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SEDIMENTOLOGY AND BRACHIOPODS OF THE LOWER JURASSIC LÚTY POTOK LIMESTONE (SLOVAKIA, WEST-CARPATHIAN KLIPPEN BELT)

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Abstract: The crinoidal Lúty Potok Limestone formerly considered as a Middle Jurassic part of the Czorsztyn Succession contains Liassic brachiopods and fragments of sponge skeletons. It belongs to the Nižná Succession. Clastic admixture derived from an external source is identical in both successions deposited on the opposite margins of the Pieninicum sedimentary zone. The Lúty Potok Limestone is penetrated by a swarm of neptunian dykes which originated during repeated movements along a Liassic synsedimentary fault zone.

Key words: Western Carpathians, Jurassic, brachiopods, crinoidal limestone, neptunian dykes.

Introduction

The klippe in Lúty Potok Valley N of Dlhá and W of Krivá villages was described by Andrusov (1938, p. 30, photo Pl. V, Fig. 1 and 1945, p. 33) as belonging to the "Subpieniny Unit" (Czorsztyn Unit in the new terminology). He mentioned the following strata: **1** - white crinoidal limestone with cherts (Bajocian), **2** - pink crinoidal limestone, **3** - lenticular body of red slightly nodular limestone with Bathonian brachiopods, **4** - coarse-grained rosy crinoidal limestone with *Pentacrinus* and belemnites (Bathonian), **5** - Czorsztyn limestone (Upper Jurassic).

Crinoidal limestones at the Lúty Potok locality display in fact the same features as Middle Jurassic crinoidal limestones of the Czorsztyn Unit (Smolegowa and Krupianka Limestones), so that later authors did not doubt their Middle Jurassic age. Liassic crinoidal limestones were known only from the Klape and Kostelec Successions; and thin (1 m) layer of red crinoidal limestone occurs in the Uppermost Liassic part of the Podbiel Succession. On the basis of brachiopod (*Liospiriferina* etc.) and ammonite occurrence, we succeeded in proving the Early Jurassic age of the crinoidal limestones in the klippes by Lúty Potok as well as by Skalka near Sedliacka Dubová village.

It is noteworthy that Andrusov (1931, p. 34, Pl. III, Fig. 1) mentioned and illustrated a loose block of fine-grained micaceous sandstone with abundant arietitid ammonites of Sinemurian age from the Lúty Potok Valley. It does not seem probable that it belongs to the Liassic strata described here as they do not contain any sandstone with ammonites (they do not occur even in the Skalka klippe near Sedliacka Dubová).

Description of the profile (Figs. 1, 2)

Liassic strata (parts A-D) are represented by Lúty Potok Limestone (new name). Its Early Jurassic age (Sinemurian-Pliensbachian) is proved by fauna of spiriferinid brachiopods collected in the points 2, 3, 6 and 12 as well as by ammonites found between points 9 and 10. It may be divided as follows:

Part A: Light grey ("white") crinoidal limestone (biosparites) with brown chert nodules - the lowest 8 m. Continuous intercalations of spongolites (10-12 cm) are present rarely. The limestones contain a psammitic admixture of quartz grains; they are locally filled by small clasts (under 5 mm) of yellowish dolomites. The limestones are well bedded. The average thickness of beds is 15 cm (maximum 50 cm) with very thin clayey interbeds. A tendency to lenticular bedding is expressed by uneven bedding planes.

Part B: Grey, locally red crinoidal limestone with chert nodules disappearing upwards - 6 m. This transition interval has more relations to the lower complex (both are biosparites).

Part C: Red crinoidal limestone, biomicrite without cherts, with intraclasts of pinkish muddy limestone containing fragments of sponge skeletons - 14 m. The maximum size of the intraclasts is 25 cm. An intercalation with lithoclasts - extraclasts (mainly dolomites up to 7 cm and quartz grains up to 3 mm) occurs in the lowermost part. It also contains large pentagonal columnalia and fragments of crinoidal stems up to 2 cm long, belemnites and brachiopods. A neptunian dyke with complex filling was found between the points 5 and 6. The highest part of the red crinoidal limestone is thin bedded.

Part D: Grey to yellowish crinoidal biomicrites - 3.5 m. This upper part of the profile comprises abundant neptunian dykes with grey and pink laminated filling and intraclasts broken from the walls of clefts.

Middle and Upper Jurassic strata - red, slightly nodular limestones with ammonites and abundant belemnites ("belemnite battle fields") - about 5 m. Only sporadic outcrops are available; the contact with the Liassic strata is covered. We suppose that this member is folded into the Liassic strata of the Lúty Potok

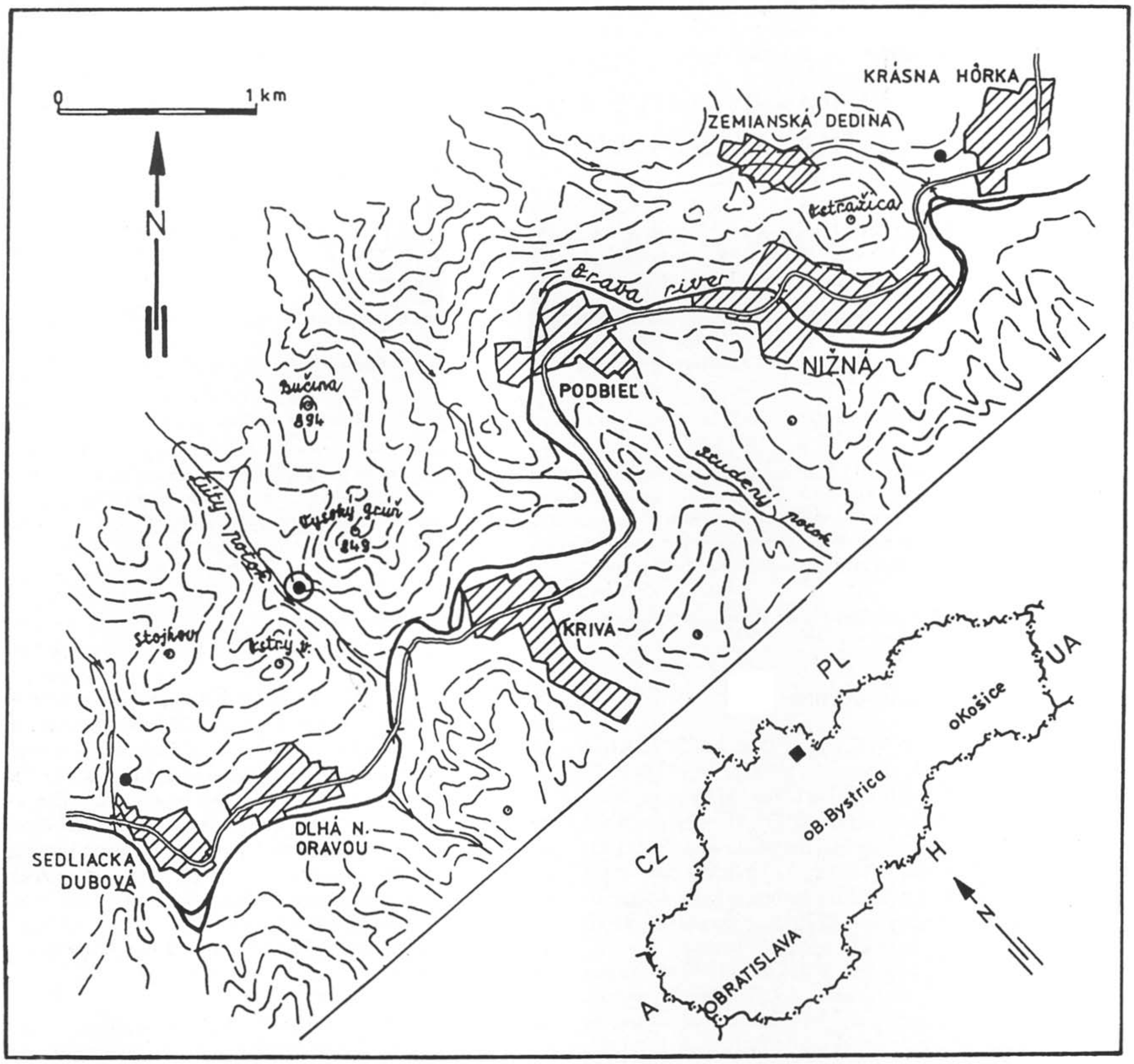


Fig. 1. Situation of the profile Lúty Potok (circle) and two equivalent localities (black points).

klippe. The lowest part includes "*Globuligerina*" - radiolarian microfacies; its Bathonian-Callovian age is supposed. The upper part is characterized by radiolarian microfauna with *Colomisphaera* and without saccocomas, with "*Rhynchonella*" aff. *agassizi* and *Aspidoceras* sp.; its Oxfordian-Lower Kimmeridgean age is most probable.

Liassic brachiopods and ammonites from the crinoidal limestones

Andrusov (1945, p. 34) mentioned the existence of a layer with Bathonian brachiopods: *Rhynchonella concinna* (Sow.) a *Rh. triplicosa fucillata* (Quenst.) among the crinoidal limestones. According to our revision, the determinations were not correct and all the associations found here indicate an Early Jurassic age. The following associations were determined:

Point 2 (Fig. 2) - white sandy crinoidal limestone: *Furcirhynchia* sp., *Cirpa* cf. *fronto* (Quenst.), *Liospiriferina* ex gr. *alpina* (Oppel).

Point 3 - pinkish crinoidal limestone with dolomite clasts: *Cirpa* sp., "*Rhynchonella*" aff. *fraasi* Oppel, *Calcirhynchia (?) plicatissima* (Quenst.), *Liospiriferina* cf. *alpina* (Oppel).

Point 6 - red crinoidal biomicrite: *Tetrarhynchia* sp., *Squamirhynchia* cf. *belemnitica* (Quenst.), *Cuneirhynchia retusifrons* (Oppel), *Lobothyris* cf. *subovoides* (Muenster).

Scarp near the top-nodular layer within the crinoidal limestones: *Squamirhynchia* cf. *squamiplex* (Quenst.), *Cuneirhynchia retusifrons* (Oppel), *Gibbirhynchia curviceps* (Quenst.), *Zeilleria (Cincta)* cf. *cor* (Lamarck), *Liospiriferina* sp., *Callospiriferina* aff. *haueri* (Suess).

Point 12 - yellowish grey crinoidal limestone: *Homoeorhynchia* aff. *almaensis* (Moiss.), ? *Tetrarhynchia* sp., *Liospiriferina* *rostrata* (Schloth.), *L.* ex gr. *obtusa* (Oppel), *Callospiriferina* cf. *verrucosa* (Buch), *Zeilleria* sp., *Z.* cf. *subnumismalis* (Davidson).

Layer equivalent to the point 12: *Homoeorhynchia* aff. *almaensis (Moiss.)*, ? *Cirpa* sp., ? *Gibbirhynchia* sp., *Callospiriferina* aff. *tumida* (Buch), *Liospiriferina* aff. *obtusa* (Oppel) - juv., *Zeilleria* sp.

The brachiopod associations indicate a stratigraphic range of Sinemurian–Pliensbachian; they are older than Domerian. At the scarp near the top (equal to the interval between the points 9 and 10) the ammonites determined by M. Rakús as *Juraphyllites* sp. and *Androgynoceras* sp. were found. Their Carixian age is in accordance with the stratigraphic range indicated by brachiopods.

Microfacial characteristic of the Liassic Lúty Potok Limestone

Light grey crinoidal biosparite with brown nodular cherts and interlayers of spongolites (points 1–4 at Fig. 2)

Crinoidal microfacies. Bioclasts: echinoderm segments with syntaxial rims, partly with twinning lamellae; voids after dissolved siliceous sponge spicules filled by calcite, brachiopod fragments, rarely bivalvians with prismatic layer in shell, rare foraminifers: *Nodosaria* sp., *Spirillina* sp. The absence of sessile foraminifers and bryozoans in comparison with their abundance in Middle Jurassic biosparites of the Czorsztyn Succession is noteworthy.

Terrigenous admixture: abundant quartz grains of psammitic size; abundant feldspars represent locally up to one quarter of the terrigenous constituent: slightly kaolinized orthoclase exceptionally with authigenic overgrowth (Mišík & Aubrecht 1994, Pl. V: Fig. 7), perthite (l.c. Pl. V: Fig. 5), microcline (l.c. Pl. V: Fig. 6) and very rarely plagioclase. Then the presence of granitoids in the source area may be deduced. Crystal forms of beta-quartz (Pl. II: Fig. 1) as well as small fragments of sphaerolitic acid volcanites (Mišík & Aubrecht 1994, Pl. I: Figs. 5, 6) were derived most probably from Permian effusive rocks. Triassic dolomicrites (up to 5 mm) rarely with silt quartz admixture (l.c. Pl. III: Fig. 5) and pelletal structure represent the most frequent lithoclasts. The clasts of fine-grained sandstone and quartzite occur exceptionally. Glauconite is very rare.

The heavy mineral fraction is dominated by garnet (64 %), accompanied by apatite (15 %), zircon (13 %), rutile (4 %) and tourmaline (3 %), rarely also by titanite and epidote.

Nodular cherts display echinoderm remains partly preserved as calcite. Smaller segments and fragments acquired scalenohedral overgrowths and their internal margins are rimmed by short-fibrous chalcedony. It fills tiny voids formed by slight corrosion of the scalenohedra by water loosened during the opal dehydratation. This phenomenon was described from chert nodules in the crinoidal limestone of the same age near Sedliacka Dubová (Mišík 1993, Fig. 2 C–F). Syntaxial overgrowths of the dog-teeth type on the bivalvian shells also display analogic rims. Chalcedony spicules present compactional and diagenetic deformations (Pl. I: Fig. 1).

Red sandy crinoidal biomicrite with intraclasts ("nodules") of pink sponge limestone (points 5–10)

Biomicrite-packstone and intrabiomicrudite, crinoidal-spiculitic-brachiopod microfacies. Bioclasts: echinoderm segments without syntaxial rims (scalenohedral overgrowths occur only in voids - Pl. I, Fig. 3); brachiopod fragments rarely also whole juvenile specimens; foraminifers: *Nodosaria* sp., *Lenticulina* sp., rarely *Dentalina* sp., *Involutina* sp., exceptionally "microforaminifers"; rare ostracods, bryozoan fragments and echinoid spines. Spicules of siliceous sponges filled by calcite occur rarely also in the matrix, but they are frequent in the micritic intraclasts.

Isolated spicules (monaxons, hexacts, desmas) and fragments of sponge skeletons (Pl. I: Figs. 5–6) are almost always the sole organic remains in those intraclasts with biomicrite-wackestone or bafflestone structures (the sponge filtrated the sediment and was hindered from penetration of the coarser detritus). The same phenomenon concerning the sponge skeletons was described by us from the Valanginian-Hauterivian Horná Lysá Limestone in Vršatec area (Mišík et al. 1994a). Pellets originated by agglutination locally formed the polarity structures. Clastic quartz is much rarer in the intraclasts than in the surrounding crinoidal limestone. Intraclasts perforated by boring organisms were found (Pl. I: Fig. 6). They probably represent small torn off sponge mounds or disintegrated intercalations of sponge biomicrite deposited during the short calm periods without currents. It is interesting that an identical Liassic facies containing intraclasts with sponge skeletons was found by us in the Vysoká Unit, at Prístodolok Hill in the Malé Karpaty Mts.

The terrigenous admixture in limestone is almost exclusively represented by quartz grains, sometimes with acicular inclusions. The feldspars are very rare in comparison with the underlying interval. Near the base (point 5), a layer about 1 m thick very rich in dolomite lithoclasts (up to 7 cm) occurs; it might be interpreted as tempestite. We have also found similar interlayers in the Middle Jurassic crinoidal limestones at the localities of Babiná-Bohunice and Mestečská Skala. A dolomite lithoclast was penetrated by bivalvian borings (Pl. II: Fig. 2). Dolomite structures unknown from the Central Western Carpathians (e.g. Pl. III: Fig. 3) occurred, but we have found them among the clasts in the Czorsztyn Unit - Krasin klippe - Dolná Súča (Mišík et al. 1994a) and Mestečská Skala. Other rock fragments are very rare (e.g. vein quartz pebble 1.5 cm).

Yellowish grey crinoidal biomicrite with brachiopods and neptunian dykes (points 11–13, Fig. 2)

Crinoid segments are accompanied by bryozoan fragments, juvenile brachiopods; rarely spicules filled by calcite, small ophtalmiid foraminifers, exceptionally serpulids, ophiuroid and *Globochaete* sp. (Pl. I: Fig. 3) occur. From the very rare clastic admixture a phosphatic lithoclast with tiny ooids is noteworthy (Pl. III: Fig. 4).

Neptunian dykes

The neptunian dyke between points 5–6 about 10 cm thick displays a very complex filling, mainly pink and grey micrite with clasts derived from the walls of the cleft. The echinoderm segments did not have syntaxial overgrowths sticking out into the void, but were covered by isopachous radiaxial cement (Pl. II: Fig. 5); perhaps they represent a product of vadose meteoric diagenesis. Intraclasts proceeding from the older filling prove the repetition of movements along this fault. Grey micritic laminae alternate with the layers of radiaxial cement. The alternation of micrite and pelmicrite laminae (pellets originated by agglutination) occur frequently. Cross laminations and microdykes following small synsedimentary normal faults were ob-

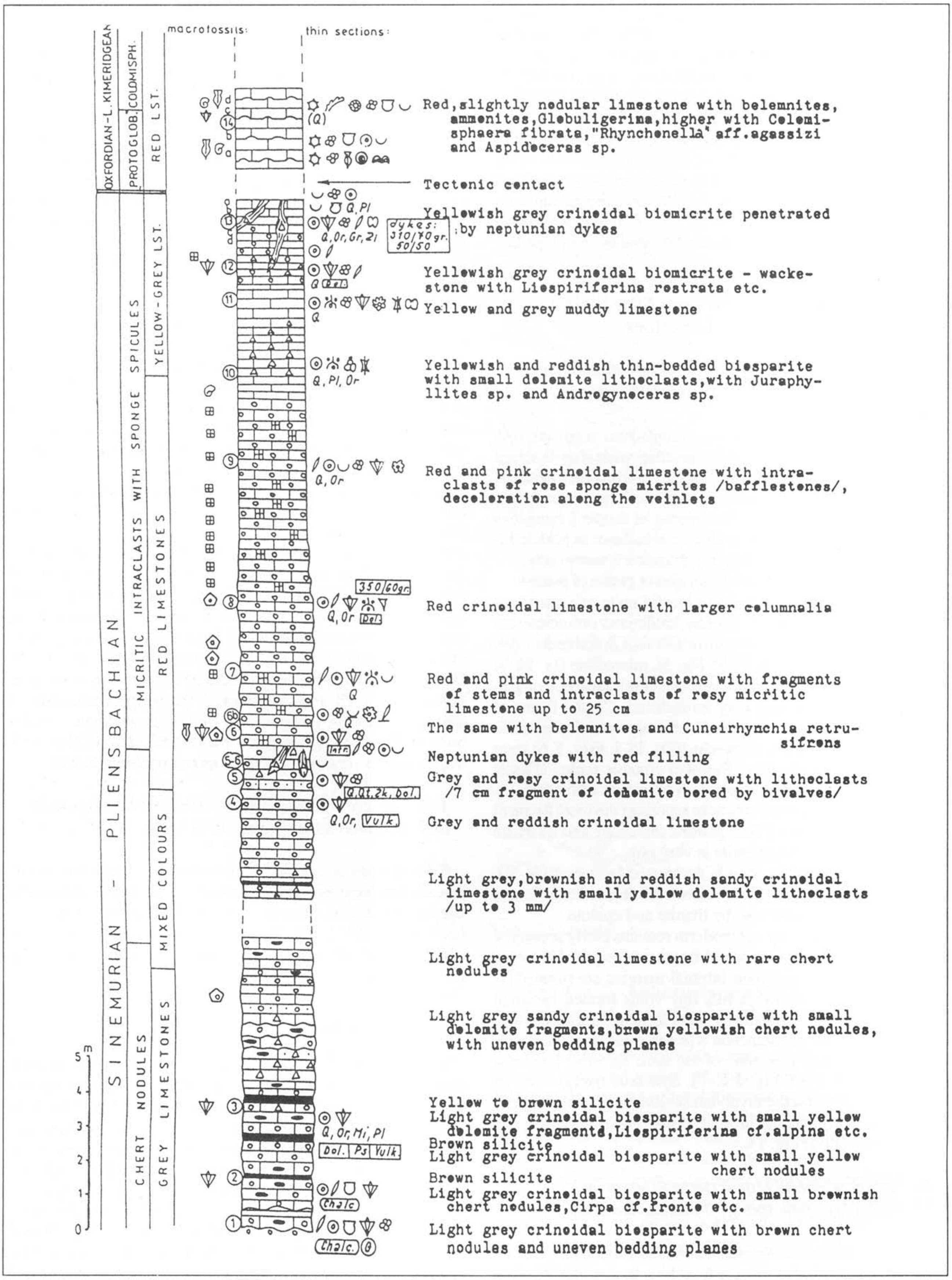


Fig. 2. Profile of the Klippe Lúty Potok (Orava). Explanations see on the next page.

served. The last empty voids are always filled by the red micrite with rare smooth ostracods and fucoids. The neptunian dyke could be considered as a synsedimentary extensional fault filled by only slightly younger sediment than the wall rock, thus also being of Early Jurassic age.

Several neptunian dykes about 10–20 cm thick with diverse orientation were enregistered within the horizon 13 a–d. Locally they swell forming larger caverns. The predominant filling is represented by pink and grey laminated micrites. The lamination is parallel with the walls. An inclined filling about 35° (Pl. IV: Fig. 1) was also observed. Clasts of the several types of crinoidal limestones coated by radiaxial cement as well as clasts of the older filling within the neptunian dykes prove repeated tectonic movements (Pl. III: Fig. 1). Discontinuous calcite veinlets show that extension was also active during the process of filling (Pl. III: Figs. 1, 3). The cavern (pocket) filling may be designated as breccia with laminae of all mentioned types and red micrite (with smooth ostracods and rare small *Patellina* and *Trocholina*) as the youngest constituent. The admixture of crystal silt (initial cement broken from the walls) is current. Dehydration cracks forming a network of dark microveinlets (Pl. II: Fig. 5) were observed exceptionally. Numerous grains of quartz and two garnet grains were entrapped in a small void ("Sandfang").

Microfacial characteristic of the Middle-Upper Jurassic Czorsztyn Limestone (points 14 a–d, Fig. 2)

Red, slightly nodular limestone locally with abundant belemnites

Biomicrite-packstone. "*Globuligerina*" - radiolarian microfacies. Abundant voids after dissolved radiolarians filled by drusy calcite or micrite, frequent *Globuligerina* sp., some small belemnite rostra corroded and penetrated by algal borings impregnated by Fe-oxides (Pl. IV: Fig. 4); the rostra are sometimes coated by bacterial Fe-oncolites. Ostracods, echinoderm segments, *Lenticulina* sp., *Ophthalmidium* sp. and holothurian sclerites *Theelia* sp. are rare. Some voids with polarity structures and intraclasts occur. Quartz is totally absent, glauconite exceptional. The abundance of *Globuligerina* ("*Protoglobigerina*") and the lack of *Calciodinellaceae* ("*Cadosinidae*") indicate the Callovian as the probable age.

Light grey muddy limestone with greenish nodules

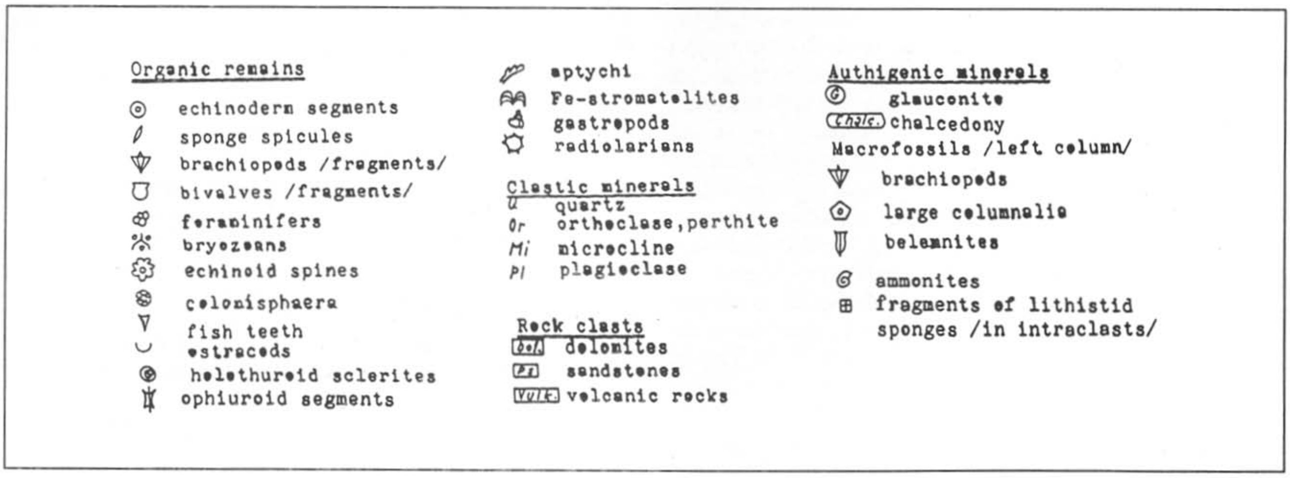
Biomicrite wackestone. Organic remains: several radiolarians preserved as phantoms, aptychi (up to 5 specimens in a thin section 2 × 2 cm), rare ostracods, bivalvian fragments, several *Colomisphaera fibrata* (Nagy), rare *Schizosphaerella minutissima* (Colom), *Spirillina* sp., *Lenticulina* sp., *Globochaete* sp. and phosphatic scales. Intraclasts of radiolarian packstone rarely occur. Clastic quartz grains (to 0.25 mm) are exceptional. The presence of *Calciodinellaceae* ("*Cadosinidae*") and absence of *Saccocoma* indicate the probable Oxfordian age. The finding of brachiopod "*Rhynchonella*" aff. *agassizi* (Zejszner) indicates possible Early Kimmeridgian age. Poorly preserved ammonites determined by M. Rakús as *Aspidoceras* sp. support Late Jurassic age.

Summary and conclusions

Finding of brachiopods and rare ammonites prove the Early Jurassic (Sinemurian–Pliensbachian) age of the 30 m thick crinoidal limestone complex formerly considered as Middle Jurassic (Bajocian-Bathonian). As this complex has no equivalent among the lithostratigraphic units of the Pieniny Klippen Belt defined by Birkenmajer (1977), the name Lúty Potok Limestone is proposed.

Its lower part is represented by white crinoidal biosparites with brown chert nodules. The upper part is formed by red crinoidal biomicrite without cherts, with frequent intraclasts of pinkish biomicrite containing fragments of sponge skeletons. An intercalation with extraclasts mainly dolomites (up to 7 cm) sometimes bored by bivalves was interpreted as tempestite. The uppermost part is remarkable for its abundant neptunian dykes with complex filling which reflects the repeated movements along the synsedimentary fault. The bioclasts belong exclusively to the benthos. A considerable part of the terrigenous admixture was derived from granitoid rocks (the relation quartz : feldspar is locally 1 : 1 - frequent orthoclase and perthite, rare microcline and plagioclase). Acid volcanic rocks (most probably of Permian age) are represented by quartz phenocrysts and tiny sphaerolitic lithoclasts. Abundant fragments of Triassic dolomites were mostly transformed into yellowish dedolomites; siltstones and phosphatic clasts with ooid structure are found occasionally.

Explanations to Fig. 2.



The contact with younger strata - red nodular Czorsztyn Limestone with frequent belemnites is covered. While Liassic crinoidal limestones contained exclusively benthonic organisms, in the red nodular limestones only planktonic and nektonic organisms occur and the terrigenous admixture is absent. According to *Globuligerina*, *Colomisphaera fibrata* and "*Rhynchonella*" aff. *agassizi*, the red nodular limestone belong to Callovian-Oxfordian (?Lower Kimmeridgian). The lack of a transitional facies suggests tectonic contact.

The second locality of the Lúty Potok Limestone is the Skalka klippe near Sedliacka Dubová crinoidal limestones with chert nodules also yelded Liassic brachiopods: *Liospiriferina* aff. *rostrata* (Schloth.), *L.* cf. *alpina* (OPPEL), *Cirpa fronto* (Quenst.), *Tetrarhynchia* aff. *subconcinna* (Davidson), *Lobothyris* aff. *punctata subpunctata* (Davidson) and *Rimirhynchia* sp.

The Lúty Potok klippe cannot be included in the Czorsztyn Succession as was thought up to now. Such Liassic crinoidal limestones are known only from the Klape, Kostelec and Nižná Successions. Red nodular limestones in the Klape and Kostelec Successions belong to the Bathonian (Rakús 1965, Began 1969) and in the Nižná Succession to the Kimmeridgian (Scheibner 1967). The proximity of Nižná type locality is in favour of the option that the klippe Lúty Potok belongs to the Nižná Succession. We have found its criterion member - Nižná Limestone in the immediate southern neighbourhood at the Ostrý Vrch Hill above Dlhá village (Mišík 1990, p. 44) and also 1 km to the NE under the Vysoký Grúň Hill near Krivá village (the locality was signalized already by J. Haško). A difference concerning the Liassic rocks in the type profile of Nižná Succession (quarry near Krásna Hôrka) should be mentioned: sandstones are there more frequent than crinoidal limestones. But the Liassic Skalka klippe near Sedliacka Dubová, which certainly belongs to the same succession as Lúty Potok klippe, displays intercalations of coarse-grained sandstones and so can be considered as a facies link between them.

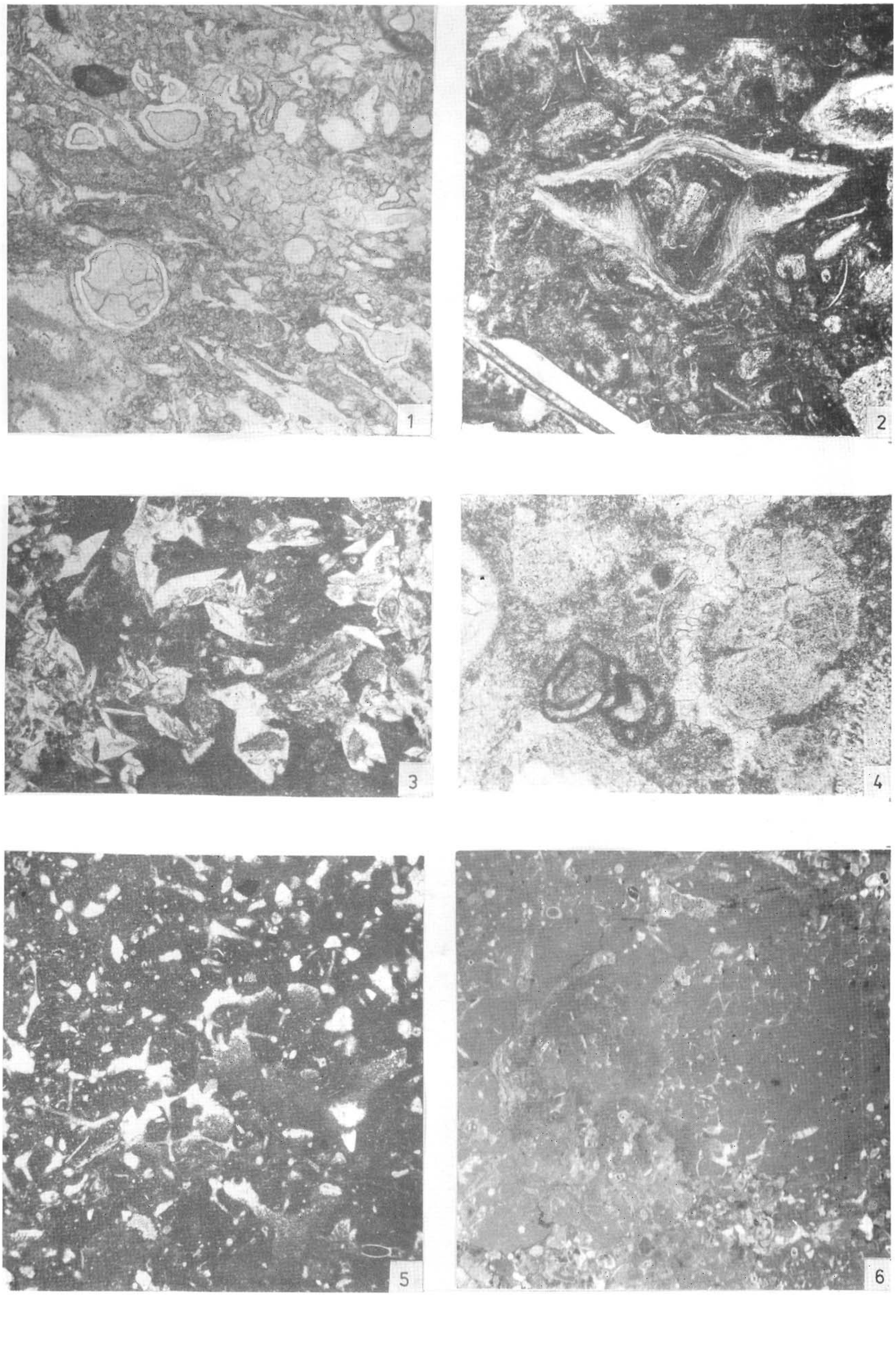
From the paleogeographical point of view the presence of the same terrigenous material (e.g. dolomite clasts with structures unknown from the outcrops in Western Carpathians, identical heavy mineral associations dominated by garnet) in the Liassic crinoidal Lúty Potok Limestone (Nižná Succession) as well as in the Bajocian-Bathonian crinoidal Smolegowa and Krupianka Limestones (Czorsztyn Succession) is important. The source area was situated externally from the future Pieniny Klippen Belt. It confirms that both successions belong to the Pieninicum. The Czorsztyn Succession was deposited in the external (NW) part of the Pieninicum sedimentary area, the Nižná Succession is thought to have been deposited in its internal marginal (SE) part with regard to the exceptional presence of Urgonian facies (Nižná Limestone). That means that the central Kysuca-Pieniny trough, forming during the Early Jurassic an obstacle to the transport did not exist and was individualized later. We are handicapped by the fact that during the strong folding of the Pieniny Klippen Belt a huge décollement occurred on the Uppermost Triassic and Liassic horizons so that only Middle Jurassic and younger strata are generally represented in the klippes (tectonic lenses). The Triassic and older strata are totally missing and Liassic strata rarely present. Its sporadic outcrops show more pronounced facies differentiation than was formerly supposed, e.g. the Liassic sequence of the Czorsztyn Unit is represented by spotty marls at the Vršatec locality and by shallow-water coquina limestones in the Dolný Mlyn klippe.

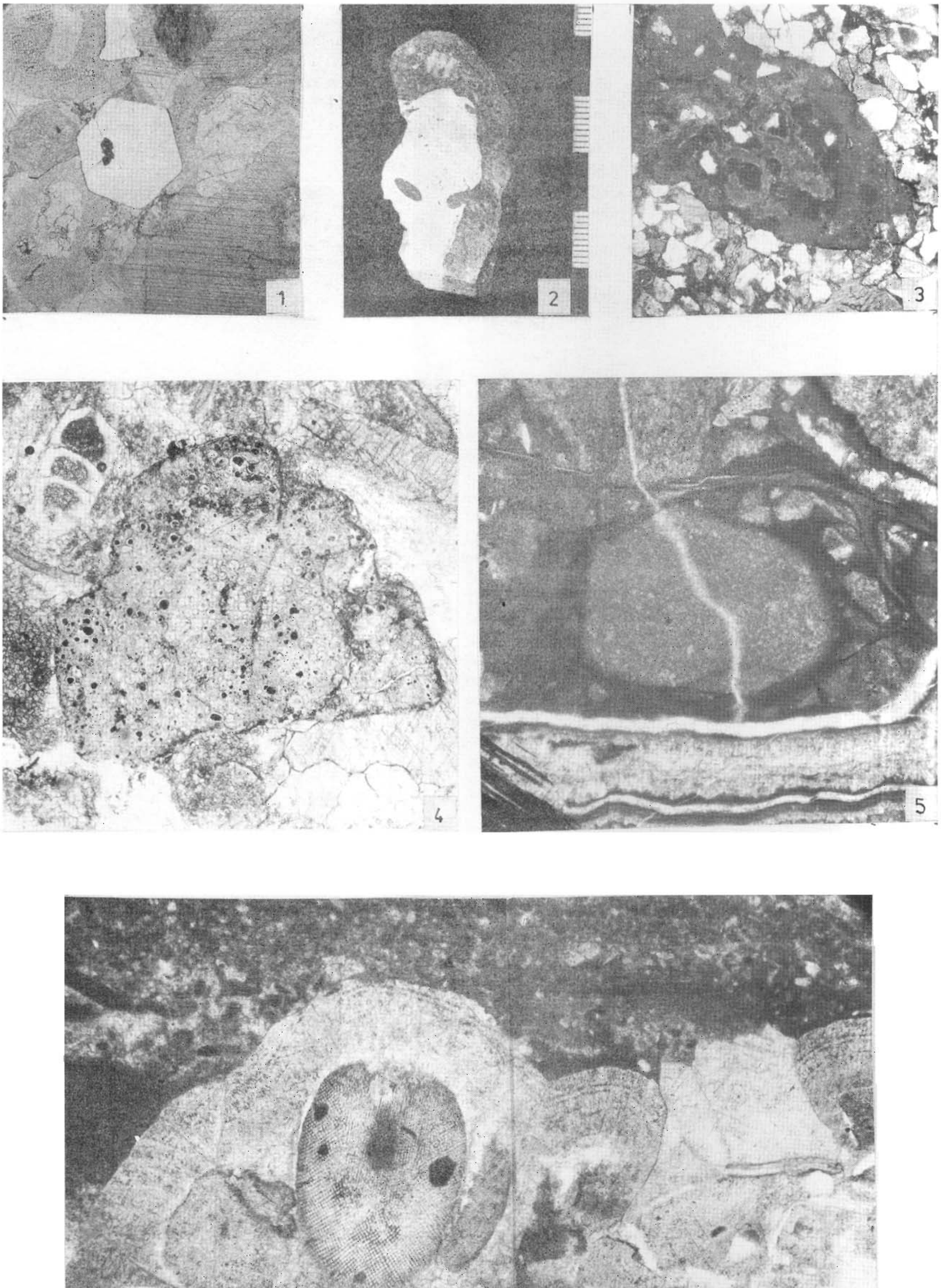
Plate I: Liassic crinoidal Lúty Potok Limestone. Lúty Potok klippe, Orava. **Fig. 1** - Compactional deformation of siliceous sponge spicules in biosparite; the voids after spicules dissolved within the semiconsolidated sediment were deformed by the load of overlying strata and then coated by tiny isopachous radial-fibrous chalcedony rims (white). The center of the void was filled by drusy calcite or one calcite grain. Sample 1, thin section No. 20 217. Magn. 40×. **Fig. 2** - Juvenile spiriferinid brachiopod in the crinoidal biomicrite. Sample L, thin section No. 20 745. Magn. 30×. **Fig. 3** - Small echinoderm fragments overgrowth to scalenohedral outlines in a void filled by micrite. Sample L, thin section No. 20 216. Magn. 30×. **Fig. 4** - *Globochaete* sp. (right), ostracod, nubecularid foraminifer and echinoderm segment in the crinoidal biomicrite. Sample 13, thin section No. 21 295. Magn. 61×. **Fig. 5** - Skeleton fragment of the siliceous sponge with dissolved spicules; voids after them are partially filled by microsparitic sediment and in their higher part by sparite cement (polarity structure). Intraclasts in the Liassic crinoidal limestone. Sample 6B, thin section No. 20 204. Magn. 20×. **Fig. 6** - Intraclast with a sponge skeleton fragment (bafflestone) bored by forking holes of boring bivalves (left). Intraclast resembles a greyish nodule in the pink crinoidal biomicrite. Sample 6A, thin section No. 20 211. Magn. 8×.

Plate II: Lúty Potok Limestone, Lúty Potok klippe (Orava). **Fig. 1** - Quartz phenocryst (horizontally cut) from the acid volcanic rocks, probably Permian tuffs. Clastic admixture in the crinoidal limestone. Sample 4, thin section No. 20 206. Magn. 20×. **Fig. 2** - Pebble of Triassic dolomite with bivalvian borings in red crinoidal limestone. Sample 5, polished section. Natural size. **Fig. 3** - Dolomite extraclast with peculiar structure. Sample 6B, thin section No. 20 204. Magn. 20×. **Fig. 4** - Phosphatic lithoclast with tiny ooids. Sample K, thin section No. 21 068. Magn. 44×. **Fig. 5** - Dark veinlets originated probably by sediment cracking during the dehydratation; neptunian dyke filling. Sample 13C, thin section No. 21 297. Magn. 20×. **Fig. 6** - Crinoidal segments covered by calcitic sinter cement formed in the vadose (meteoric ?) environment. Filling of a neptunian dyke. Sample 5-6, thin section No. 26 308. Magn. 20×.

Plate III: Filling of neptunian dykes within the Liassic crinoidal limestones, Lúty Potok klippe (Orava). **Fig. 1** - Fragment of older laminated filling in a younger filling generation disturbed by synsedimentary calcite veinlet. Sample 13C, thin section No. 21 290. Magn. 20×. **Fig. 2** - Synsedimentary disturbed laminated filling (e.g. normal fault in the lower part of the photo). Sample 13C, polished section. Slightly magnified (1.2×). **Fig. 3** - Laminated filling disturbed by extensional faults (calcite veinlets). Sample 13C, thin section No. 21 459. Magn. 20×. **Fig. 4** - Complex filling of a neptunian dyke. Sample 13C, polished section. Natural size.

Plate IV: **Fig. 1** - Cross bedded laminated micrite within a complex filling. Neptunian dyke penetrating the Liassic crinoidal limestone, Lúty Potok klippe (Orava). Sample 13C, polished section. Natural size. **Fig. 2** - Complex dyke filling; laminae are parallel with the walls of the original cleft. As above. Magn. 1.2×. **Fig. 3** - Complex dyke filling with fragments of crinoidal limestone derived from the cleft walls. As above. **Fig. 4** - Corroded belemnite rostrum with borings of epifaunal organisms. Red nodular limestone of Oxfordian–Early Kimmeridgian age. Lúty Potok klippe (Orava). Sample 14C, thin section No. 21 304. Magn. 26×.

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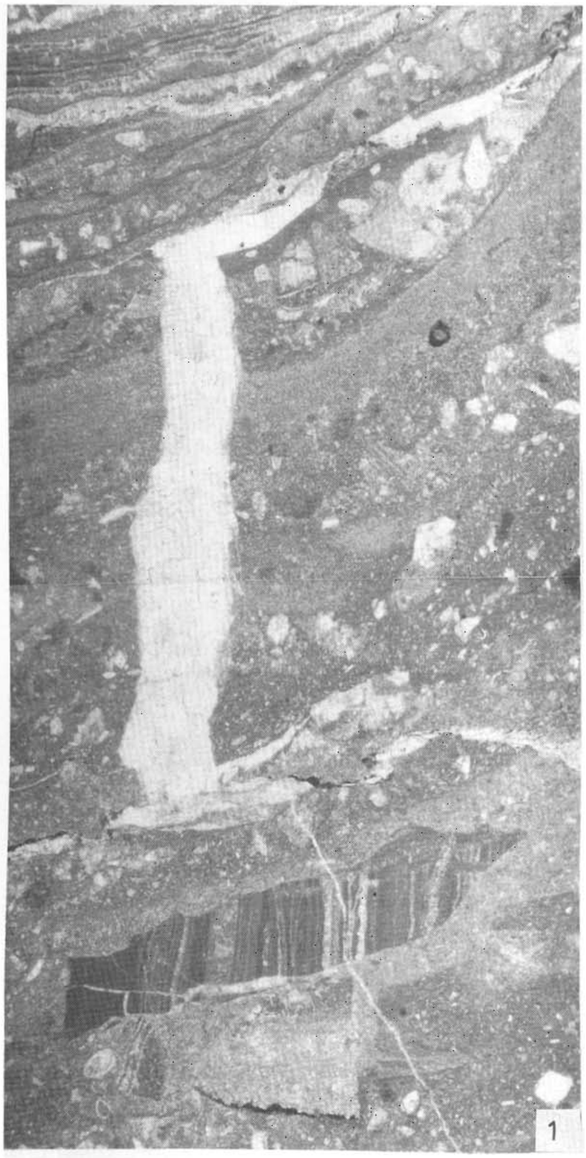

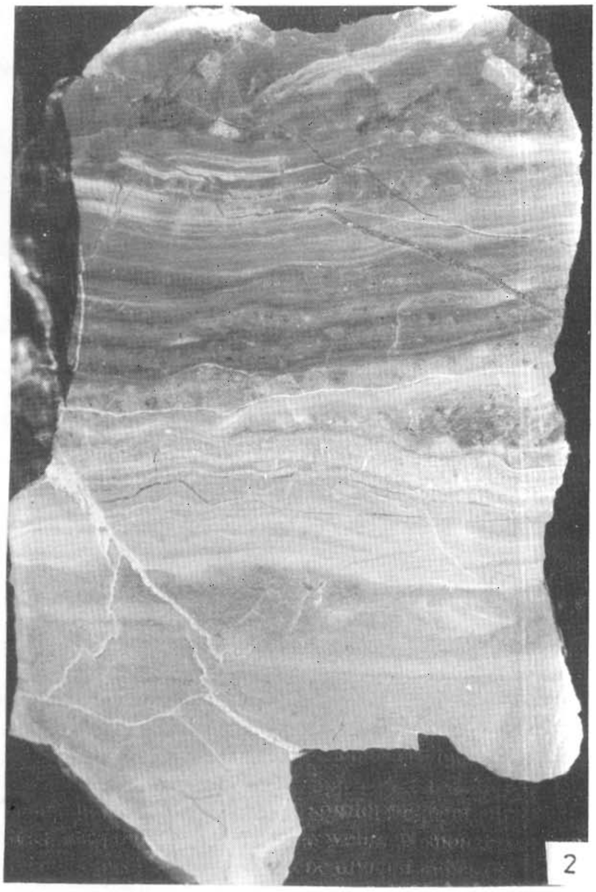

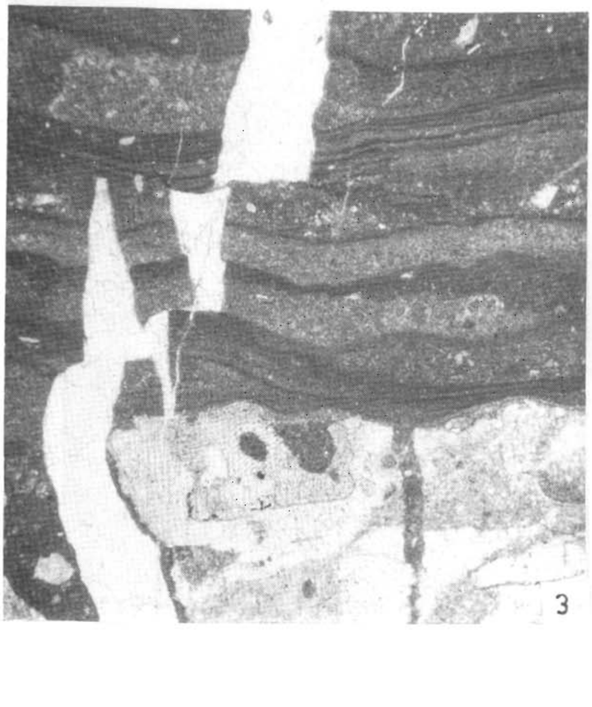

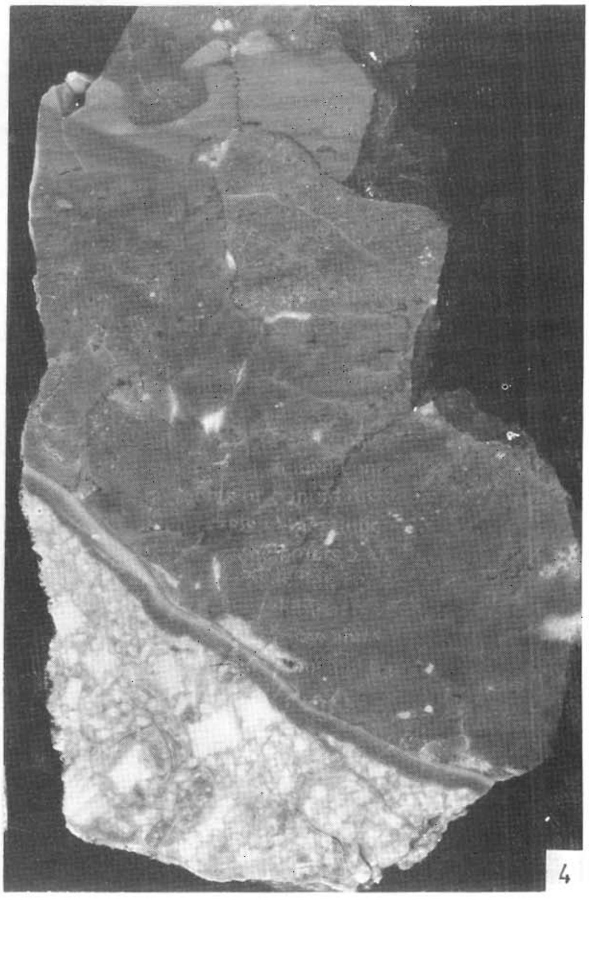

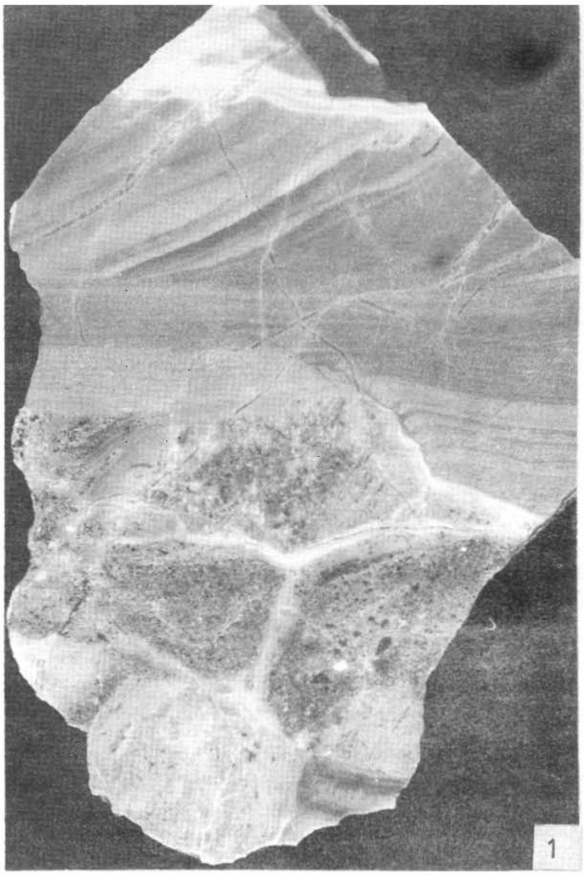
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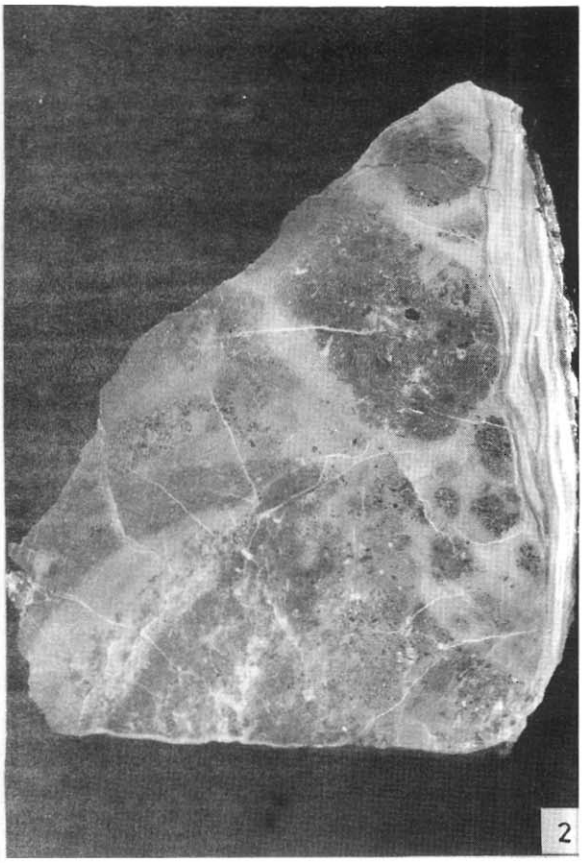
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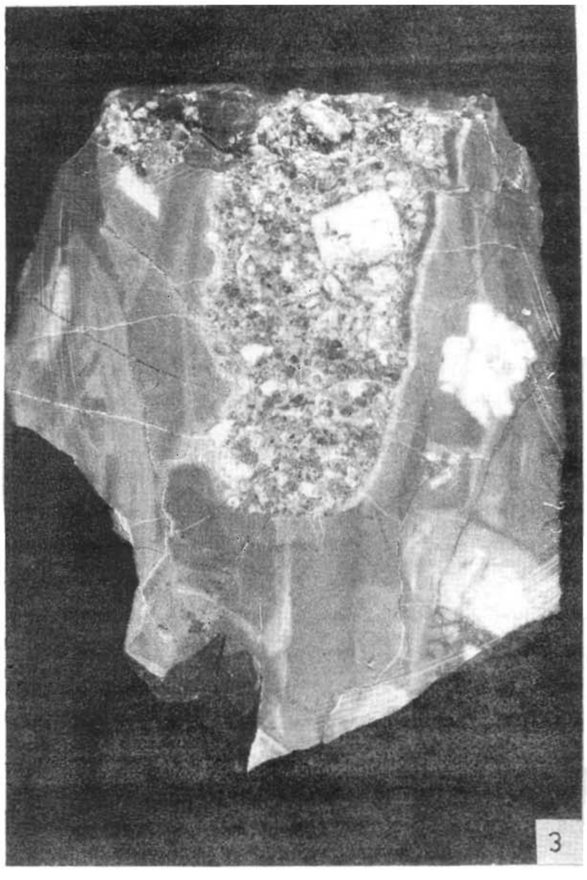
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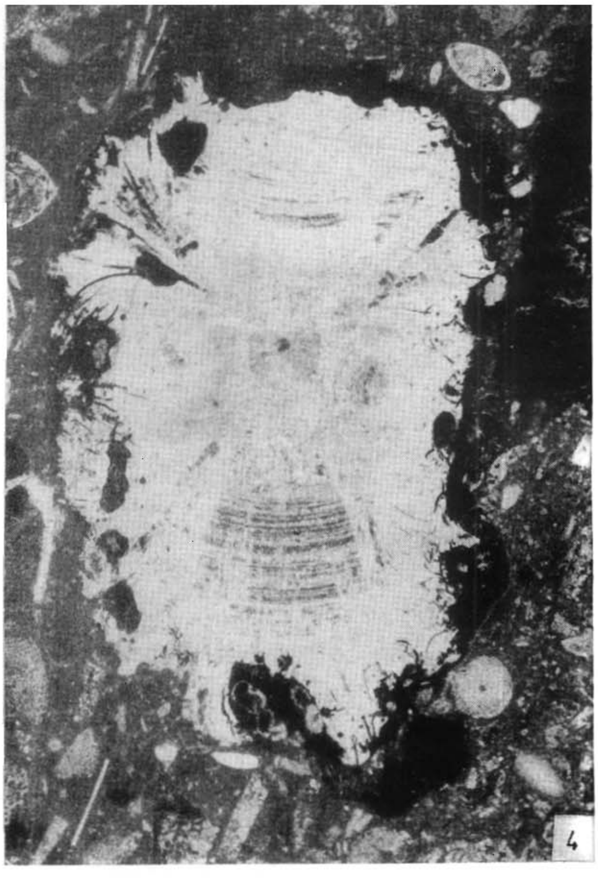
4

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