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MESTEČSKÁ SKALA KLIPPE AND ITS IMPORTANCE FOR STRATIGRAPHY OF CZORSZTYN UNIT (BIELE KARPATY MTS., WESTERN SLOVAKIA)

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Abstract: A repetition of white and red crinoidal limestones was found in the Czorsztyn klippe Mestečská skala. The repetition is not tectonic, which is proved by the Oxfordian neptunian dykes cutting the whole limestone complex. This fact, together with facial analysis shows, that both limestones can be laterally substituted. The microscopical study of thin sections and heavy minerals analyses were used in the study.

The Pieniny Klippen Belt is a tectonically very complicated zone situated between the Central and Outer West Carpathians. It is conventionally divided into several geographical sectors (SCHEIBNER in BUDAY, et al. 1967). This paper deals with Mestečská skala klippe situated in Púchov sector, about 10 km NW of the town Púchov, near the village Mestečko (Fig. 1).

It represents an outcrop of Czorsztyn Unit with stratigraphical range from Bajocian (?) to Berriasian, with transgressive remnants of the Albian.

It is important to shortly remind the conventional stratigraphical scheme of Czorsztyn Unit (Fig. 2a). After Aalenian there is an abrupt change of sedimentation in Czorsztyn Unit. Marl and clay sedimentation gives way to carbonatic sedimentation in form of crinoidal limestones. The complex of crinoidal limestones is traditionally divided into older, white crinoidal limestone (Bajocian) and younger, red crinoidal limestone (Bathonian). Then follows red nodular Czorsztyn Limestone, with stratigraphical range from Callovian to Lower Tithonian. It represents the relatively deepest facies in the Jurassic of Czorsztyn Unit. In the shallower parts of Czorsztyn sedimentational area the pink micritic limestone with ammonites originated. Rare coral bioherms in present day known as Vršatec Limestone (MIŠÍK 1979) were formed on the most elevated parts. Middle Tithonian and Beriasian are represented by the Calpionella limestone with lateral transition to crinoid - brachipodal limestone and Rogoznik Limestone (together they are known as Durstyn Limestone). The carbonatic sedimentation lasted to Hauterivian. On the preceding series, after sedimentational break up and erosion there lie the trasgresive remnants of Albian and Lower Cenomanian marlstones. The variegated Globotruncana marls reach the Maastrichtian age.

This stratigraphical scheme is very general, but Czorsztyn Unit is not uniform in it's stratigraphical contents. BIRKENMAJER (1963) distinguished 11 types of Czorsztyn Unit. These types differ from each other only by their development in Tithonian and Cretaceous. Prior to the Kimeridgian they show

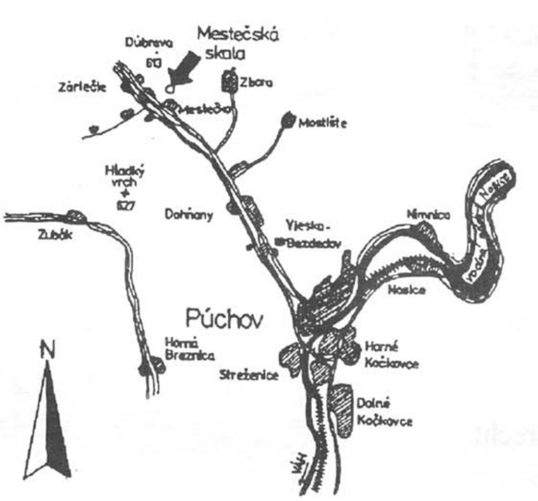

Fig. 1. Location of Mestečská skala klippe

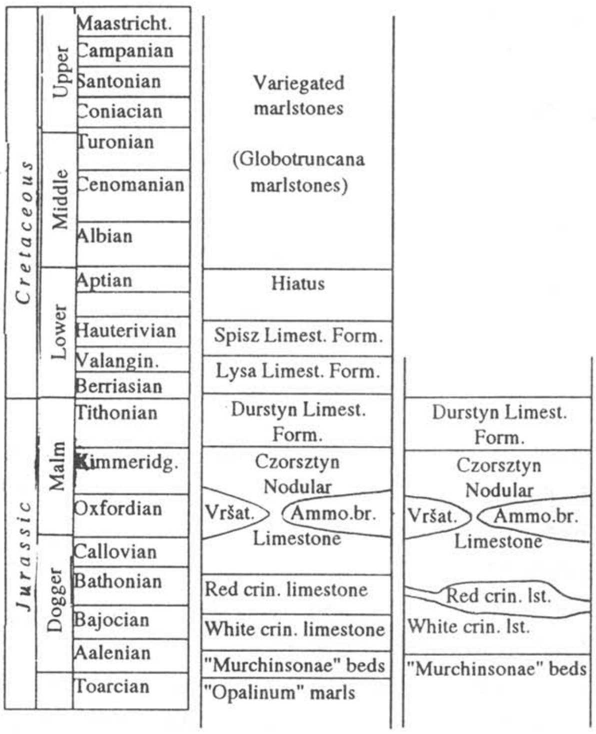

Fig. 2. Comparison of conventional lithostratigraphical scheme of Czorsztyn Unit (a) with the new scheme (b) based on new research

surprising facial uniformity, which does not correspond to later research. MIŠÍK (1979) distinguished special type of Czorsztyn Unit (Vršatec type) from the klippes near Vršatec. In this type biohermal Vršatec Limestone occurs instead of Czorsztyn nodular limestone. It represents the shallowest part of Czorsztyn sedimentational area. Mestečská skala klippe also ranks among the types with shallower facies of Oxfordian. It does not contain Vršatec Limestone too. It can be considered as a special, 13-th type of Czorsztyn Unit, named Mestečko type. Almost the whole profile of Mestečská skala klippe can be studded in the quarry. It is an outcrop of carbonatic sequence in reversal stratigraphical position with direction of striking 145° and dipping 32°. The situation in the quarry can be seen in Fig. 3. One of the most important facts is the repetition of crinoidal limestones of both colours in the profile. This repetition is not tectonic, which is proved by the long neptunian dykes coming out from the underlying pink micritic limestone and cutting the whole complex of crinoidal limestones above, together with untypical intercalation of red nodular limestone. The dykes are of Oxfordian age and there is no evidence of tectonic movements in Czorsztyn Unit before Oxfordian. To understand such situation, all the succession in the klippe must be dealt in detail.

Crinoidal limestones

In the past the complex of crinoidal limestones in Czorsztyn Unit was known as Vills beds. MOJSISOVICS in 1967 divided it into lower white crinoidal limestone and upper red crinoidal limestone. This division persisted almost up to the present time.

BIRKENMAJER (1977) named the first one Smolegowa Limestone of Bajocian age and the second one Krupianka Limestone of Bathonian age. This division does not correspond to the facts supported by finds of brachiopods Monsardithyris ventricosa (ZIETEN) and Antiphychina aff. bivalvata (EUD. - DESL.) in the white crinoidal limestone from Vršatec klippes (SIBLÍK 1978). Both species refer to the Bathonian age. REHÁKOVÁ (1979) mentioned from the surroundings of Lednica the find of Acantothyris spinosa (LINN.) with stratigraphical range from Bajocian (?) to Bathonian. JURKOVIČOVÁ (1980) mentioned the brachiopod fauna Acantothyris spinosa (LINN.), Dundrythyris retrocarinata (ROTHPLETS) and Monsardithyris ventricosa (ZIETEN) in the similar white crinoidal limestone from the surroundings of Krivoklát (these Bathonian brachiopods were determined by M. SIBLÍK). The most important information was provided by BEGAN (1968, 1969), when he mentioned the finds of Caliphylloceras disputabile (ZITTEN), Oppelia sp. and Teloceras cf. blagdeni (SOWERBY) from

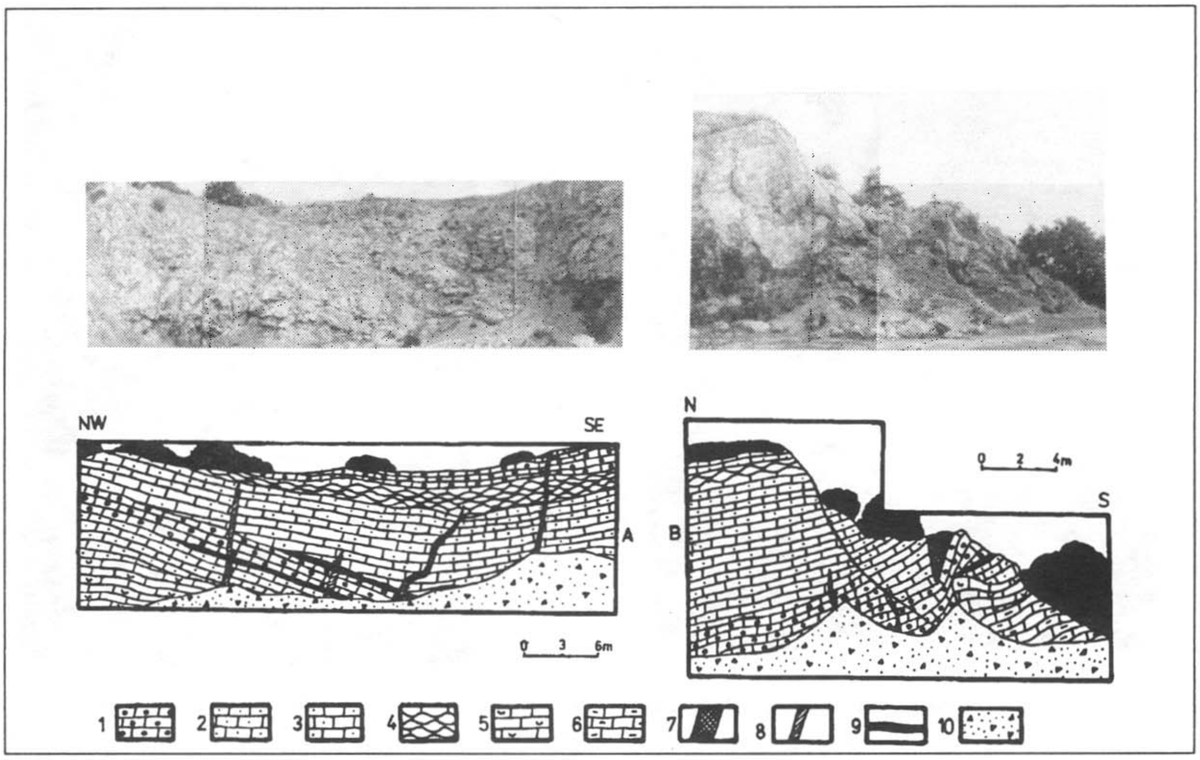

Fig. 3. Sketch of Mestečská skala quarry.
A - face of the quarry; B - right part of the quarry
1 - white crinoidal limestone, Bajocian (?) - Bathonian; 2 - red crinoidal limestone, Bathonian; 3 - red, less crinoidal limestone, Bathonian; 4 - red nodular limestone, Bathonian; 5 - pink micritic limestone with juvenile ammonites, Oxfordian; 6 - pink Saccocoma limestone, Kimmeridgian; 7 - neptunian dyke with breccia filling; 8 - perpendicular neptunian dykes (older generation), Oxfordian; 9 - subparallel neptunian dykes (younger generation), Oxfordian; 10 - debris

the white crinoidal limestone at not very exactly situated locality west of Vieska - Bezdedov (about 5 km from Mestečská skala klippe). In the author's opinion this indicates, that the stratigraphical range of white crinoidal limestone reaches Callovian.

White crinoidal limestone

It represents medium to coarse grained crinoidal limestone of white, pink to yellowish colour. It is massive to thick-bedded, with presence of coarse-grained clastic admixture of quartz and dolomite. From microscopical point of view it represents crinoidal biosparite-grainstone, sometimes with remains of unwashed lime mud. The sparite represents syntaxial cement grown on the organic remains, sometimes with parallel rows of micritic inclusions indicating possible replacement of micrite by the sparite (Fig. 4).

In the whole limestone abundant clasts of dolomite (or dedolomite) and quartz occur. The dolomite clasts reach the size to 5 mm, while those of quartz are smaller, only of psammitic size. The quartz clasts are angular, often corroded, with undulatory extinction and sometimes forming aggregates. Rarely the clasts of siltstones can be found. The clastic admixture sometimes represents up to 20 % of the sediment. The crinoidal segments, which form almost 90 % of the sediment, are often rounded, but with well-preserved inner structure. Neither in the segments, nor in sparite the twin-lamelles were observed. That indicates, that the rock was not affected by the pressure. Of the other remains the echinoid spines and bryozoans (especially "uniserial" similar to Aetea sp. quoted also by MIŠÍK 1979) were observed. Serpulid worms and sessil Nubecularid foraminifers in the growing position on the crinoid segments are typical in the limestone. Besides that the cross-sections of bivalves and brachiopods with "dog teeth" overgrowths were observed. Foraminifers Ophthalmidium cf. carinatum LEISCHENER, Lenticulina sp. and Nodosaria sp. are typical too. Sponge spicules and cherty concretions known from other localities are absent. It is remarkable from the description, that almost all organic remains belong

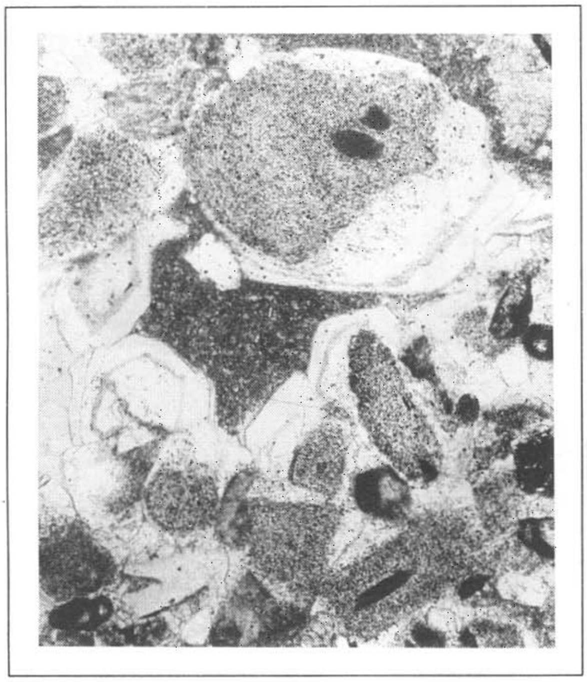

Fig. 4. Rythmical syntaxial overgrowths of calcite and imperfectly washed-out micrite in white crinoidal limestone.
X 35 photo: L. OSVALD

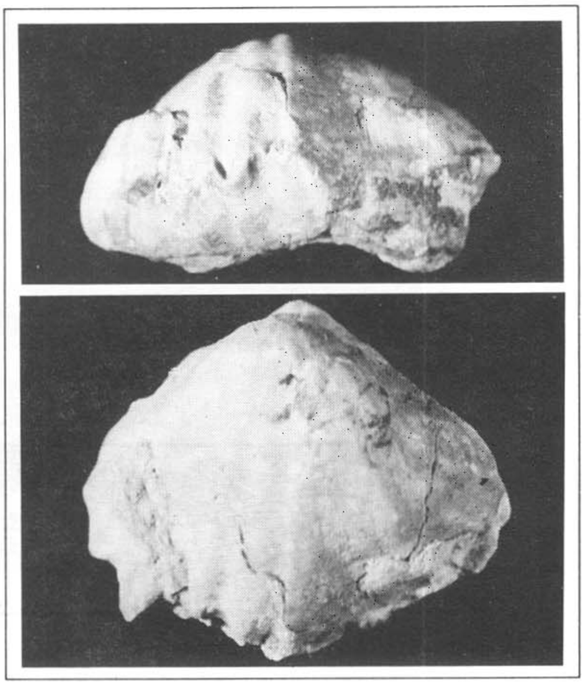

Fig. 5. "Rhynchonella" aff. triplicosa (QUENSTEDT) from red crinoidal limestone. Stratigraphical range: Bathonian - Callovian (determined by M. SIBLÍK). A-frontal position B-ventral position, photo: L. OSVALD

to benthos which require continual food supply and water streaming, but it cannot bear muddy environment. Determinable macrofauna was not found, thus the stratigraphical assignation is indirect. It results from fauna in surrounding red crinoidal limestone, which indicates Bathonian age.

Red crinoidal limestone

It is thick-bedded to massive, fine, medium to coarse grained crinoidal limestone of pink, red to dark-red colour. It's age determination is based on the finds of brachiopods Monsardithyris ex gr. ventricosa (ZIETEN), "Rhynchonella" aff. triplicosa (QUENSTEDT) (Fig. 5), "Rhynchonella" aff. ehningensis (QUENSTEDT) and Nucleata cf. curviconcha (OPPEL) (determined by SIBLÍK).

This fauna indicates Bathonian to Callovian age. Only the last species has wider stratigraphical range during the whole Dogger. From red crinoidal limestone in this locality PEVNÝ (1969) described this fauna of brachiopods: Linguithyris curviconcha (OPPEL), Lobothyris ventricosa (HARTMANN), "Rhynchonella" edwardsi CHAP. et DEW., Rhaetorhynchia subtetraedra (DAV.), Cymatorhynchia quadriplicata (ZIETEN), "Rhynchonella" sublacunosa SZAJN., "Rhynchonella" aff. concinna (SOWER- BY) and "Rhynchonella" morierei DAV. The author assigns all the species to Bathonian. The limestone contains abundant clastic admixture of quartz and dolomite, sometimes in form of fine conglomerate intercalations. Striking is the contrast in grain-size of clastic admixture in red and white crinoidal limestones. In the red crinoidal limestone the size of dolomite debris is up to 1 cm, while those of quartz to 5 cm. In the dolomite debris the well-preserved fauna and inner structures occur, for example ostracodes, shrinkage pores (Fig. 6), coprolitic structures and sometimes structures similar to Liesegang's strinkage, which indicates possible weathering on the dry land. The clasts are well-rounded, but elongated, with low sphericity.

Quartz grains are of larger size. In some cases a bimodal association with fine-grained (silt to sand size) and coarse- grained (size to 5 cm) clastic admixture was observed. That indicates more possible sources of clastic material. Also twin-lamelled albite and chloritized biotite in quartz were found in thin sections. The analyses of heavy minerals from the red crinoial limestones, mentioned by HALAJOVÁ (1981) from the localities Dolná Maríková, Červený Kameň and Babiná show association of zircon, garnet and routile, sometimes

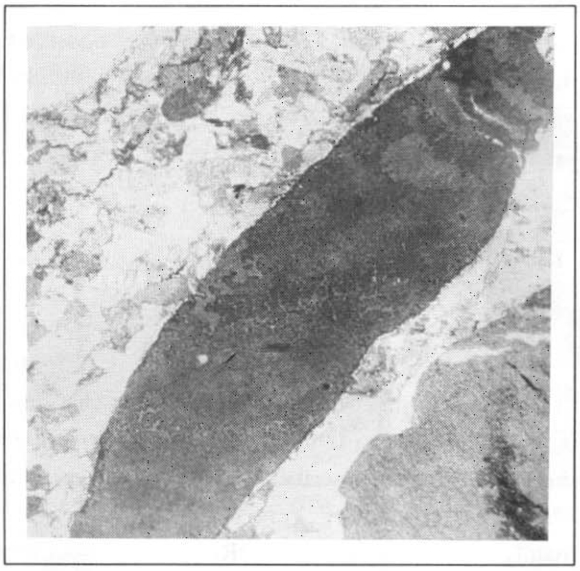

Fig. 6. Shrinkage pores in dolomite clast in red crinoidal limestone.
X 20 photo: L. OSVALD

Fig. 7. Saccocoma microfacies in Kimmeridgian limestone.
X 20 photo: L. OSVALD

accompanied by tourmaline and apatite. Analysing the minerals from Mestečská skala klippe HCl was used at solution, thus the possible apatite was not tabled to the results. From 1302 grains 95 % were opaque minerals, predominantly limonite and pyrite. From transparent minerals this proportion was found out:

garnet	............52%
tourmaline	............24%
routile	............11%
chlorite	............6%
biotite	............3%
zirkon	............3%
sum total	............99%

In comparison with the data of HALAJOVÁ (l.c.) the smaller quantity of zircon and some less quantity of routile is remarkable. On the other hand there is surprising high quantity of tourmaline. The red crinoidal limestone represents crinoidal biomicrite, rarely biosparite with not perfectly washed-out micrite. The most frequent organic remains are the segments of crinoids, fragments of their stems and connected basals. Proportion of the crinoids and micrite moves to the predominance of micrite (to crinoidal wackestone) toward the top. This transition is very slow. There is remarkable absence of echinoid spines, rare are also bryozoans and sessile Nubecularid foraminifers. Very frequent are Ophthalmidium sp., Lenticulina sp. and Nodosaria sp. The microstylolithes and pressure solution can be observed in the limestone too.

Red nodular limestone

In the complex of crinoidal limestones in the top part of the quarry a 1.5 m thick layer of red nodular limestone occurs. it is very similar to Czorsztyn nodular limestone, but it occurs in atypical position. In the microscope the signs of condensed sedimentation are remarkable. The limestone has no siliciclastic admixture, which strikingly contrasts with fine- conglomerate layers in the surrounding red crinoidal limestone. It represents biomicrite-packstone with abundant organic remains. Surprising is the large number of echinoid spines, "uniserial" bryozoans similar to Aetea sp., small crinoid segments, frequent are also the fragments of little bivalve shells, ostracodes and Terebratulid brachiopods. Indirect age is indicated by finds of Bathonian fauna in surrounding limestones. ANDRUSOV (1945) mentioned thin intercalations of red nodular limestone in crinoidal limestone from some localities. RAKÚS (1990) described Bathonian to Upper Bajocian ammonitic fauna from the lowest parts of Czorsztyn nodular limestone. The intercalation of nodular limestone in Mestečská skala klippe can be indicated as Czorsztyn Limestone too. The unusual position among the crinoidal limestones testifies the lateral transition of these limestones.

Pink micritic limestone with juvenile ammonites

It is pink to red micritic limestone, massive, with signs of bedding. In the weathered parts the pith-casts of juvenile ammonites and belemnites can be seen. The organic remains are so frequent, that they from ammonitic coquina. It represents probably "ammonitic breccia" mentioned by ANDRUSOV (1959). The limestone represents biomicrite with Globuligering sp. (former Protoglobigerina sp.), with some coprolites and pellets, without clastic admixture. The mass occurrence of Globuligerina sp. indicates Oxfordian age other foraminifers, Spirillina sp., Lenticulina sp. and numerous "microforaminifers" (chitinous membranes of juvenile tests) are also present. Very frequent are cross sections of juvenile ammonites, aptychi, ostracodes and fragments of bivalve shells. The geopetal structures are very well developed in ammonites tests. Orientation of libelles in various tests does not correspond to each other, so we can suppose later redeposition of the tests after partial filling. Besides that Globochaete alpina LOMBARD, Carpistomiosphaera cf. borzai (NAGY) and poorly preserved radiolarians occur in the limestone. This limestone represents also the filling of neptunic dykes, formed after the short hiatus following after the sedimentation of crinoidal limestones. The dykes are dealt with in separate chapter.

Pink Saccocoma limestone

It is the light-pink to greyish-pink limestone with plentiful Saccocoma sp. Bedding cannot be distinguished. In the left part of the quarry it slowly grades into pink micritic and organogene limestone of Tithonian. The limestone represents biomicrite, sometimes to biosparite with segments of Saccocoma sp. (Fig. 7), often with unperfectly washed-out lime mud. In the biosparite the syntaxial overgrowths can be observed. Some foraminifers such as Spirillina sp., Lenticulina sp. and agglutinated foraminifers occur in the limestone. Frequent is also Globochaete alpina LOMBARD. In one thin-section a micritic nodule with preserved radiolaria-globochaetic microfacies was observed. Around the nodule the limonitic hem with clay minerals occurs, but any other signs of condensed sedimentation are not present.

Pink and grey Calpionella and organogene limestone

It is micritic, sometimes crinoidal micritic limestone with juvenile ammonites and brachiopods. It is very similar to the above described Oxfordian limestone former described, but it is different if studded in microscope. Very frequent are tintinids, mainly Calpionella alpina LORENZ, Crassicollaria intermedia (DURAND DELGA) and Tintinopsella carpathica (MURG. et FILIP.), frequent are also foraminifers Marsonella sp., fragments of bivalve shells, aptychi and juvenile ammonites. The strings of Globochaete alpina LOMBARD are typical too. The limestone can be indicated as Dursztyn Limestone (BIRKENMAJER 1977), which is polyfacial and can be divided into several partial members (see BIRKENMAJER, l.c.).

Variegated marls and marlstones

They represent the transgressive deposits after hiatus during Neocomian to Albian. BEGAN (1959) described some occurrences of these marlstones from the surroundings of the quarry, with fauna of foraminifers with stratigraphical range from Albian to Campanian.

Neptunian dykes

Neptunian dykes in the Czorsztyn Unit were first noted by BIRKENMAJER (1958) who assumed that the fractures probably formed by earthquakes had been filled with Tithonian limestone. SCHEIBNER (in BUDAY et al. 1967) mentioned, that the neptunian dykes are the signs of young Deister, Osterwald and Hills phase of folding. From the Vršatec area, MIŠÍK (1979) has described four generations of neptunian dykes. They belong to Callovian-Oxfordian, Upper Tithonian, Neocomian and Albian. The neptunian dykes of uncertain age were described by REHÁKOVÁ (1979) from the

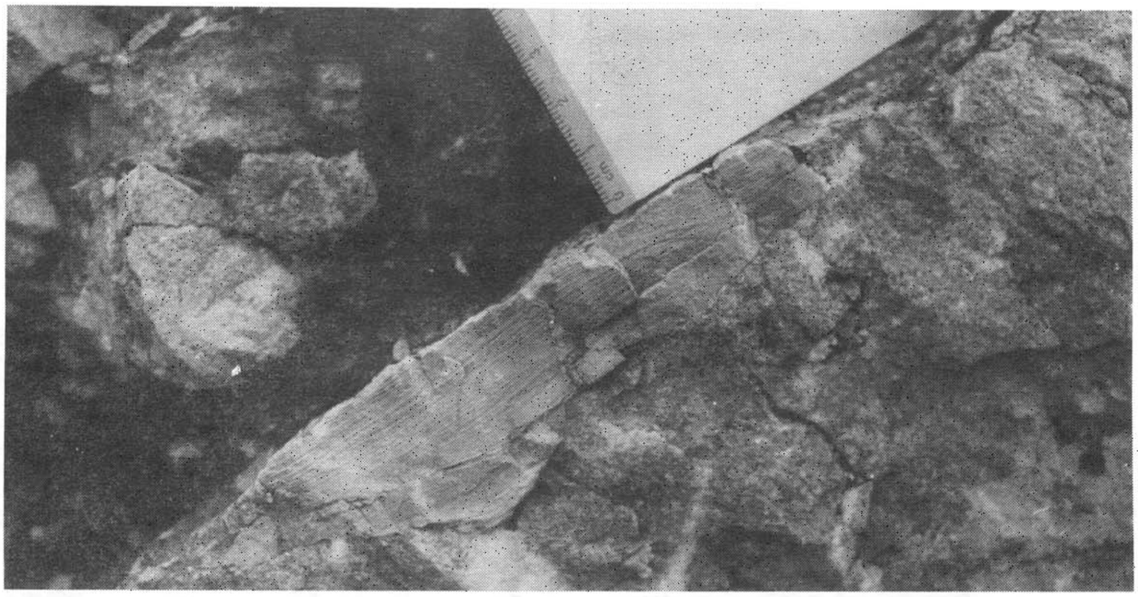

Fig. 8. Neptunian dyke from the right part of the quarry, subparallel with the bedding. It occurs at the contact of white and red crinoial limestone. Parallel lamination is well visible.
photo: R. AUBRECHT

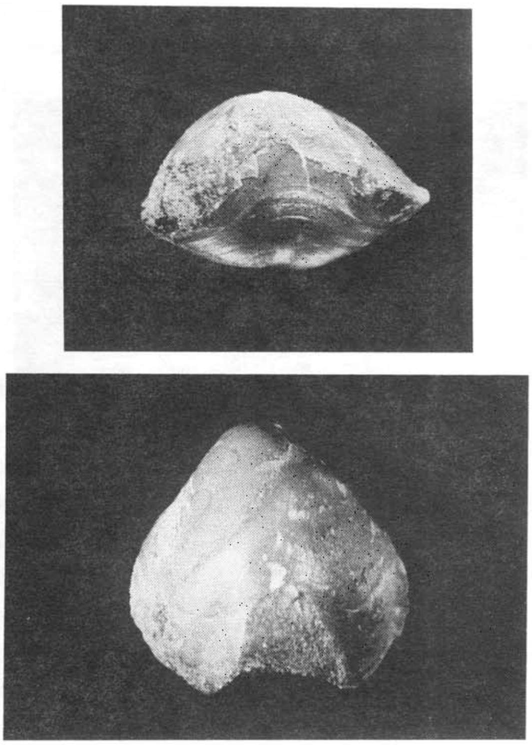

Fig. 9. Nucleata rupicola (ZITTEL) from perpendicular neptunian dyke from the face of the quarry. Stratigraphical range: Oxfordian - Tithonian (determined by M. SIBLÍK). A-frontal position B-ventral position photo: L. OSVALD

Fig. 10. Neptunian dyke with "Protoglobigerina" (Globuligerina) microfacies in red crinoidal limestone
X 20 photo: L. OSVALD

Fig. 11. Fragment of hardground in neptunian dyke with filmentous microfacies.
X 35 photo: L. OSVALD

Fig.12. Well preserved basal s of crinoid in the neptunian dyke
X35 photo: L. Osvald

Fig. 13. "Protoglobigerina" (Globuligerina) microfacies with juvenile ammonites represents the first phase of filling of neptunian dyke from Fig. 8.
X 20 photo: L. OSVALD

Fig. 14. Second phase of filling of neptunian dyke from Fig. 8. It contains thin-shelled ostracodes with net-form surface structure.
X 20 photo: L. OSVALD

	White crinoidal limestone	Red crinoidal limestone
crinoid segments	++	++
micrite	-	++
sparite	++	-
clastic admixture	+	++
Nubecularia foraminifer.	+	-
Bryozoa	++	+
Brachiopoda	-	++
Serpulia worms	+	--
Echinoia spines	++	--

Fig. 15. Comparison of microfacies content in white and red crinoidal limestones

klippe Mončeková. JURKOVIČOVÁ (1980) mentioned dykes of Bathonian-Callovian and Callovian-Oxfordian age from Drieňová klippe. Neptunian dykes were also mentioned by RAKÚS (1990) from Jarabiná klippe. In Mestečská skala klippe the two generations of neptunian dykes can be distinguished. The microscopical study indicates that these generations are not stratigraphically very different. Some older generation pierce almost perpendicularly the succession of crinoidal limestones and is originated from the pink micritic limestone of Oxfordian. The dykes coming out from the limestone become narrow and disappear toward the top (stratigraphically to the below). They have perpendicular lamination. In some cases the polyphasicity and piercing can be observed. The younger generation is subparallel with the bedding in the klippe and piercing the older one. It represents filling of intrastratal fractures formed at the end of the "dyke- forming" process. The younger dykes are often parallelly laminated (Fig. 8). Their connection with the pink Oxfordian limestone cannot be observed directly, but it results from microscopical study.

Older generation of neptunian dykes

In these dykes the brachiopods Nucleata rupicola (ZITIEL) (Fig. 9) and Septocrurella sanstaclarae (ROEMER) (determined by M. SIBLÍK), were found. Both species indicate Oxfordian age. The dyke filling represents red to dark-red limestone with rare lamination. The dykes are different in their microfacial contents. Frequent are filmentous microfacies, formed by thin bivalve shells and "Proto- globigerina" microfacies containing abundant Globuligerina sp. (Fig. 10). The limestone with filmentous microfacies represents typical biomicri- te-packstone, rarely containing clastic admixture of size less than 1 mm. The debris of surrounding rocks and hardgrounds (Fig. 11) are frequent. The dykes are often separated from the surroundings by the limonitic hem, which can be observed also on the fragments of shells, connected with pressure solution. Of organic remains, the crinoids with well preserved basals (Fig. 12), echinoid spines, juvenile ammonites, aptychi, rhyncholites, serpulid worms, shark teeth, ostracodes, brachiopods, rare ophiurs segments and Holoturia sclerites Theelia sp. can be found. Such association occurs also in the pink micritic limestone of Oxfordian mentioned before. The most abundant foraminifers include Marsonella sp., Lenticulina sp., Vidalina sp., Spirillina sp., Patellina sp. and Nodosaria sp.. Microforaminifers are frequent too. The dykes with "Protoglobigerina" microfacies contain the similar fauna, but without juvenile ammonites and aptychi, on the other hand the "microforaminifers" are more frequent. Some dykes do not contain any fauna. The perpendicular lamination is typical in these dykes. The average thickness of laminae is 0.5 cm. They are often disturbed by the bioturbation, they contain only fragments of filments and silt admixture of quartz.

The younger generation of neptunian dykes

Lamination is typical, with usual contents, but in two cases the small grains of authigene albite were observed. The most of the dykes are sterile, but some dykes contain rich microfauna. Such is for example the dyke in the right part of the quarry (Fig. 8) drawn also in the scheme in Fig. 3. The dyke occurs at the contact of the white and red crinoidal limestone and contain two-phase filling. The first phase represents micrite with "protoglobigerine" microfacies containing juvenile ammonites (Fig. 13). The second phase is represented by almost sterile micrite, but with thin-shelled ostracodes with net-form surface structure. They can be observed in tangential and cross sections (Fig. 14). These ostracodes are were noted by MIŠÍK (1979) and JURKOVIČOVÁ (1980). It is supposed, that they represent autochthonous fauna, which lived probably in sea bottom fractures. They were never found in other environment.

Conclusions

The position of nodular limestone intercalation among the crinoidal limestones and the repetition of crinoidal limestones of both colours are unusual in so far known Czosztyn succession. Possible tectonic explanations are elliminated by the neptunian dykes. The intercalation of nodular limestone indicates, that the beginning of its sedimentation can be placed to Bathonian, which is supported by RAKÚS (1990). The repetition of crinoidal limestones indicates lateral substitution of these limestones and their facial difference. There is a remarkable difference in microfacies contents of both limestones from scheme in Fig. 15.

The white crinoidal limestone is almost devoid of micrite and grains of heavy minerals, but the sessile benthos is present. In the red crinoidal limestone the micrite and heavy minerals are present, but it contain few sessile microfauna. That indicates, that the white crinoidal limestone was formed in the environment with water currents (or waves), while the red one was formed in calm water.

Translated by author

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