, were deposited in greater depths than the preceding ones. This may be proved by lithofacial character of sediments (presence of green stains of reduction character and absence of clastics) and general absence of sessil or vagil benthose. On the ground of these data we supposed that the lithofacies developed on a shelf near the continental slope.

In the typical development the lithofacies has been found mainly in the Krížna overthrust in Veľká Fatra (localities: Nolčovo, Borišov, Gaderská dolina,

Turecká) and in Červený Kameň near Podbiel (the Podbiel development of the Pieniny series). Further it may be found in Vysoké Tatry, Tribeč (Baranie rožky). In Malé Karpaty the lithofacies has been developed only to a small extent (D. Andrusov, 1959). In the Strážovská hornatina the lithofacies has been replaced by crinoidal limestones of organodetritic structure (Kozí chrbát near Valašská Belá, M. Maheľ, 1961). In the southeastern part of the mountain-range near Diviacka Nová Ves resting over the Fleckenmergel series there is a thin bed of red, slightly nodular limestones with crusty ferruginous sediments.

Lithofacies of Fleckenmergel. The lithofacies is characterized by sedimentation of Fleckenmergel with intercalations of claystones. Spongolites occure frequently. In some places (e. g. in western part of Malá Fatra) clay shales are prevailing. Pyrite is relatively frequent. Contents of total bituminous matter varie within 1—2 % (cf. orientation analyses by M. Šulcová, 1962). There was an intermittent transport of clastic material (turbidity currents?). In the locality Skladaná skala occures a bed of calcarenites (1 m thick) in the Fleckenmergel sequences, which may be regarded as an evidence of turbidity current.

From the biofacial standpoint the lithofacies is characterized by occurence of sponge spicules and worm furrows (Chondrites). Ammonites are rather rare while Belemnites are more frequent. The amount of benthic forms generally in this facies is rather small.

Concerning the position of the area during sedimentation the lithofacies originated on the continental slope and partly in the basin. The position is indicated by rhythmicity, lack of benthose and presence of organic carbon.

In the typical development the lithofacies is exposed in northern parts of the Krížná nappe in Veľká and Malá Fatra, in Strážovská hornatina, Inovec, Malé Karpaty (Lošonec), Tribeč and Ružbachy island.

Lithofacies of dark marly shales. Lithofacies of this type is characterized by development of dark-grey black marly shales, alternating with strata of dark-grey sandy or marly limestones. Pyrite is frequent. Transport of clastic material is irregular. Sometimes occure also conglomerates. Contents of organic carbon ranges within 4,18 %, Sulphur 2,78 % in the shales (S. Polák, 1957). Occassionally also low grade manganese ores are present. Rhythmicity is frequent.

From the biofacial point of the view the lithofacies is characterized by a general absence of fauna. Whether this lack of fauna in given case is primary (abundance of $H_2S$) or only secondary is hard to determine. Sporadically occure Sponges, Crinoids and Ammonites, more abundant are worm furrows (Chondrites) and Belemnites.

Intercalations of crinoidal limestones and presence of clastic material would probably indicate shallow-water sedimentation. By the general character the lithofacies resembles that of the Domanik type which is a shallow-water one (N. M. Strachov, 1960). From the typical Domanik lithofacies it differs by the absence of combustible matter and the total contents of organic carbon is lower.

In its typical development the lithofacies is defined by M. Maheľ (1959) as the West-Carpathian group of series. The lithofacies is well developed in the Malé Karpaty series, in the Inovec, Malá Magura, Žiar and western part of Šipruň series.

Distribution of Toarcian Lithofacies. In the series regarded as mantle or Tatridy series, two different types of lithofacies may be distinguished: sandy-crinoidal lithofacies and lithofacies or dark shales. The distribution of lithofacies is such, that the lithofacies of dark marly shales is distributed among the sandy-crinoidal lithofacies (see Textfig. 1).

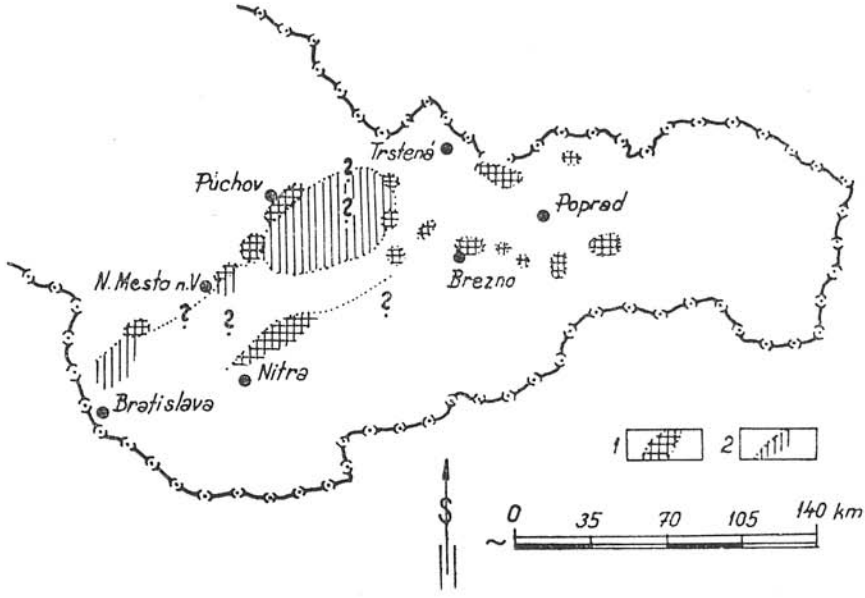


Fig. 1. 1. Lithofacies of sandy crinoidal limestones. 2. Lithofacies of dark shales.

East of Veľká Fatra the lithofacies of dark marly shales is not developed. There appears only the sandy-crinoidal lithofacies.

Concerning the distribution of lithofacial types in the Krížná nappe (see Textfig. 2) in Malá and Veľká Fatra, Nízke Tatry and Tribeč, the lithofacies under question are distributed in the following order (from north or northwest to the south): toward the north and northwest occures the Fleckenmergel lithofacies. To the south of it is developed the lithofacies or red nodular limestones and the southern most is lithofacies of crinoidal limestones.

The above mentioned sequence of lithofacies may be well observed in Veľká Fatra and in the southern part of Nízke Tatry, where from the north to the south the following profile may be observed: in the northern part of Veľká Fatra appears well developed (cca 50 m) the Fleckenmergel lithofacies. Further to the south is the lithofacies of red nodular limestones and marls. Thickness is rather small, not exceeding 2–5 m. In southernmost parts of Veľká Fatra occures the shallow-water lithofacies represented by the development of more or less crinoidal limestones with thin intercalations of ferruginous sediments.

Such sequences may be found also in the area of Vysoké Tatry. (D. A n d r u s o v, 1959), where the red nodular limestones have been developed with irregular intercalations of ferruginous sediments in Ružbachy "island", where

the Fleckenmergel lithofacies with spongolites (M. M a h e ľ, 1962) may be observed.

In Humenské pohorie (M. M a h e ľ, 1959) the Toarcian has been developed in lithofacies of red crinoidal limestones. Lithofacies of deep water are unknown here.

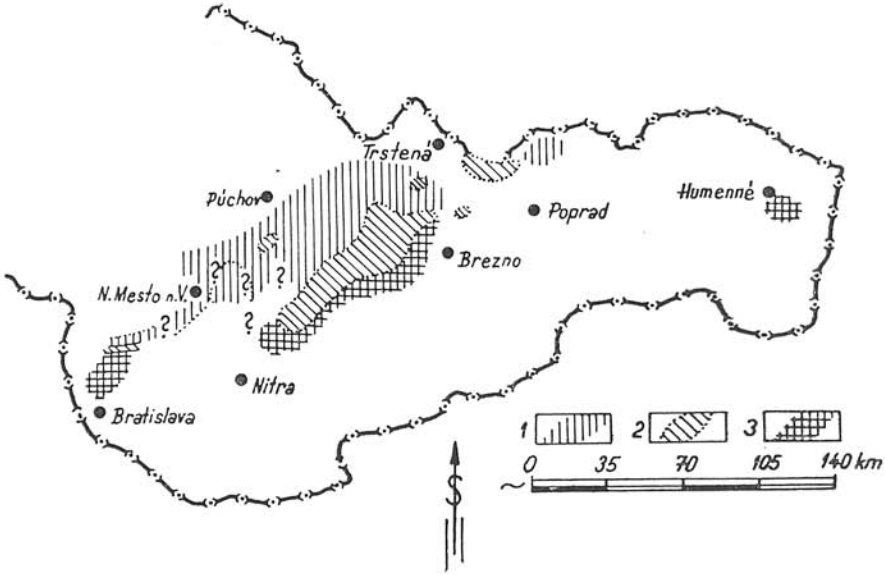


Fig. 2. 1. Lithofacies of Fleckenmergel. 2. Lithofacies of red nodular limestones. 3. Lithofacies of crinoidal limestones.

Essentially more complicated is the situation in Inovec. In northern part of the mountain range occures the lithofacies of Fleckenmergel. The lithofacies corresponding to the shelf or coastal conditions are absent however. M. M a h e ľ (1951, 1962) has pointed out the very complicated structure of this mountain-range.

In the Malé Karpaty the situation is different. Lithofacies of crinoidal limestones with beds of ferruginous sediments is rather well distributed (Vysoká series). Lithofacies of red nodular limestones has been developed only to a small extent in the northern part of the mountain-range (D. A n d r u s o v, 1959). In the same area of the mountain-range occurs the Fleckenmergel lithofacies which — according to M. M a h e ľ (1962) could reach up to the Toarcian. If we admit that possibility, then there is the same sequence preserved as e. g. in Veľká Fatra with the difference that the shallow-water lithofacies has a greater distribution.

In Strážovská hornatina the lithofacies of Toarcian are similarly distributed as in Veľká Fatra. In the northwestern part of the mountain-range occures the Fleckenmergel lithofacies southward replaced by shallow-water lithofacies represented by the development of fine-grained crinoidal limestones with organodetritic structure (M. M a h e ľ, 1962). Lithofacies of red nodular lime-

stones is developed only in the southeastern part of the mountain-range near Diviacka Nová Ves. In the southernmost parts coastal lithofacies is developed characterized by red crinoidal limestones with thin interbeddings of ferruginous sediments. According to M. Maheľ (1961, 1962) each of the lithofacies mentioned represents a particular structure.

In the Choč nappe there is only one lithofacial type known, sedimented in peripheral areas of the shelf. The most typical rocks here are ferruginous sediments. Their thickness does not exceed 0,5 m. As Toarcian must be regarded also a part of crinoidal complex with thin interbedding of ferruginous sediments. The general lithofacial character indicates, that the southern parts of the Krížná coastal lithofacies (crinoidal limestones) and the coastal lithofacies of Choč nappe have sedimented in the same sedimentation area, i. e. in the shallow-water conditions of the shelf.

According to the above mentioned facts the mutual relations of particular lithofacies of Toarcian of the Krížna and Choč nappes may be presented on the following scheme (Textfig. 3).

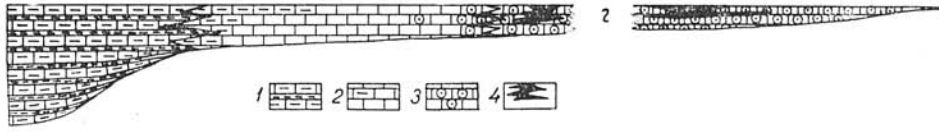


Fig. 3. 1. Lithofacies of Fleckenmergel. 2. Lithofacies of red nodular limestones. 3. Lithofacies of crinoidal limestones. 4. Ferruginous sediments.

## The Problem of Zonality and Abrupt Lithofacial changes in the Toarcian

In the preceding chapter we have observed that distribution of separate lithofacial types of the Toarcian in the Krížna overthrust shows a sequence. This sequence is a function of position during the sedimentation in the basin. Mutual relations of lithofacies indicate change of conditions in the basin the way, that from the north to the south decreased the depth of water. The circumstances indicate that the change of character of the lithofacies is rapid in the transversal direction (perpendicular to the axis of basin) but slow in the longitudinal direction (parallel to the axis of basin). Such relations of lithofacial changes deserve the zonality. There is a supposition, however, that zonality cannot be understood in the sense that throughout the whole extension of the lithofacies the same types of rocks must be found. It is obvious, that the change of lithofacies continued also in lateral directions (in longitudinal sense). The change is slowlier, however as it has been shown on the case of Veľká Fatra.

Toarcian lithofacies in the Krížna nappe in Veľká Fatra (in other mountains too) change their character from the coastal to the deep sea lithofacies with transitional development. Measuring the distance between the extreme occurence of deep water lithofacies (Fleckenmergel) and shelf lithofacies (red nodular limestones) in the area of Ružomberok (northern part of Veľká Fatra) and in the

area of Borišov and Lysec (northwestern part) of Veľká Fatra, it has been found, that this distance ranges in the average about 6 km. The distances of extreme occurrences of shelf lithofacies and coastal lithofacies in southern part of Veľká Fatra range about 3–4 km. In zones with transitional developments occure the lithofacies bearing the character of both extreme lithofacial types. Thus in transition from Fleckenmergel to red nodular limestones there are often light-brown slightly nodular massive limestones (e. g. mouth of the Terlen valley). In the transitional zone of nodular limestones crinoidal developments increase and pass even to crinoidal limestones.

Situation is complicated here by the heaping of crinoidal limestones in a narrow belt from Tajov to Moštenica. M. Mišík and M. Rakús (1963, in press) explain the presence of these limestones by the existence of currents. Occurrence of transitional developments indicates that in the area of Veľká Fatra in the Toarcian of the Krížna overthrust there are no sharply limited lithofacial types conditioned by abrupt lithofacial changes.

In the area of Malé Karpaty, Inovec and Strážovská hornatina it seems that the minimum distance in which lithofacial change may take place, is smaller. It is possible however that "shortening" of the minimum distance in comparison with Veľká Fatra Mts is caused by secondary agents-complicated tectonics.

In the Mantle series the situation is still more complicated, since there are only two types of lithofacies known, differing from each other. Occurrence of two lithofacies side by side would indicate relatively abrupt lithofacial change (e. g. in Inovec, Šipruň series in Veľká Fatra Mts.). On the other hand the distribution of Toarcian lithofacies in the Malé Karpaty series shows a gradual transition (M. Maheľ, 1962).

Presence and influence of the lithofacial changes cannot be excluded from sedimentation processes. Their influence may be expected mainly in areas of continental slope and shelf (falaises).

## Outline of Paleogeographic Situation of the Toarcian in Mantle Series (Textfig. 4)

From the paleogeographic standpoint, in the West-Carpathian geosyncline an important role had the elevated swell with the extension parallel to the axis of the West-Carpathian geosyncline. South-western part of the zone (approximately west or southwest of Veľká and Malá Fatra Mts.) has been divided into two secondary geanticlinal elevations by a depression. In the depression marly shales with limestone interbeddings have been deposited. Conditions for the formation of this were close to those responsible for the origin of the Domanik type of sediments. In geanticlinal zones shallow-water facies of Envelope series (lithofacies of sandy crinoidal limestones) have been deposited. Geanticlinal zones did not represent great cordillera of remarkable relief. They were just slightly elevated ridges consisting of mantle Mesozoic (mainly of Triassic age). Such interpretation of the character of geanticlinal elevations is supported by the fact, that in the Toarcian (and Jurassic in general) remarkable coastal lithofacies (conglomerates) is absent. It may also indicate that in this period denudation did not reach the crystalline substratum of geanticlinal elevations.

Northern geanticlinal belt known as Kadlubec–Beckov–Manín–Haligovec separated the Pieniny sedimentation area (in the north) from the sedimentation area (depression) with deposition of dark marly shales ("the Domaník facies"). Character of sediments and occurences of low grade Mn-ores show that conditions of sedimentation in the Pieniny sedimentation area and in the named depression are similar.

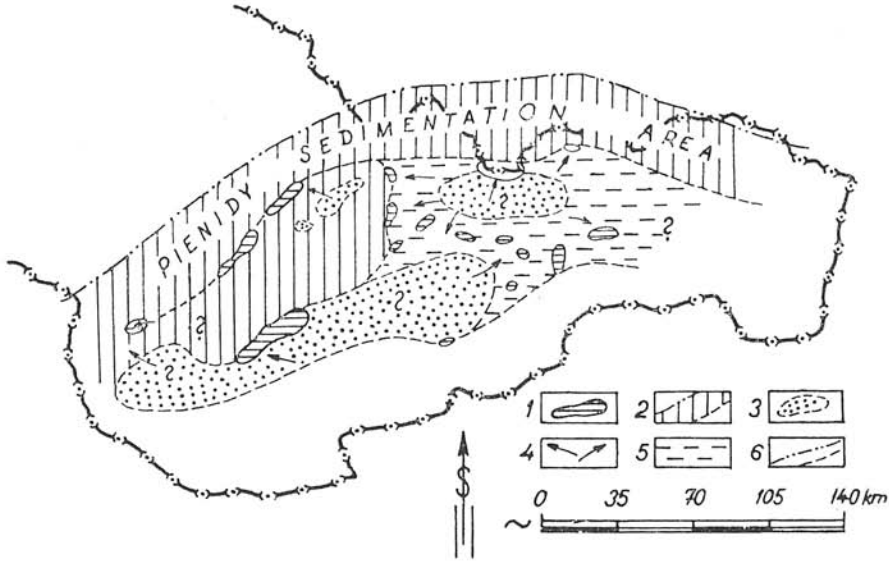


Fig. 4. 1. Sedimentation area of lithofacies of sandy crinoidal limestones. Present-day extension of lithofacies is limited by full line. 2. Sedimentation area of dark shales. 3. Emerging geanticlinal ridges, where the transport of clastic material originated. 4. Probable directions of the transport of clastic material. 5. Territory, with absence of sandy crinoidal lithofacia, their presence, being just supposed. 6. Probable border-lines of particular sedimentation areas.

South from the depression of anticlinal elevation was raising the southern geanticlinal Tribeč–Vepor belt. Transport of the clastic material was in various part different. In the eastern part of the elevated area, east of Veľká Fatra Mts. extended the shallow-water sedimentation area (sandy crinoidal lithofacies) of Mantle series. As the source of the clastic material in this part of the swell was an "island" situated in southern part of Vysoké Tatry Mts. and further the eastern parts of the Tribeč Vepor geanticlinal zone.

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Review by D. Andrusov.