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UPPER JURASSIC AND LOWER CRETACEOUS FACIES, MICROPLANKTON AND CRINOIDS IN THE KUCHYŇA UNIT, MALÉ KARPATY MTS.

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Abstract: The article gives the lithostratigraphic, sedimentological and paleogeographical characteristics of an Upper Jurassic and Lower Cretaceous sequence of the Tatric of the Malé Karpaty Mts. It is concerned with the microfacies of seven informal lithostratigraphic units, which are correlated with developments in the neighbouring regions of the Alps and Carpathians. It gives descriptions of associations of microfauna, and the first finds of Berriasian crinoidal fauna in the Tatric of the Western Carpathians. A new Berriasian lithostratigraphic unit, the Staré Hlavy Formation, is described.

Key words: Western Carpathians, Upper Jurassic, Lower Cretaceous, slope/basinal carbonates, microfacies, calcareous microplankton, crinoids.

Introduction

Up to now, only very little data about the occurrence of fossils, giving support for the dating of the formation, has come from the Tatric Formation of the Malé Karpaty Mts. Detailed sedimentological studies of these rocks, often affected by weak dynamo-metamorphism, are also scarce. We have recently studied these sequences, by documenting various sections in the Kuchyňa Unit in detail. We found relatively well preserved remnants of micro-organisms (calpionellids) and macro-organisms (crinoids) of the Upper Jurassic and Lower Cretaceous ages.

Regional setting

The Kuchyňa succession outcrops on the western slope of the Malé Karpaty Mts., in a stripe from the summit of Jastrabník near Pernek, to the area of Skalka hill, east of Mt. Vysoká (Fig. 1). The area is wooded, hilly, and cut by the valleys of six streams. Their slopes are a not very steep, and covered by a varied, course weathered mantle, giving only sporadic, relatively unconnected outcrops. In spite of this, we succeeded in documenting six sections, from which it is possible to form an idea of the development of the Jurassic and Lower Cretaceous sedimentation in this area (Fig. 2).

Geological setting

According to Plašienka et al. (1991), the system of Central Carpathian superficial nappe units, shifted over units of the Tatric basement, form the Malé Karpaty Mts. The Mesozoic cover of the Tatric units, together with its crystalline basement, was also spatially reduced by nappe tectonics. Today, in a small area, it is possible to study facies belonging to the margin of the Penninic, the Borinka halfgraben, the Lungau Ridge, and small basins and raised areas on its inner side. The Kuchyňa succession was sedimented in the innermost (southernmost) Tatric part of the Malé Karpaty Mts. This inner part was, like the Bratislava Nappe, moved over the outer parts of the Tatric, and therefore occupies a high place in the structure of the basement of the Malé Karpaty Mts. Plašienka & Reháková in Maheľ et al. (1986), and Plašienka et al. (1989) give the characteristics of the stratigraphic sequence of the Kuchyňa succession.

The area of the Tatric of the Malé Karpaty was significantly affected by Early Cimmerian deformation. Dykes of Liassic breccias and carbonates penetrate through the locally preserved eroded remnants of Lower Triassic quartzites, to the underlying basic metavolcanites (actinolithic tuffitic shales and amphibolites) and the crystalline complexes of the Bratislava Nappe. During the Early and Middle Jurassic transition time, subsidence of the basin accelerated. A Toarcian (to Aalenian?) formation of dark micaceous (sometimes laminated) marlstones, with lenses of dark sandy, cherty limestones and black massive spongolites, has a thickness of 10 - 30 m. In an upward direction, it passes into a Bajocian to Lower Kimmeridgian (?) complex of light thin bedded silicites (radiolarites), and siliceous cherty limestones. In the lower parts of the 30 to 50 m thick complex, thin bedded deposits of dark grey biodetritic allodapic limestones, alternating with silicites are frequent. Five to 20 metres of thin bedded to heavy bedded micritic limestone of the "biancone" type, with occasional chert nodules, represent the Kimmeridgian to Berriasian, or usually only Tithonian to Berriasian sedimentation. The Valanginian to Hauterivian part of the sequence is characterized by 10 to 30 m of thin bedded micritic limestone with a white patina and nodular black cherts. Barremian to Lower Aptian thin bedded, biodetritic, often gradationally bedded limestone (calciturbidites) alternate with grey marlstones. Heavy bedded crinoidal limestones forming redeposited bodies in marly and siliceous shales, are up to 20 m thick. In the Upper Aptian to Lower Albian formation of dark grey to black silicified marlstones, siliceous and cherty limestones, and often laminated aleuro-pelitic shales, bodies of hyaloclastic basic volcanites are present. The largest of these, situated

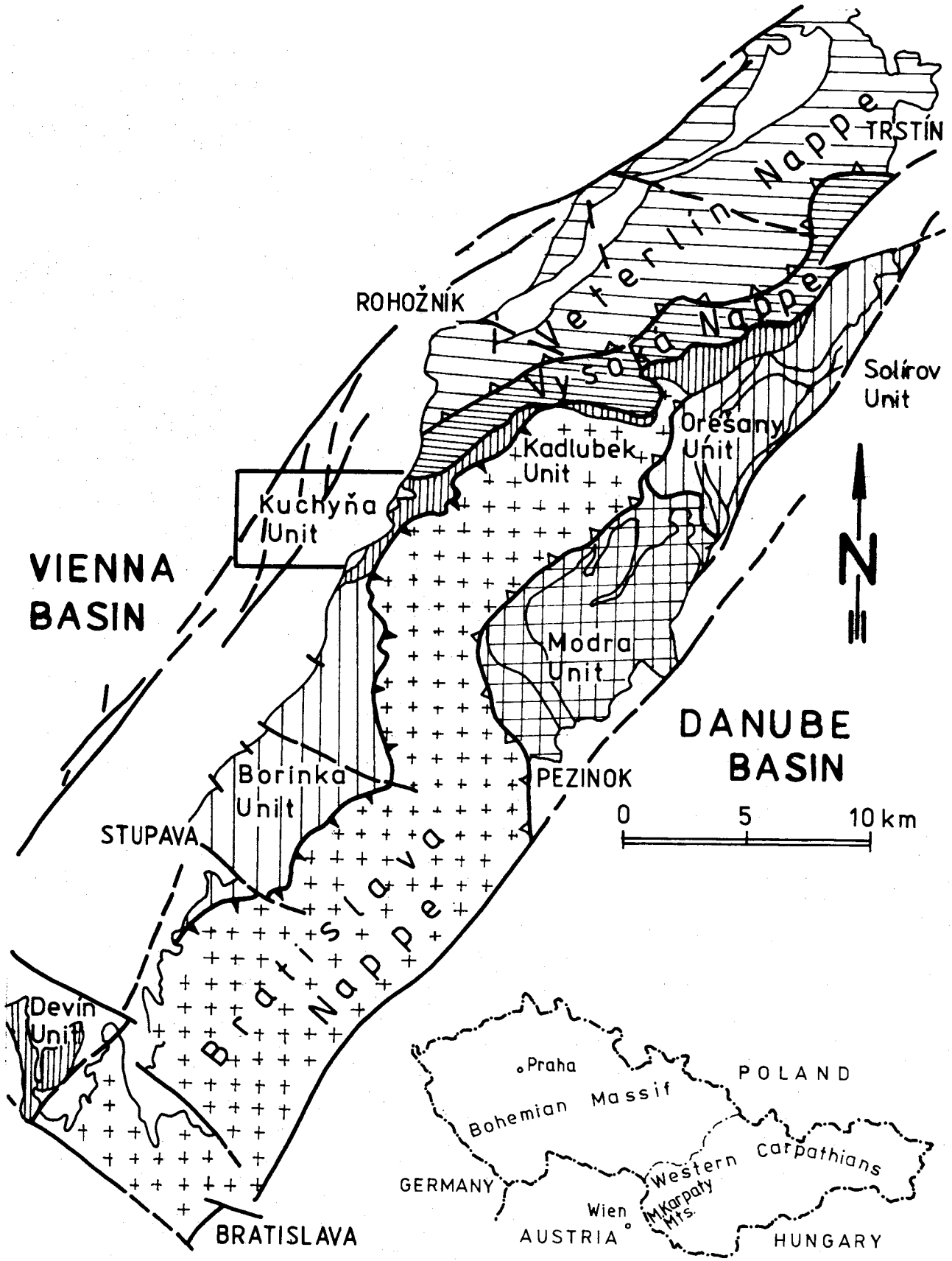

Fig. 1. Map showing the position of the Kuchyňa Unit in the Malé Karpaty Mts.

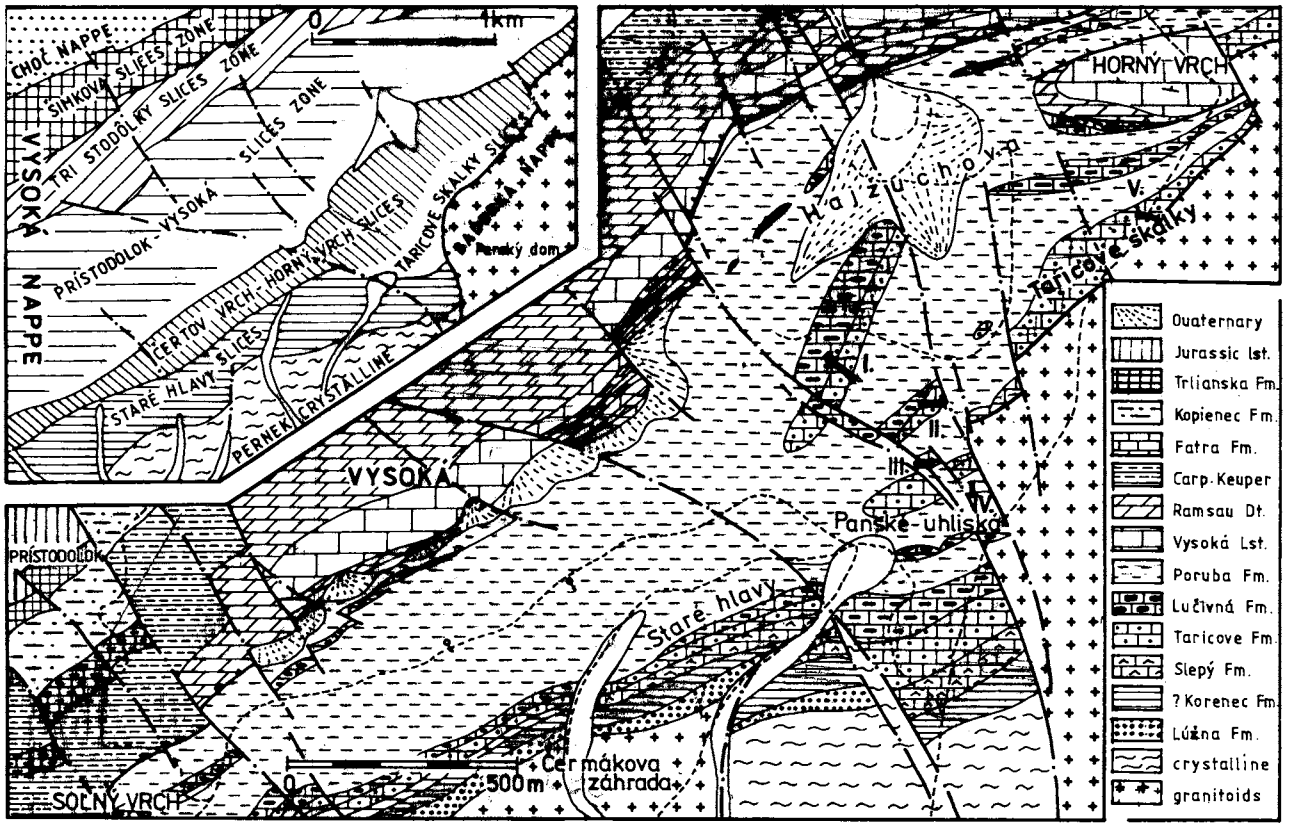

Fig. 2. Geological map of the district, with the situations of the profiles studied.

on the southern slope of Mt. Vysoká under the Soľný vrch hill, has a thickness of up to a 100 m, and a length of about 1 km.

The Middle Albian and Cenomanian (Lower Turonian?) flysch formation contains dark grey, weakly marly claystone, with inserts of fine grained sandstones, which increase in an upward direction. The highest parts of the formation have inserts of grey-green medium grained greywacke sandstones, and occasional occurrences (Soľný vrch hill) of conglomerate with well rounded pebbles of quartzites, carbonates and coarse grained granitoids.

The outcrops in the area studied, give an opportunity to trace in detail the Upper Jurassic to Lower Cretaceous sequence of the Kuchyňa Unit, with a thickness of perhaps 250 - 270 metres. We have divided this sequence into seven lithostratigraphic units (Fig. 3), which we will describe in detail in the following text.

Lithology and microfacies

1 - Calciturbiditic pelmicritic-oosparitic grainstones Oxfordian - Kimmeridgian

The dark grey massive limestones are pelmicritic, and in places microclastic (Pl. 1, Fig. 6). Sphaerical micritic pellets enclose fragments of planktonic ostracods, bivalves and sections of the zoospore *Globochaete alpina* Lomb. In the surrounding mostly micritic to microsparitic matrix, there are also fragments of the foraminifers, *Lenticulina* sp., *Dentalina* sp. The matrix is moderately silicified in places. The clastic admixture is represented by very small grains of quartz. Occasional pressure junctions are emphasized by Fe minerals. Thin bedded (12 to 22 cm) limestones with signs of lamination occur in the middle of the formation.

Pelmicritic and pelmicrosparitic limestones change into oosparitic limestones (Pl. 1, Fig. 5). Among the pelmicritic or microsparitic material oosparitic intraclasts are frequent, with sparitic cement. The ooids are larger (1 mm) than the pellets, and their concentric structure is mostly wiped out by recrystallization. The pellets and ooids enclose similar types of organic remains: globochaets, fragments of ostracods, bivalves, foraminifers and crinoid columnalia.

Biomicrites with abundant fragments of juvenile shells of bivalves occur in the Hajzuchová section (Fig. 5). Fragments of aptychi, ostracods, foraminifers, crinoid ossicles, calcified radiolarians, *Globochaete alpina* Lomb. and sporadic *Saccocoma* sp. occur in association with "fibers". It lacks a clastic admixture, but from the epigenetic minerals, pyrite (idiomorphic crystals and framboids) is represented.

Detritus formed by fibers of juvenile bivalves, fragments of crinoid ossicles, small grains of clastic quartz up to 2 mm, scales of mica and fragments of chloritic shales, is significantly graded in the Pansky Dom section. The gradational rhythms begin with crinoidal packstone to grainstone (Pl. 1, Figs. 3,4), continuing into filament - crinoidal packstone, and finally to micritic limestones with dispersed fine detritus, and traces of bioturbation (Pl. 1, Figs. 1,2). Their age is Oxfordian to Kimmeridgian, on the basis of sporadic Saccocomae.

2 - Indistinctly nodular packed biomicrite

Light grey, in places brownish thin bedded limestones with significantly uneven bedding surfaces, have the character of biomicritic packstones without a clastic admixture. Globochaete-Saccocoma and Saccocoma-Globochaete microfacies are characteristic (Pl. 2, Fig. 1). The most abundantly repre-

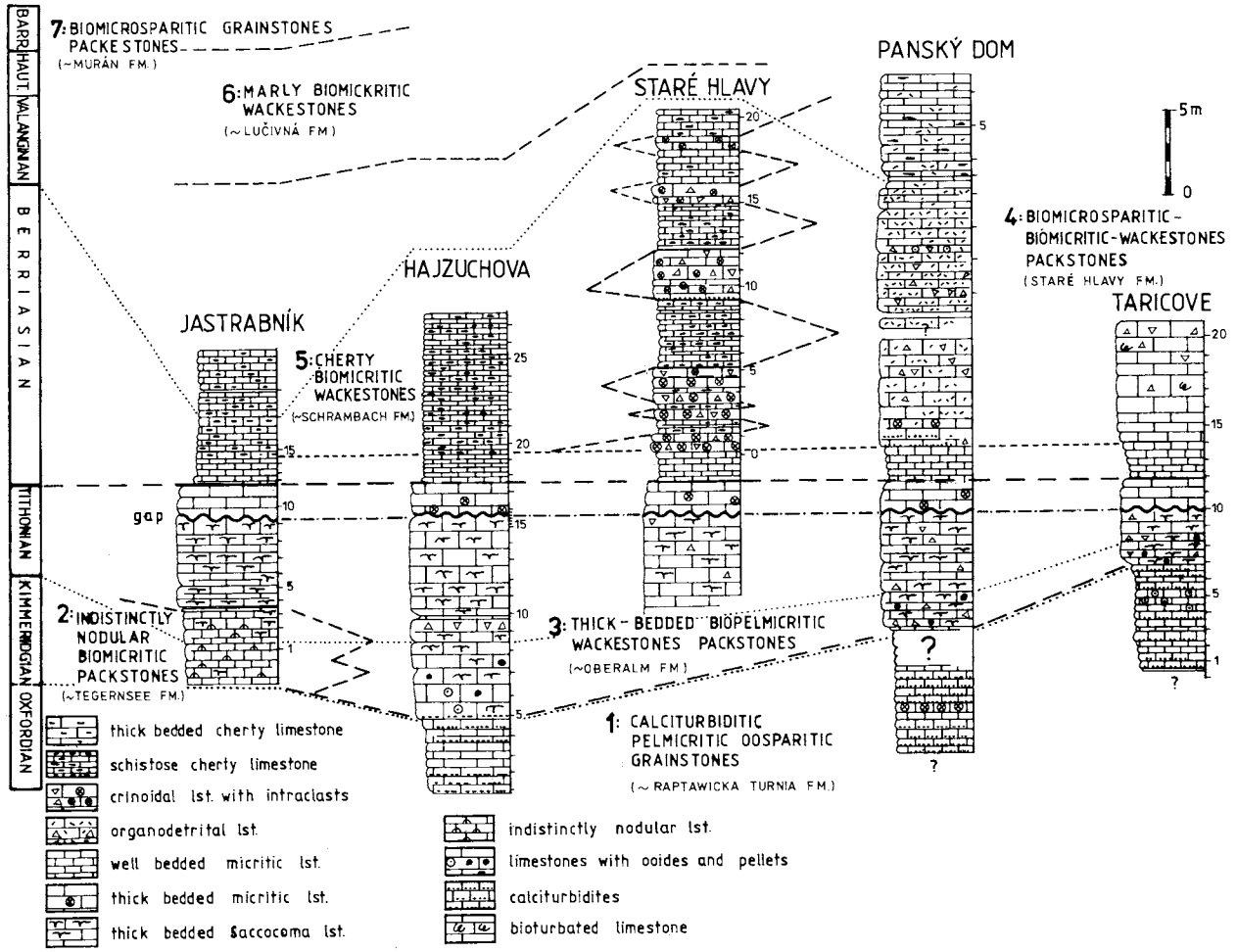

Fig. 3. Correlated lithostratigraphic scheme of the Upper Jurassic and Lower Cretaceous sequence in the five section of the Kuchyňa Unit.

sented organic remains are sections of *Globochaete alpina*, ramulae and secundibrachialia *Saccocoma* Agassiz. Fragments of aptychi, foraminifers (Pl. 5, Fig. 10), calcified radiolarians, juvenile ammonites (Pl. 5, Fig. 16), *Colomisphaera minutissima* (Vogler), *Carpistomiosphaera borzai* (Nagy) and *Parastomiosphaera malmica* (Borza) (Pl. 5, Fig. 1), occur in association with them. The microfossils mentioned, allow us to distinguish the Early Kimmeridgian to Late Tithonian zones "Borzai" and "Malmica".

3 - Thick-bedded biopelmicritic wackestones-packstones

Grey and cream grey thin bedded fine grained limestones, with a crassicolarian microfacies occurs in the Jastrabník section. They contain *Crassicollaria* aff. *intermedia* (Durand Delga), *Cr. massutiniana* (Colom), *Cr. parvula* Remane (Pl. 2, Fig. 2), *Calpionella* sp., *Tintinnopsella carpathica* (Murg. et Filip.), aptychi, crinoid ossicles, mostly substituted by double lamelar calcite.

In the western outcrop at Jastrabník, a layer with a significant crassicolarian-calpionellid microfacies, where the first large forms of *Calpionella alpina* Lor. are associated with Upper Tithonian crassicolarians (Pl. 2, Fig. 4).

Pinkish heavy bedded micritic limestones in the other sections contain dispersed fine detritus, with soft pebbles of darker pelmicrite, in some layers. *Globochaete alpina* Lomb., crinoid ossicles, ostracods, bivalves, aptychi, the foraminifers (*Lenticulina* sp., *Dentalina* sp.), dominate in the association of microfossils, while *Saccocoma* sp. occur occasionally. The microoncoids enclose fragments of ostracods, globochaetes and *Saccocoma* sp.

Saccocoma - Globochaete, and Globochaete microfacies with *Saccocoma*, *Globochaete alpina*, sections of juvenile ammonites, fragments of aptychi, bivalves, ostracods, crinoid ossicles, the foraminifer *Lenticulina* sp. and occasional, difficult to determine sections of calpionellids (*Crassicollaria* sp., *?Cr. brevis* Remane, *Cr. massutiniana* (Colom)), can be identified in the grey to creamy grey, less significantly heavy bedded packstones (also with soft pebbles of micrite) (Pl. 2, Fig. 3). Silt sized grains of quartz represent the clastic admixture, and epigenetic framboidal pyrite is frequent. The rock bears signs of isochemical and allochemical diagenesis (selective dissolution), origin of microstylolites with a small amplitude, silicification of the sediment.

4 - Staré Hlavy Formation (new name) (Biomicrosparitic - biomicritic wackestones-packstones)

Name: After the hill of the same name south east, under Mt. Vysoká, north above the valley of Vývrat near Kuchyňa.

Type locality: Profile in the wood on the east slope of Staré Hlavy Hill, south east under Mt. Vysoká.

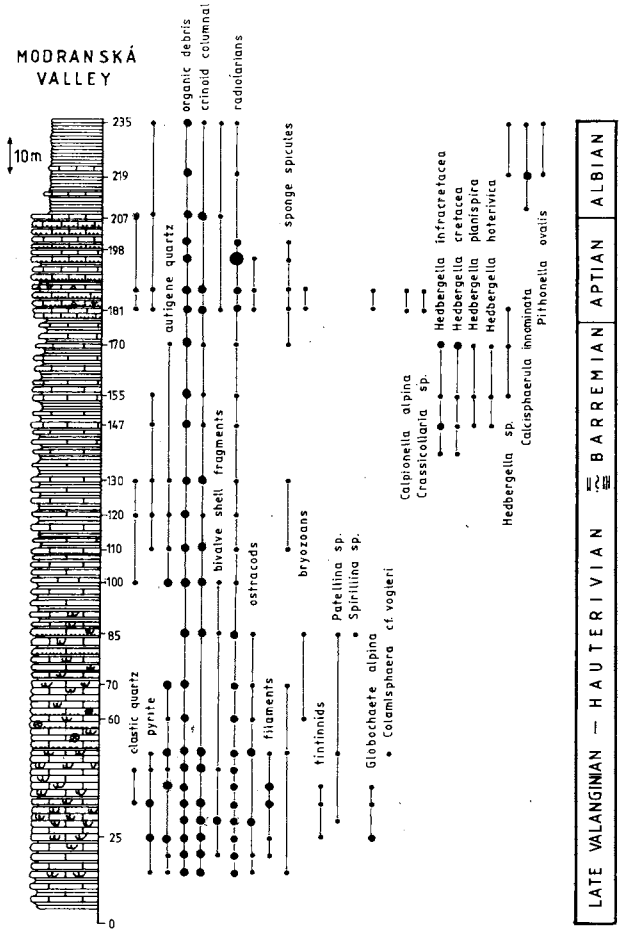

Fig. 4. Lithological, microfacial and biostratigraphic profile in Modranská dolina Valley near Kuchyňa.

Reference section: Pansky Dom section: a small rock outcrop in the wood, near the cross roads of the tourist route east under Mt. Vysoká.

Thickness of the formation: 20 to 25 metres.

Lithology: The grey, coarse heavy bedded to massive organodetritic wackestones to packstones in the Pansky Dom section, have a lower horizon of significantly graded detritus at their base. They contain abundant aptychi, crinoids, belemnites, brachiopods and bivalves (Pl. 3, Fig. 4). The microfacies of the limestones is calpionellid-globochaetid, calpionellid-radiolarian, to radiolarian - calpionellid-sponge. In the association of Berriasian microfossils, *Calpionella alpina, C. elliptica* (Cadisch), *Tintinnopsella carpathica, T. remanei* Borza, fragments of *Laevaptychus* sp., foraminifers, bryozoa, bivalves, crinoid ossicles, ostracods, sponge spicules, and calcified radiolarians are dominant. The greater part of the sequence is evidently of Early Valanginian age.

Brecciated layers, a possible equivalent of the Nozdrovice Breccia sensu Borza et al. (1980), contain small clasts of micrite without fossils, and well rounded microclasts with calpionellids (Pl. 3, Fig. 2).

A layer of significantly granular microoncolithic limestones, with nodules of cyanophyceans, which enclose fragments of foraminifers, ostracods, bivalves, saccocomas, calpionellids (*Crassicollaria* sp. and *Calpionella* sp.), crinoid ossicles and globochaetes (Pl. 3, Fig. 5), is interesting. In places, zoospores are associated with "fibers". In places the matrix is weakly recrystallized, and the nodules of cyanophyceans have no preserved concentric structure. A similar type of sediment has been described from the Valanginian - Hauterivian Tatric sequence of the High Tatras Mts., by Lefeld & Radwanski (1960), Lefeld (1962), Borza (1980) and Mišík (1966).

The brownish and grey thin bedded to thinly heavy bedded (3 to 50 cm), silicified (Pl. 5, Fig. 15), fine grained to micritic limestones with cherts (biomicritic packstones to wackestones), in the Staré Hlavy section, contain layers of coarsely organodetritic limestones (biosparitic grainstones). The graded detritus is often pressure directed, and concentrated in laminae (Pl. 3, Fig. 1). Crinoidal-spongal and crinoidal microfacies are characteristic of the limestones. Fragments of crinoid ossicles, with double lamellae prevail among the microfossils, but their original pore structure is only rarely preserved. Sponge spicules are also dominant elements, while bivalves, aptychi, foraminifers, ophiuroids, and globochaetes are less frequent. Sporadic calpionellids (c. 3 specimens on one thin section: *Calpionella alpina, Crassicollaria* sp., *?Remaniella* sp.) in the mostly microsparitic matrix, indicate a Berriasian, or in the uppermost part perhaps already Early Valanginian age.

Small clasts are formed by dolomite, dolomitic limestone, micritic limestone without fossils, micritic and microsparitic limestone with calpionellids and globochaetes. The clastic admixture (small quartz grains) and epigenetic pyrite are rare, but occur more frequently in layers with coarse organic detritus.

In the upper part of the formation, in the Pansky Dom section, Valanginian heavy bedded to thin bedded, grey and brown-grey, weakly detritic to micritic, in places significantly bioturbated limestone (wackestones, packstones) with chert nodules, occur. Radiolarian-cadosinid and cadosinid-crinoid microfacies belong to it (Pl. 2, Fig. 6). The association of microfossils is composed of *Tintinnopsella carpathica* (Murg. et Fil.), *Calpionellopsis simplex* (Colom), *C. oblonga* (Cadisch), *Calpionellites darderi* (Colom), *Stomiosphaera alpina* (Leischner), *S. wanneri* Borza, *Globochaete alpina* Lomb., calcified radiolarians, fragments of aptychi, crinoids, ophiuroids, foraminifers, ostracods, brachiopods, bryozoa and sponge spicules. In the Pansky Dom profiles, such as at Jastrabník Hill, sections of silicified globular chambers occur frequently, while fragments of pachyodont bivalves occur occasionally (Pl. 2, Fig. 6; Pl. 3, Fig. 6).

Boundaries: The lower boundary is indistinct, determined by the transition from thin bedded pinkish limestones to heavy bedded limestones with graded detritus. The transition to the micritic and microsparitic cherty limestones of the Lučivná Formation, marks the upper boundary.

Age: Berriasian to Valanginian, on the basis of the calpionellid microfauna.

Extent: The Kuchyňa Unit of the Tatric para-autochthonous sequence of the Malé Karpaty Mts.

Correlation: It has no equivalents, but its lithological character resembles the rocks of the Dursztyn Formation, and the Raptawicka Turnia Formation (Birkenmajer 1977; Lefeld et al. 1985).

Characteristic environment: The formation was evidently sedimented on the lower part of a submarine slope, in the area of a system of channels, bringing the remains of organisms living on a carbonate platform.

5 - Cherty biomicritic wackestones

Cherty biomicritic wackestones form the essential part of the Lower Cretaceous sequence in the Jastrabník section, Modranská Dolina and Hajzuchova Valley (Figs. 4, 5). The grey thinly heavy bedded micritic limestones with a calpionellid -globochaete

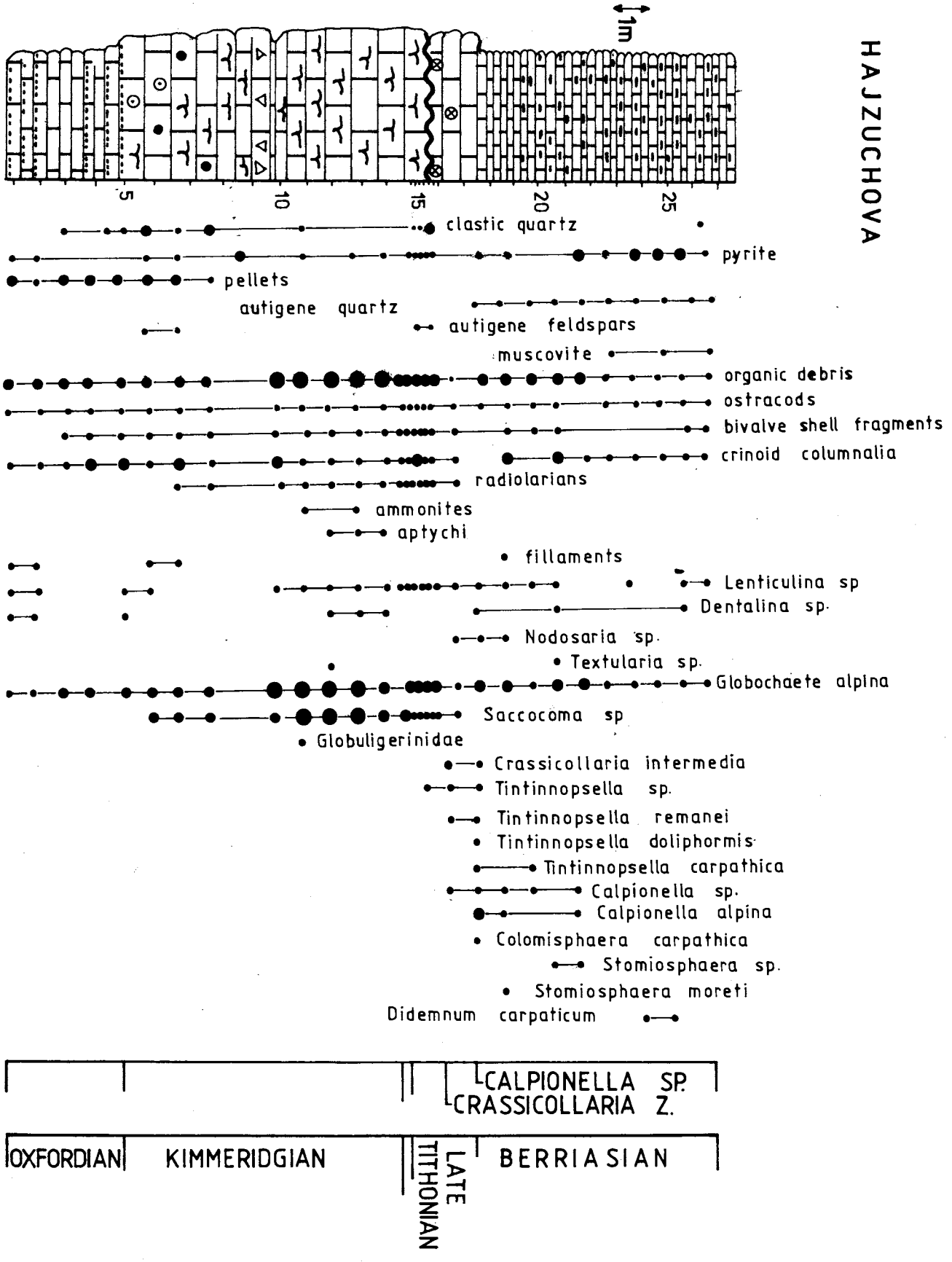

Fig. 5. Lithological, microfacial and biostratigraphic column at Hajzuchova in Rohožník Valley.

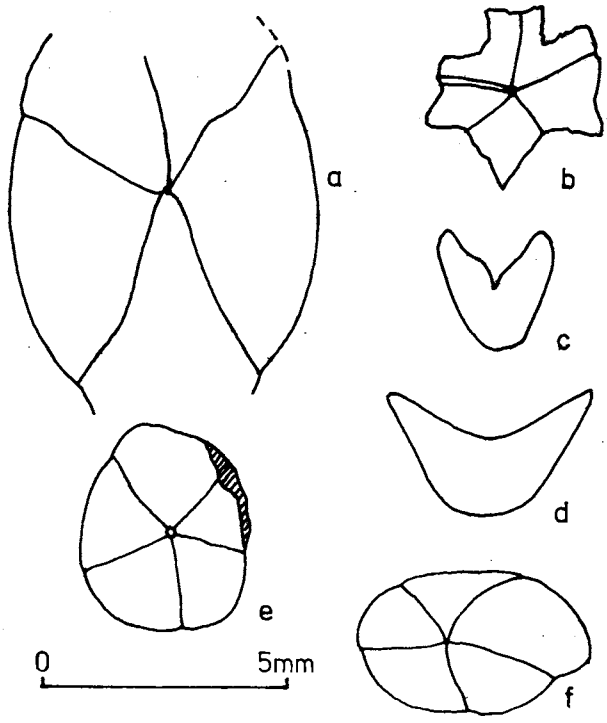

Fig. 6. Parts of crinoid skeletons, weathered on the surface of the limestone. **a** - probable part of hemicrinid calyx spoon like element (limestone fragment no. 1); **b** - cross section of a calyx close to the genus *Apsidocrinus* (limestone fragment no. 2; **c-d** - brachialia of sclerocrinid or hemicrinid type (limestone fragment no. 1); **e** - cross section of a calyx of sclerocrinid type: damage by breaking (limestone fragment no. 5); **f** - ditto (limestone fragment no. 4).

microfacies, in the Jastrabník profile, contain sporadic aptychi, belemnites and sea urchins. The majority of organic remnants are sections of *Calpionella alpina* (Pl. 5, Fig. 2) and *Globochaete alpina*. *Crassicollaria parvula* (Remane), *Cr. intermedia* (Dur. Delga), *Calpionella* sp., *Gemeridella minuta* Borza & Mišík, fragments of aptychi, foraminifers, crinoid ossicles, and occasional *Nannoconus* sp. occur together with them. These Berriasian limestones do not have a clastic admixture.

The Berriasian grey thinly bedded, weakly marly, micrites to biomicrites (wackestones-mudstones), in the Hajzuchová section, contain nodules and stratiform layers of chert. Sporadic, badly preserved microfossils represent *Calpionella alpina* (Pl. 2, Fig. 5), *Tintinopsella carpathica*, *Globochaete alpina*, *Stomiosphaera moreti* Durand Delga, *Didemnum carpaticum* Mišík & Borza, crinoid ossicles, ostracods, foraminifers (*Lenticulina* sp., *Nodosaria* sp.), and fragments of bivalves. Small grains of quartz from the silt fraction are occasionally present, and from epigenetic minerals, pyrite is present in the rock.

Valanginian - Hauterivian thin bedded, marly biomicrites (wackestones, packstones) with cherts, follow higher in the Jastrabník section (Pl. 5, Fig. 14). Their microfacies is radiolarian, cadosinid-crinoidal to cadosinid, and *Tintinnopsella carpathica*, *Calpionella* sp., *Calpionellopsis simplex* (Col.), *C. oblonga* (Cad.), *Calpionellites dardari* (Col.), *Stomiosphaera alpina* Leischner, *Colomisphaera vogleri* (Borza), *C. heliosphaera* (Vogler), small fragments of crinoid ossicles, foraminifers, calcified radiolarians and silicified sections of globular chambers, with significant silicified pressure borders on opposite walls, occur in it (Pl. 5, Fig. 4). We also observed similar preservation in cross sections of *Cadosina fusca fusca* Wanner, or *Stomiosphaera*

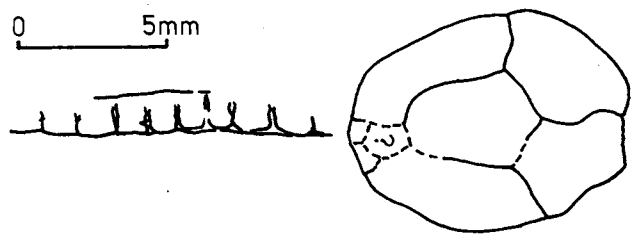

Fig. 7. Deformed calyx of a crinoid with part of the stem (cf. also Pl. 2, Fig. 2). Limestone fragment no. 6.

wanneri Borza from the Vysoká Unit of the Malé Karpaty Mts. Tectonic orientation and compression also affected other organic remnants.

6 - Marly biomicritic wackestones

Dark grey micritic, weakly marly, in places spotted biomicritic limestones (wackestones) and dark grey marl, in the Jastrabník, Modranská, Švancpošská Dolina Valley and under Soľný vrch Hill profiles are significantly reoriented by pressure (Fig. 1). The organic remnants are almost exclusively the Barremian planktonic foraminifers, *Hedbergella infracretacea* (Glaessner), *H. Planispira* (Tappan), *H. globigerinelloides* (Subbotina) and small stages of *Thalmaninella* sp. (Pl. 4, Figs. 1,2). A dense network of microstylolites is emphasized by haematite pigment. The limestones do not contain a clastic admixture. The marlstone contains practically no organic remnants. The matrix is finely silicified.

7 - Biomicrosparitic grainstones - packstones

Dark grey Barremian thin bedded fine detrital limestones, characterized by the graded structure types of grainstone, with the more significant occurrence of cement and smaller granularity, and packstone occur on the eastern slope of Horný Hill. Apart from the tubes of serpulid worms (Pl. 4, Figs. 3,4), crinoid ossicles, small nodosariid, miliolids (Pl. 4, Fig. 5), textulariids and hedbergelids (Pl. 5, Figs. 11,12), foraminifers, and occasional fragments of bivalves, ostracods and brachiopods are present. Dark structureless pellets and clasts of micritic and biomicritic limestones are abundant, while ooids occur occasionally (Pl. 4, Fig. 6). Clastic quartz grains are very rare, but small autigennous feldspar and pyrite are present.

Crinoidal macrofauna

The incomplete preservation of the remnants of echinoderms, coming from *lithofacies 4* in the Panský Dom profile and Staré Hlavy, complicated their study (Pl. 6, Figs. 1,2). This concerned exclusively disassociated skeletons. The individual types of element are mutually mixed, and often concentrated into thin inserts. The elements are not graded by size (Pl. 6, Fig. 2). Later recrystallization, and dynamo-metamorphic processes caused strong deformation, mostly preventing more exact determination of the type of elements, and so also their membership, not only of lower, but also of higher taxonomic units (subphyla). Smaller elements, up to 1 mm in size, with growth of calcite were transformed into unidentified granules. In addition, this disturbance of skeletal elements from echinoderms, is accentuated by weathering. All the material studied was observed only on strongly weathered surfaces of limestone rocks.

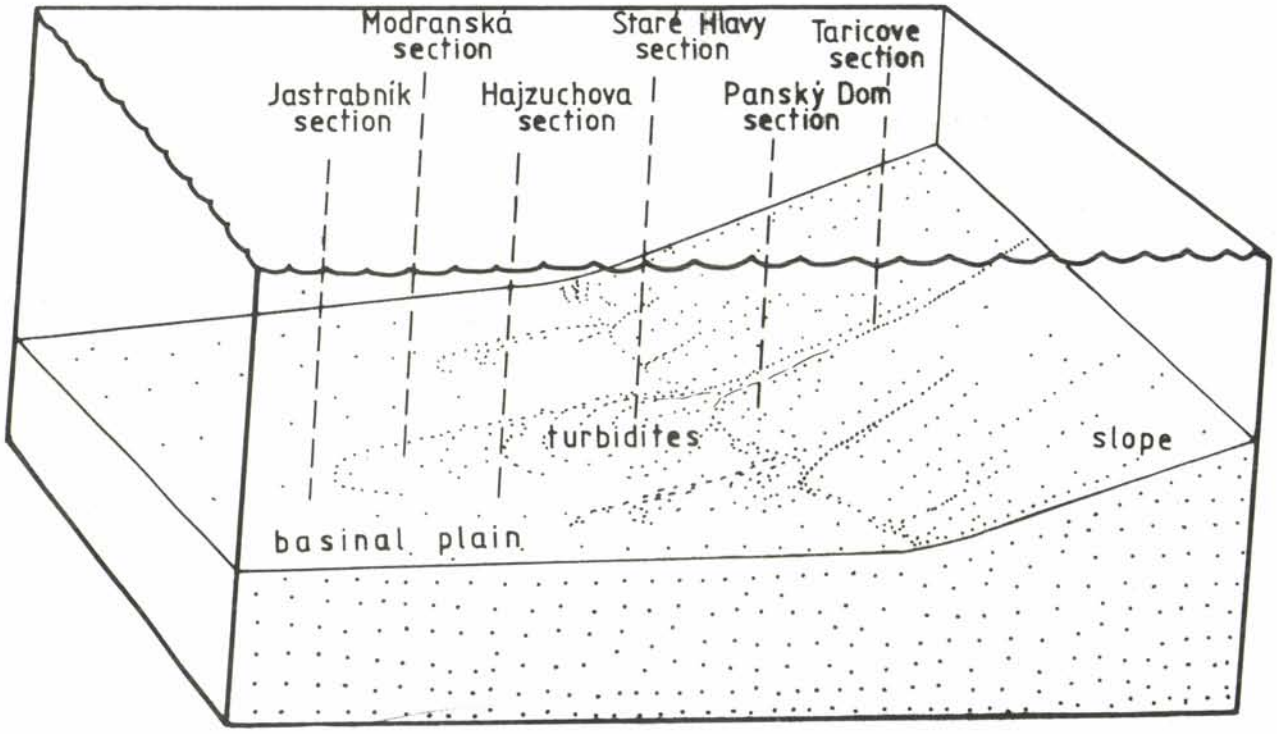

Fig. 8. A sedimentological and environmental model of Upper Jurassic and Lower Cretaceous sedimentation in the Kuchyňa Unit.

Rhombohedral splitting of calcitized remnants was the main criterion for identifying of the crinoid calyxes, which are composed of various skeletal elements (radial plates). Here even strong recrystallization does not cross over the boundaries of the sutures between distinct crystallo-optically oriented elements. However such finds are very scarce. Strongly deformed and covered elements also had correspondingly curved split surfaces.

In the mass of echinoderm skeletal elements, only the presence of crinoids was determined with certainty. In one case a columnal of *Isocrinus (?)* sp. was found (Pl. 6, Fig. 3). All the other cases found, evidently belong to cyrtocrinids (*Cyrtocrinida* Sieverts). Calyxes were observed in six cases. However, none of them could be more exactly determined. A calyx with significantly radial lobes was found in the vertical cross section on the axis and situated approximately under the level of the floor of the ventral cavity (Fig. 6b). Among cyrtocrinids, representatives of the genus *Apsidocrinus* are above all marked by a similar morphology. Other calyxes are unlobed and belong to other cyrtocrinid groups. The find illustrated in Fig. 6a recalls the calyx part of a hemicrinid, others could belong to the sclerocrinid (Fig. 6e, f), or eugeniacrinid (Pl. 6, Fig. 5) types. Elements of indefinite shape, but always massive and elongated scarcely occur in the material and it was possible to speculate that they were originally hemicrinid spoon like elements and their fragments (Žítt 1983), therefore parts of skeletons, including the stem part as well as the calyx (Hess 1975; Pisara & Dzik 1978; Žítt 1983; Gluchowski 1987).

Relatively large, massive brachialia with significant lateral protuberances on the sides of a deep ventral groove (Fig. 6c, d; Pl. 6, Fig. 6) are very abundantly represented in the associations. They are evidently cyrtocrinid brachialia, which, however, do not belong to the phylocrinids, and therefore not to the above mentioned genus *Apsidocrinus*. All phylocrinid brachialia were tiny and subtle, as a result of rudimentary development of the branches. It is therefore most possible that they are brachialia of the sclerocrinid or hemicrinid type. The possibility of identification of these brachialia, with the above mentioned unlobed calyxes, or with spoon like hemicrinid elements is suggestive.

The formation illustrated in Fig. 7 and Pl. 6-Fig. 4, which is composed of five elements, mutually joined by a suture, is very interesting. Each of these elements has an independent crystalo-optic orientation and splitting of the calcite of its material. There is great probability that it is a strongly defined crinoid calyx. An elongated process, leading to its dorsal (?) part (Fig. 7) suggests the stem part of the skeleton. However the material of the "columnalia" is only very indistinctly preserved, and their cylindrical form is observable only thanks to the calcite border on their circumference, and on the "sutures". Only further, better preserved material could clarify the actual nature of this find.

Among the monocrystallic elements of echinoderms in the associations, some recall sea urchin spines and isometric asteriid elements. However they cannot be described more closely.

The almost complete disarticulation of skeletons, and the mixing of different types of elements, bears witness to a sedimentary environment with the action of moderate currents. The elements of echinoderm skeletons, broken up after death, were easily mobilized here, and transported for an unknown distance. The distance of transport is difficult to estimate, since badly preserved elements, did not enable the study of the working of their surface. However, in an environment of relatively fine sedimentation, it could have been considerable. However, the grading of elements, according to their morphological or hydrodynamic properties is insignificant. Compared to the original representation of the different types of crinoid skeletal elements, there is perhaps a moderately increased relative abundance of the smaller ones (dominance of brachialia). The influence of currents on the final deposition is observable in places, in a subparallel arrangement of elongated elements (Pl. 6, Fig. 4).

Although the quantity of reliable data about the species composition of the associations is very small, it appears that the main source of elements was skeletons of the cyrtocrinid (*Apsidocrinus*

?, Sclerocrinus ?, Hemicrinus ?, Torynocrinus?) crinoids. There are rheophobic (*Apsidocrinus*), and also rheophilic types. With the rheophilic type, there was also an isocrinid filtrator *Isocrinus* ?sp.

The probable presence of sea urchins and star fish points to the existence of significantly developed and diversified communities of echinoderms, in the source areas of the skeletal elements. The dominance of cyrtocrinids in these communities, are also characteristics of other Lower Cretaceous Western Carpathian localities, for example Vršatec in the Klippen Belt (Žítt 1984), Štramberk (Žítt 1978, 1983, etc.), or the area of Crimea (Arendt 1974).

Discussion

The prevailing part of the lithofacies, which form the sequence studied, originated in an environment of a moderate submarine slope, and its transition to the level bottom of a basin. This environment was influenced by channels, transporting biogenic detritus from the shallows, and clastic fragments of carbonates from eroded underlying formations. The quantity of terrigenous material was mostly very low, and its composition indicates the probability of redeposition. In spite of this, the presence, although only occasionally, of the crystalline basement rock fragments is puzzling. Turbidity currents did not form a stronger near-slope fans, and the material was deposited only in thin layers, of at most 10 - 30 cm, on large areas below the foot of the slope (Fig. 8).

Lithofacies 1 represents a typical calciturbidite lithofacies formed in the mouth of channels in the lower part of the slope. Clastic material evidently came from the products of a carbonate platform (Plašienka et al. 1991). In addition, the formation has features corresponding to those of the Raptawicka Turnia Formation of the Polish Tatras Mts. This lithofacies may be compared with the deeper part of the Trassenstein limestones, on the transition to the Barmstein calciturbidites in the Alps, or with the Szársomló Formation of the Villány mountains. *Lithofacies 2* is the product of a relatively stable bottom of a basin, with slow sedimentation, similar to the Tegernsee Limestone.

At the end of the Jurassic period, a reduction of the bathymetric difference between the slope and the basin occurred. It was evidently caused by an overall deepening. *Lithofacies 3*, composed of coarsely bedded Saccocoma limestones, similar to the **Oberalm Beds**, covered the whole area studied. The rocks contain a quantity of well preserved crassicolarians and calpionellids, which point to the assumption, that the depth of the basin did not approach the CCD level.

The configuration at the beginning of the Early Cretaceous was again clearly differentiated. Slope deposits represent the characteristic *lithofacies 4*, with a quantity of transported calcareous skeletons of crinoids and cephalopods. It is of coarsely detritic (mainly crinoidal, biosparitic grainstone, packstone and wackestone) composition, which is associated with a threshold facies. They have common features with the **Dursztyn Fm.** of the Outer Carpathians, or with the **Sobótka Member** of the **Raptawicka Turnia Fm.** (Lefeld et al. 1985). Since we do not know an exact equivalent of this lithofacies, either from the Alpine or Carpathian literature, we have distinguished it with the new name **Staré Hlavy Fm.**

Thin bedded marly, cherty limestones, recalling the **Schrambach Beds**, or the younger **Hlboč Fm.**, represent basin *lithofacies 5*. Remnants of the tests of microorganisms are usually significantly corroded, and although we admit that their poor preservation may be partly caused by early diagenetic silicification, pressure dissolution and crushing during tectonic deformation of the formation, it is probable that the basin floor subsided to a level close to the CCD. Although calpionellids occur in this facies, among the fine calcite detritus, the association of microfossils is often composed of up to 50 % calcified radiolarians and sponge spicules, and the originally calcified tests of cadosinids and others are silicified. Some of the cross-sections which are considered as cadosinids, could belong to one-chambered tests of planktonic foraminifers.

The Upper Hauterivian to Barremian basin of *lithofacies 6*, which again covered the whole area studied, corresponds to the definition of the **Lučivná Fm.** Finally, *lithofacies 7* represents redeposited sediments of the slope of a Barremian carbonate platform, similar to the **Muráň Fm.**

Plate 1: Fig. 1 - filament microfacies in Oxfordian grey finely detritic limestone. The organodetritus is gradationally bedded. An allodapic layer rich in clastic quartz. Fragments of chloritic shales are present. There are traces of burrowing activity by infaunal organisms. Panský Dom, section I, enlarged 13 x. Fig. 2 - detail of the allodapic layer (Fig. 1, see rectangle). Enlarged 25 x. Figs.3, 4 - allodapic layer of crinoidal grainstone from Oxfordian grey finely detritic limestones. The organodetritus is graded and clastic quartz is present. In the upper part of Fig. 3, the transition to biomicritic wackestone filament - globochaete microfacies is visible. Locality as Fig. 1. Fig. 3 enlarged 25 x, Fig. 4 enlarg. 36 x. Figs.5, 6 - Upper Oxfordian to Lower Kimmeridgian pelmicrosparitic to oosparitic limestones. The concentric structure of the ooids mostly wiped out. They enclose fragments of ostracods, bivalves, foraminifers, and crinoid ossicles. Rohožník Valley - Hajzuchova, Hradisko section (5), Tarica rocks (6). Enlarged 25.5 x.

Plate 2: Fig. 1 - Saccocoma microfacies in the Kimmeridgian light grey coarse thin bedded to heavy bedded, finely detritic limestones (wackestone). Occasional cross-sections of globuligerinids. Rohožník Valley, Tarica rocks. Enlarged 52 x. Fig. 2 - *Crassicollaria parvula* (Remane) in the Tithonian grey to brownish grey micritic wackestone. Pernek, Jastrabník. Enlarged 155 x. Fig. 3. Crassicolarian microfacies in the Upper Tithonian grey micritic limestones (wackestones). Ramuli and secundibrachialia of *Saccocoma* Agassiz. Rohožník Valley, Škôlka section. Enlarged 60 x. Fig. 4 - crassicolarian-calpionellid microfacies in the Upper Tithonian grey micritic wackestone. The first large forms of *Calpionella alpina* Lorenz. Pernek, Jastrabník - west. Enlarged 60 x. Fig. 5 - calpionellid microfacies in Berriasian grey, weakly marly cherty wackestone. Hajzuchova, end of Rohožník Valley, Hradisko section. Enlarged 55 x. Fig. 6 - *Calpionellopsis simplex* (Colom) and silicified cross-sections of cadosinids in Berriasian - Valanginian, weakly marly cherty wackestone with cadosinid microfacies. Panský Dom, section II. Enlarged 60 x.

Plate 3: Fig. 1 - Berriasian massive organogenic packstone with significantly oriented, and in the lower layers graded, detritus. Staré Hlavy. Enlarged 20 x. Fig. 2 - Berriasian grey micritic organoclastic wackestone to packstone. Small microclasts are a product of synsedimentary erosion. They contain cross-sections of calpionellids, preserved just as in the matrix. Panský Dom, section II. Enlarged 25 x. Fig. 3 - radiolarian microfacies in Berriasian to Valanginian grey thin bedded limestone (wackestone), with cross-sections of calcified radiolarians and small crushed crinoid ossicles. Locality as Fig. 2. Enlarged 60 x. Fig. 4 - Berriasian (Calpionella Zone) grey to creamy grey massive wackestone to packstone with a rich gradationally bedded detritus, with fragments of aptychi, belemnites, crinoids, ostracods, bivalves and brachiopods. Locality as Fig. 2. Enlarged 20 x. Fig. 5 - Berriasian to Valanginian pseudooolitic limestone. Small nodules of cyanophycei enclose crinoids, ostracods, globochaetes, foraminifers and calpionellids. Locality as Fig. 2. Enlarged 45 x. Fig. 6 - fragment of pachyodont bivalve shell in Valanginian grey cherty wackestone with cadosinid-crinoidal microfacies. Locality as Fig. 2. Enlarged 19.5 x.


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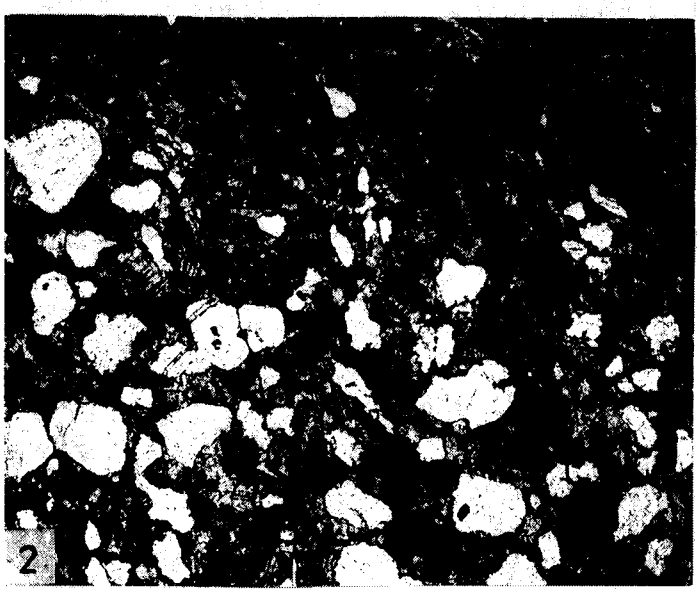
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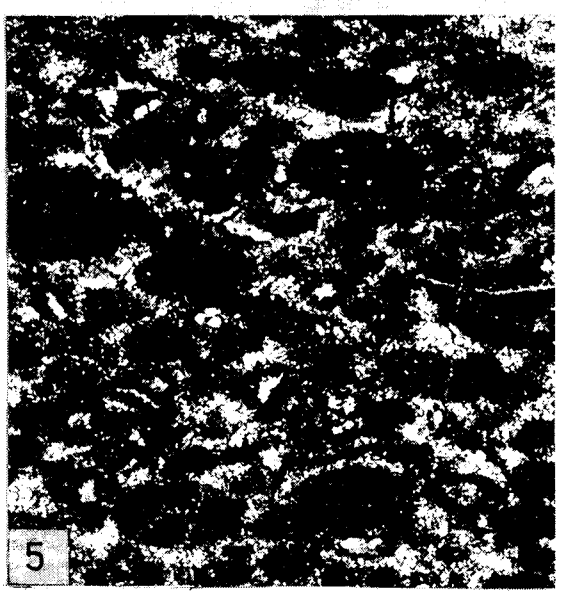
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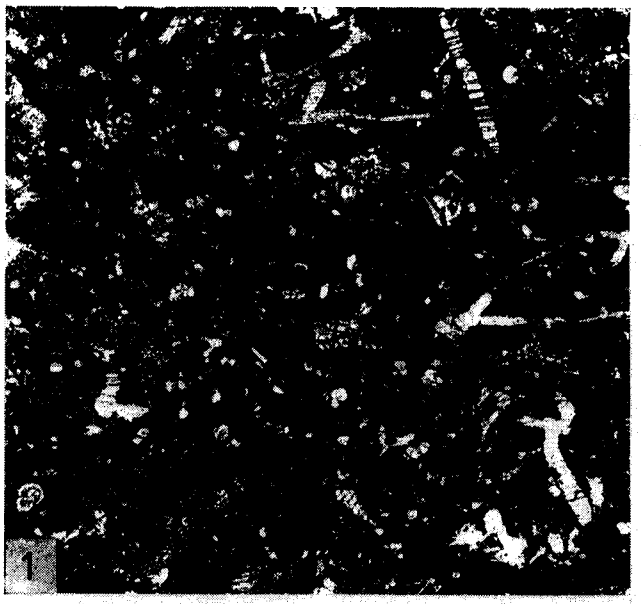
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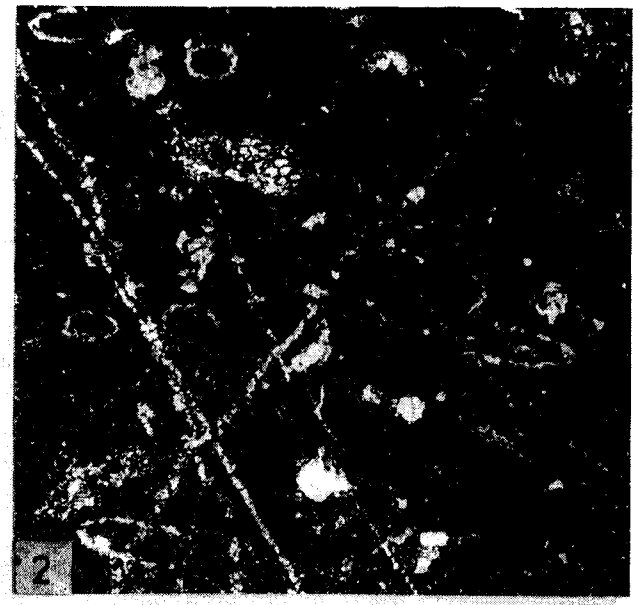
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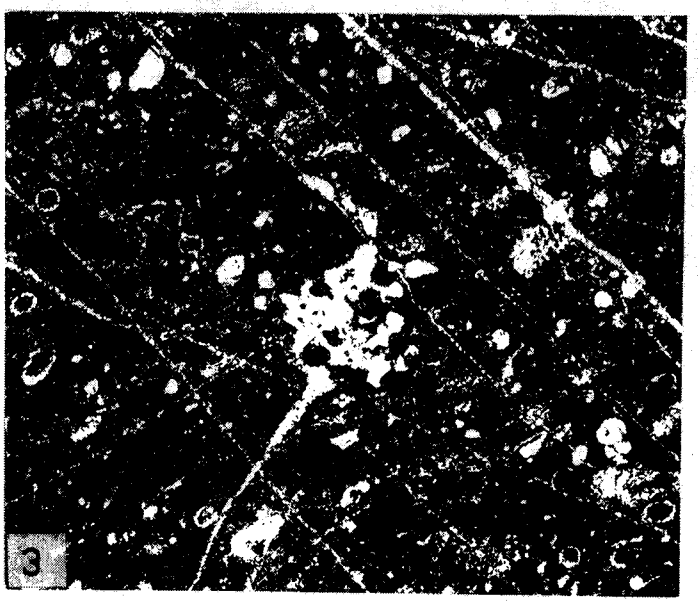
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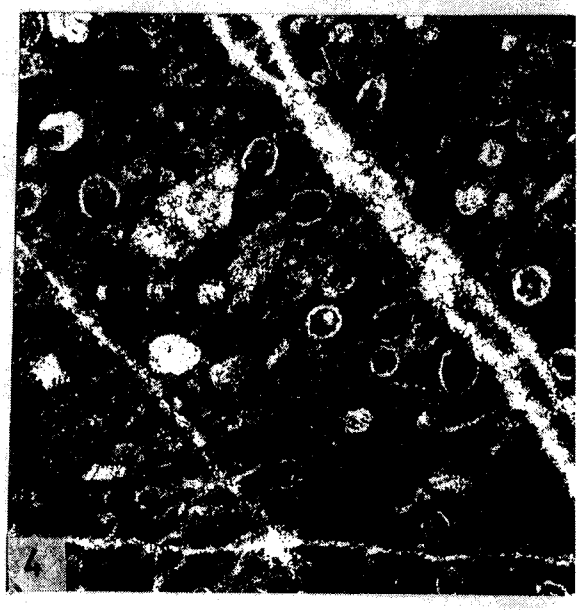
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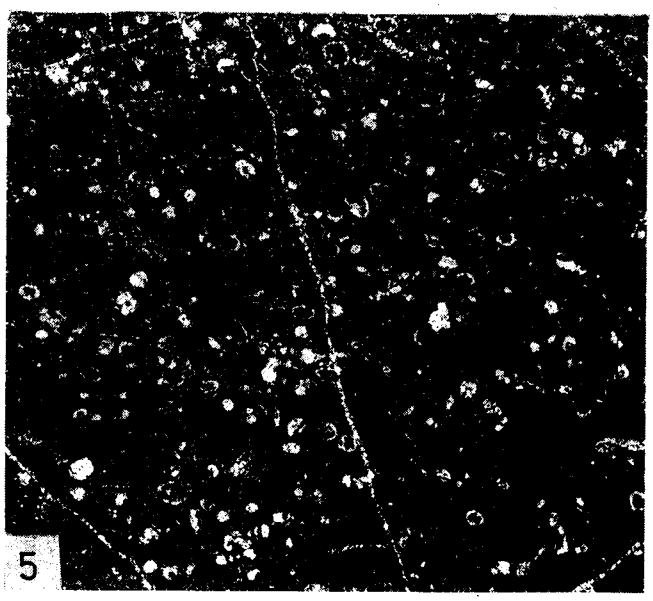
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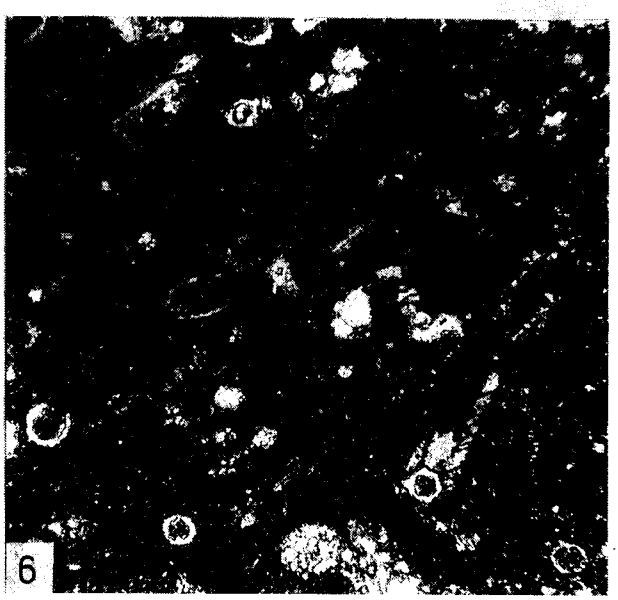
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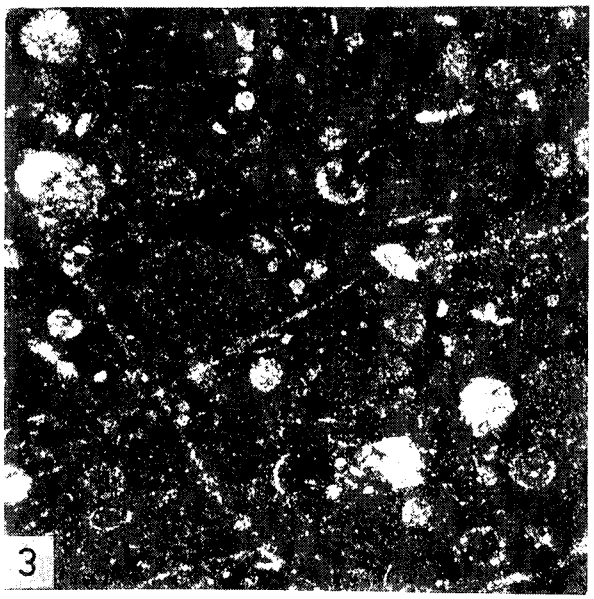
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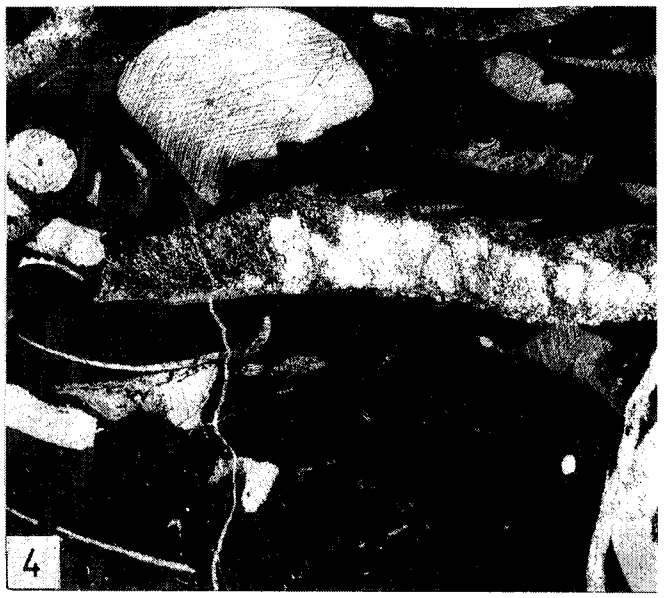
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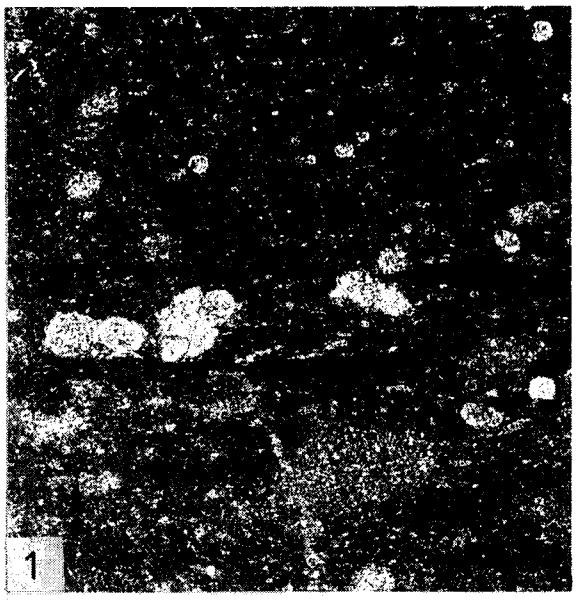
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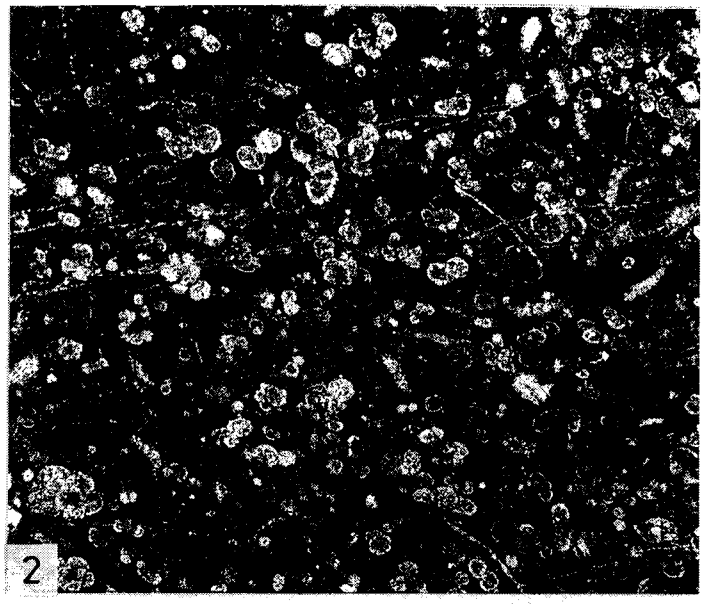
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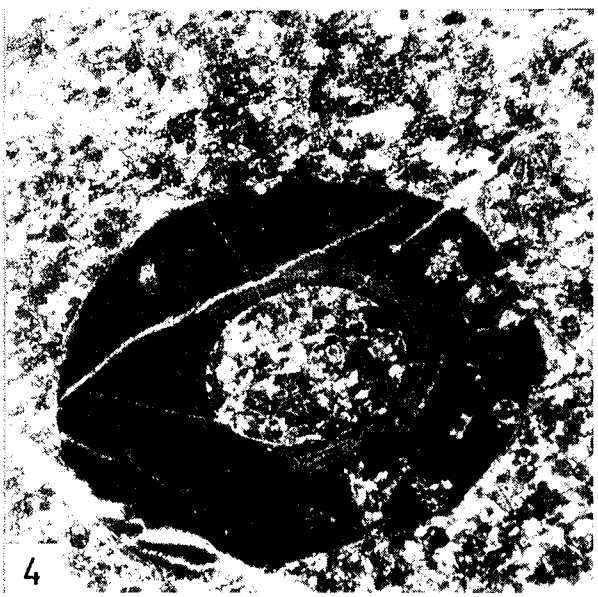
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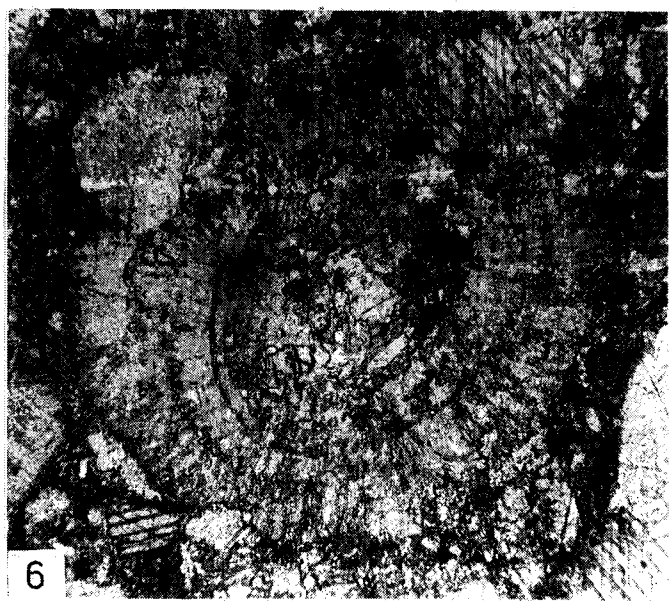
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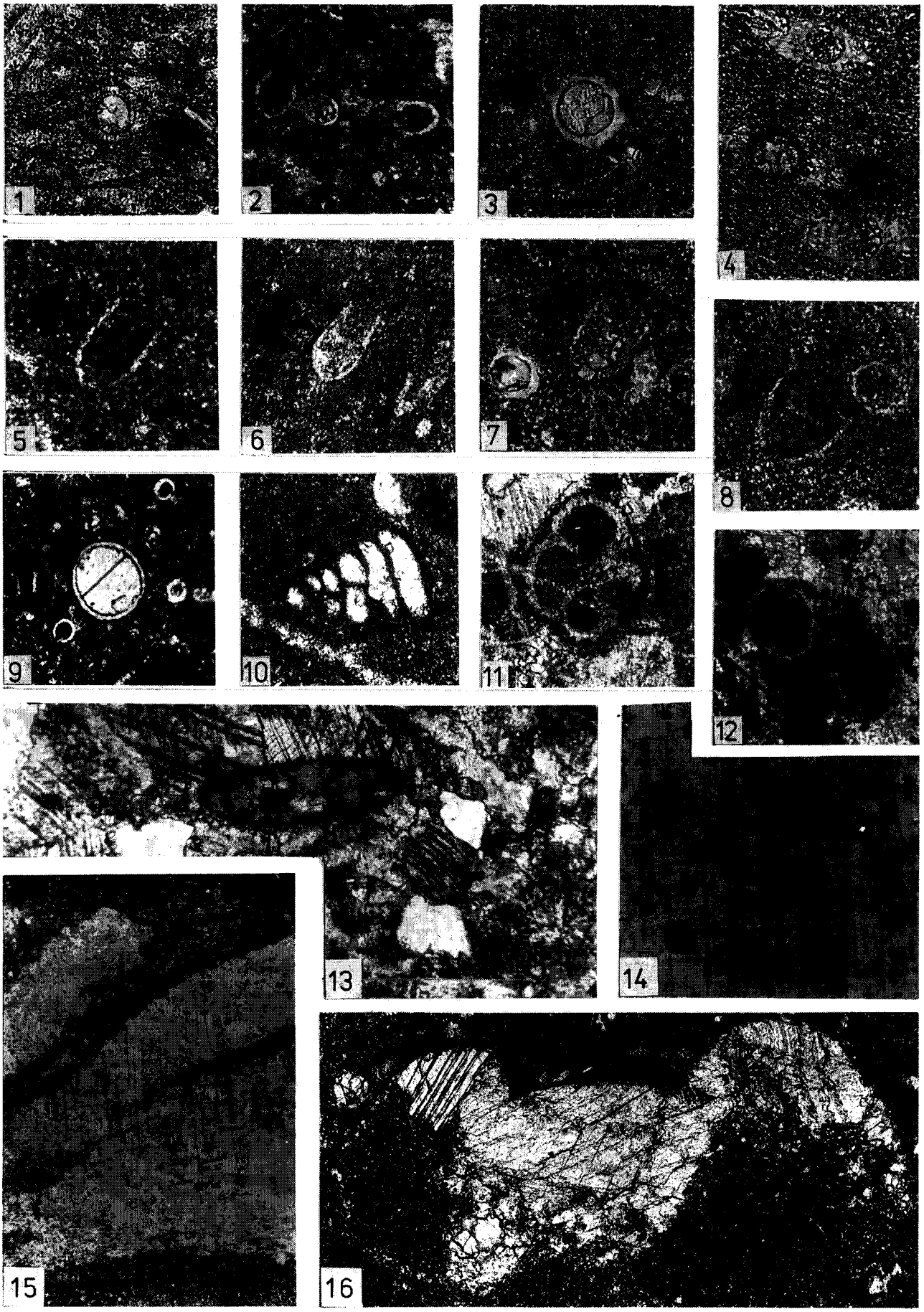
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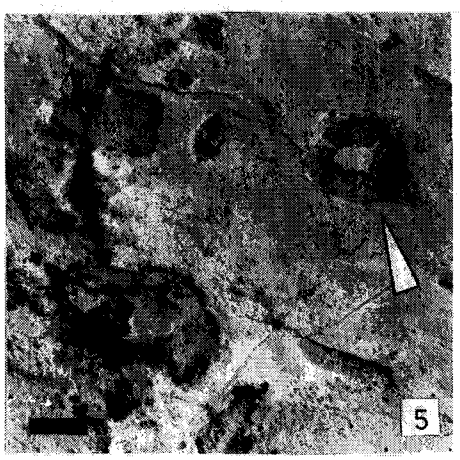
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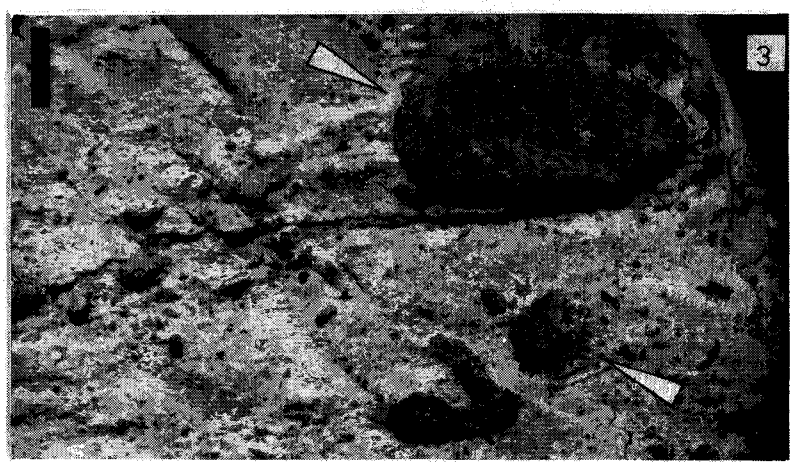
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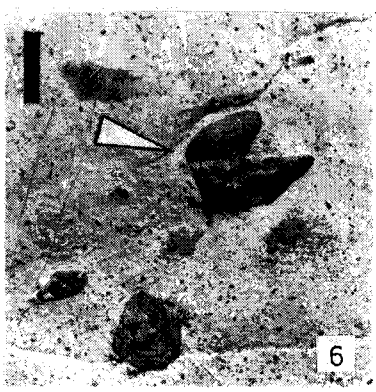
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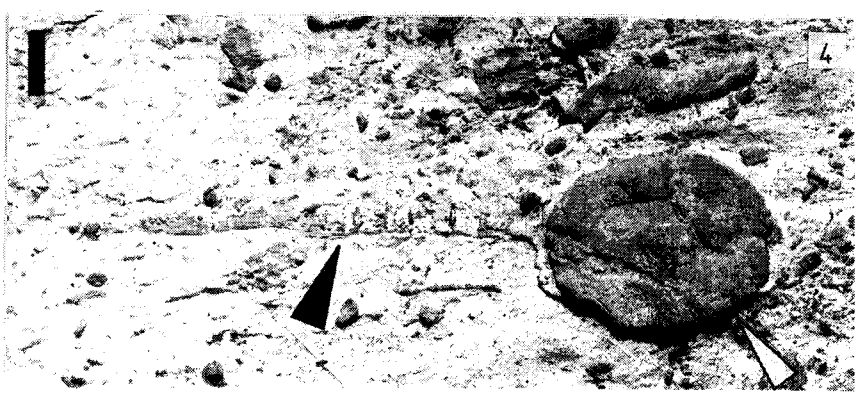
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Plate 4: Fig. 1 - Barremian grey marly oriented wackestone with cross-sections of *Hedbergella infracretacea* (Glaessner) and small stages of *Thalmaninella*'s Pernek, Jastrabník. Enlarged 43 x. Fig. 2 - *Hedbergella* microfacies in the Barremian thin bedded grey marly packstone with *Hedbergella infracretacea* (Glaessner), *H. cretacea* (d'Orb.). Kuchyňa, Švancpošská dolina Valley. Enlarged 25 x. Figs. 3, 4 - serpulids in Barremian thin bedded finely detritic grainstone to packstone. The tube on Fig. 4 is damaged by boring organisms. Rohožník Valley, Hajzuchova, Hradisko section (3), profile below Horný vrch Hill (4). Fig. 5 - miliolid foraminifers in Barremian finely detritic grainstone. Rohožník Valley (as Fig. 4). Enlarged 25 x. Fig. 6 - ooid with relatively well preserved concentric growth layers in Barremian finely detritic packstone. Rohožník Valley, as Fig. 4. Enlarged 25.5 x.

Plate 5:. Fig. 1 - *Parastomiosphaera malmica* (Borza). Pernek, Jastrabník. Enlarged 265 x. Fig. 2 - *Calpionella alpina* Lorenz. Locality as 1. Enlarged 155 x. Figs. 3-4 - *Stomiosphaera wanneri* Borza. Panský Dom, section II. Enlarged 450 x. 4. as Fig. 1, enlarged 265 x. Fig. 5 - *Calpionellopsis simplex* (Colom). Panský Dom, section II. Enlarged 265 x. Fig. 6 - *Calpionellopsis oblonga* (Cadisch). As Fig. 5. Figs. 7, 8 - *Calpionellites darderi* (Colom). As Fig. 5. Fig. 9 - *Stomiosphaera alpina* Leischner. As Fig. 1. Enlarged 155 x. Fig. 10 - *Textularia* sp. As Fig. 1. Enlarged 60 x. Figs. 11-12 - *Hedbergella cretacea* (d'Orbigny), *H. infracretacea* (Glaessner). Rohožník Valley, under Horný vrch Hill. Enlarged 115 x. Fig. 13 - fragment of crystalline shale in allodapic inserts of Oxfordian limestones. Locality as Fig. 5. Enlarged 52 x. Fig. 14 - chert in the Valanginian thin bedded marly limestone with radiolarian microfacies. Locality as Fig. 1. Enlarged 43 x. Fig. 15 - Berriasian silicified organodetritic limestone. Staré Hlavy. Enlarged 43 x. Fig. 16 - shell of a juvenile ammonite in recrystallized biomicritic limestone of Saccocoma microfacies. Locality as Fig. 1. Enlarged 60 x.

Plate 6: Fig. 1 - weathered surface of limestone with an accumulation of echinoderm elements. Fragment no. 1. Scale = 3 mm. Fig. 2 - ditto. Fragment no. 3. Strongly elongated echinoderm elements of various types (a-possible elements of asteroids, k-possible columnalia of crinoids, elements of crescent form are the brachialia of crinoids). Scale = 3 mm. Fig. 3 - surface of limestone with weathered elements of echinoderms. The left arrow indicates a fragment of a large element belonging to an asteroid or cyrtocrinid. The right arrow = columnalia of *Isocrinus* ?sp. Limestone fragment no. 6. Scale = 2 mm. Fig. 4 - deformed calyx (white arrow) with part of the stem (black arrow) of a crinoid (see also text-fig. 2). Limestone fragment no. 6. Scale = 3 mm. Fig. 5 - calyx similar to genus *Eugeniacrinites* Miller (arrow), in limestone fragment no. 7. Scale = 2 mm. Fig. 6 - brachial elements of a crinoid (arrow), on the surface of limestone fragment no. 8. Scale = 3 mm. Locality Staré Hlavy. The material is deposited in the collections of the Slovak National Museum in Bratislava.

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