GEOLOGICA CARPATHICA, 46, 5, BRATISLAVA, OCTOBER 1995
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EARLY CRETACEOUS SEDIMENTARY CHANGES IN WEST-CARPATHIAN AREA

JOZEF MICHALÍK[1], DANIELA REHÁKOVÁ[1]
and ZDENĚK VAŠÍČEK[2]

[1] Geological Institute, Slovak Academy of Sciences, Dúbravská 9, 842 26 Bratislava, Slovak Republic
[2] Department of Geology and Mineralogy, Mining University, Třída 17. listopadu, 708 33 Ostrava-Poruba, Czech Republic

(Manuscript received March 14, 1995; accepted in revised form June 14, 1995)

Abstract: Latest Tithonian bottom relief denivelization, local erosion, as well as successive origin of Berriasian/Valanginian carbonate breccias influenced the sedimentary regime of the carbonate basins in Central Western Carpathians. The Nozdrovice Breccia is interpreted here as the product of sedimentation below an active fault slope. The distribution and composition of clastic intercalations in hemipelagic carbonate sequences indicate the dynamics of these basins during the Jurassic/Cretaceous transition.

Key words: Late Jurassic/Early Cretaceous, Western Carpathians, basin evolution, carbonate sediments, breccias, microplankton, ammonites.

Introduction

Setting

Neocimmerian deformation changed the eustatic and hydrodynamic regime of the Tethyan basins (Michalík 1990). Increased calcium carbonate production by benthic (reef building) and planktonic organisms (saccocomas, globochaetes and calpionellids) caused both a gradual increase in the sedimentation rate and a change of sedimentary lithology (Vašíček et al. 1983, 1994; Michalík & Vašíček 1989; Soták 1989; Michalík et al. 1991; Reháková & Michalík 1994; Michalík in press).

At the beginning of the Berriasian, reef growth in the Beskydic of the Western Carpathians ceased. Neritic sediments are rare (Raptawicka Turnia Formation in the Tatric, pebbles in younger conglomerates). Prevailing nannocone biomicrites of the majolica (Pieniny Formation) or biancone types (Oberalm, Padlá Voda, Osnica and Ladce Formations; Reháková & Michalík 1992; Reháková in press) originated in eupelagic well aerated conditions. While microplankton skeletons form a substantial constituent of the sediment, remnants of nektonic organisms occur only rarely, benthic fossils are almost missing. This situation is in accordance with the condition of mass plankton development in upwelling sites (Moissette & Saint Martin 1992).

Lithostratigraphy

Studied sections

Results of sedimentological, microbiostratigraphical and correlation studies of detailed sampled Jurassic/Cretaceous West-Carpathian sections are summarized in Borza & Michalík (1986, 1987), Reháková & Michalík (1992, 1994), Michalík et al. (1994), Vašíček et al. (1994). The diachronic character of sedimentation (Boorová 1994), and local erosion (Michalík & Reháková in press) make estimation of the J/C boundary difficult.

Seven sections from the Central Western Carpathian Fatric Zone (Fig. 1) are analysed here: the Strážovce (1; Borza et al.

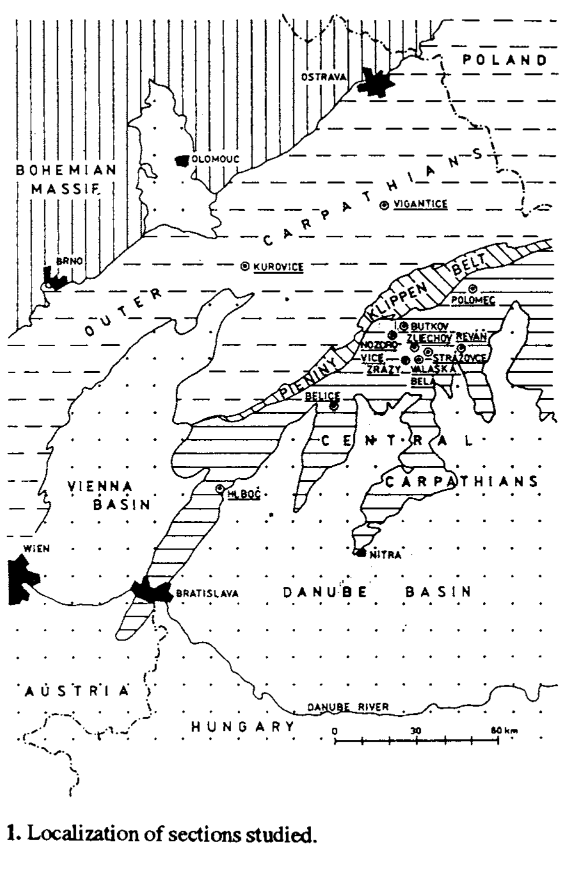


Fig. 1. Localization of sections studied.

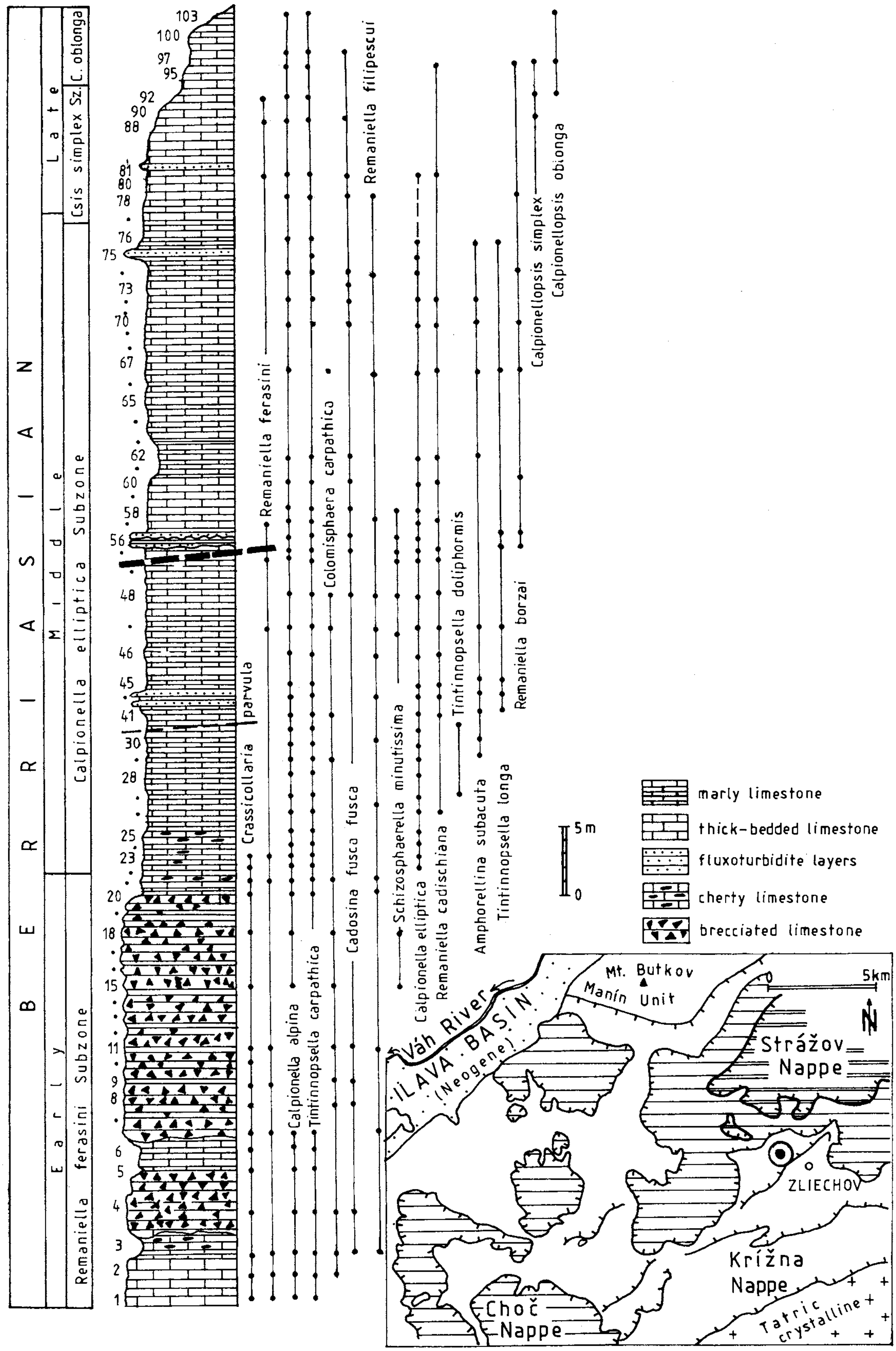


Fig. 2. Biostratigraphy of the Zliechov section. Fluxoturbidite layers consist of fine detrital limestone with skeletal fragments of shallow - marine organisms.

1980), Reváň (2; Reháková & Michalík 1994) and Zrázy sections (3; Michalík et al. 1993) representing the Zliechov Basin development (Jasenina, Osnica and Mráznica Formations); the Zliechov section (4; Fig. 2) with channel development of the Osnica Fm; the Nozdrovice (5; Tegernsee, Osnica and Mráznica Fms; Michalík & Vašíček 1980) and Hlboč sections (6; Tegernsee, Padlá Voda and Hlboč Fms; Borza & Michalík 1987, 1988; Michalík et al. 1988, 1990) in marginal development of the Zliechov Basin, as well as the Butkov section (7; Borza et al. 1987; Michalík & Vašíček 1987) in the Manín elevation (Tegernsee, Ladce, Mráznica Fms).

Uppermost Jurassic formations

a - The Upper Jurassic sequence of the Fatric Zliechov Basin is represented by the **Jasenina Formation** (Michalík et al. 1990). The dark shaly marlstone/marly limestone sequence is about 30-40 m thick. Irregular allodapic intercalations, more frequent in the lower part of the formation, are represented by thin silt laminae with juvenile aptychi concentrations. The anomalous sedimentation rates of the uppermost part of the Jasenina Formation (16.3 mm/Ka in comparison with the 4-7 mm/Ka of its lower and middle Tithonian part) was probably caused by fine terrigenous imput. Planktonic mikroorganisms of the Moluccana, Malmica and Crassicollaria Zones along with index aptychi indicate a Kimmeridgian/Tithonian age for the formation.

b - Upper Jurassic basins were separated by wide flat elevations with nodular Ammonitico Rosso-type limestone sedimentation. While the nodular limestones of the **Tegernsee Formation** represent practically all the Middle and Upper Jurassic sequence in the Manín Gorge, sedimentation of this type started as late as in the Callovian in the Butkov (7) and Hlboč (6) sections (Michalík & Vašíček 1987). Borza & Michalík (1986), Michalík et al. (1990) and Michalík & Reháková (1992) compared this formation with the Czorsztyn Formation.

Lowermost Cretaceous formations

a - While the base of "Neocomian" well bedded micrite limestones of biancone type called the **Osnica Formation** (Michalík et al. 1990) is still Late Tithonian in age in the Zrázy, Strážovce, Osnica and Lúčky sections, this formation was dated as Early Berriasian (Alpina Subzone: Boorová 1994) in the Motyčky section near Banská Bystrica. Thus, the character of the boundary between the Jasenina and Osnica Fms is diachronic, becoming younger southwards into the basin. Similarly, the upper boundary of the formation also seems to be diachronic: planktogene carbonates, the depocentre of which was probably below the foot of slope, were gradually thinned by fine terrigenous admixture basinwards.

b - The Berriasian **Padlá Voda Formation** started by erosive contact with the Tegernsee Formation followed by a sedimentary breccia (Borza & Michalík 1987) at the base of massive cherty limestones covered by the schistose Hlboč Formation limestones in the Hlboč section (6; Fig. 3).

c - The Lower Cretaceous hemipelagic sequence starts with the **Ladce Formation** in the Butkov section. Lower clastic (Pl. I: Fig. 1) and upper pelagic members (the latter formed by thin bedded limestones with brownish limonite spots) are distinguishable in it. Sporadic graded calciturbidite layers occur in the uppermost part.

Microfacies of lithoclasts

Types of microfacies

Sample sets from each section have been studied by optical microscope. Two standard microfacies (Wilson 1975) and seven microfacies types have been recognized in the analysed sequences: six of them belong to basinal SMF-3 while the remaining is typical for fluxoturbidites (SMF-4).

MF-a: Saccocoma wackestone to packstone with *Saccocoma* sp., *Parastomiosphaera malmica* Borza, *Colomisphaera pulla, Carpistomiosphaera tithonica, Chitinoidella boneti, Ch. dobeni, Praetintinnopsella andrusovi, Globochaete alpina* Lomb., crinoid columnalia, ostracod, aptychi, ammonite, juvenile bivalve fragments. It forms breccia clasts in the Butkov and Hlboč sections.

MF-b: *Crassicollaria wackestone* with *Crassicollaria intermedia* (Dur. Delga), *C. brevis* Remane, *C. massutiniana* (Colom), *C. parvula* Remane, *Tintinnopsella remanei* Borza, *T. carpathica* (Murg. & Filipescu), *Calpionella alpina* Lorenz, radiolarians, *Saccocoma* sp., globochaetes, juvenile ammonites, aptychi, crinoids and bivalve fragments. It forms breccia clasts in the Hlboč, Zliechov (Pl. II: Fig. 2), Strážovce, Butkov, Reváň and Nozdrovice sections.

MF-c: Calpionellid-globochaete (resp. globochaete-calpionellid) wackestone with *Calpionella alpina, Remaniella ferasini, Nannoconus* sp., *Crassicollaria parvula, Tintinnopsella carpathica, Schizosphaerella minutissima* (Colom), radiolarians and globochaetes. This type of microfacies forms Berriasian breccia clasts in all the studied sections (Pl. II: Figs. 1, 3-6).

MF-d: Nannoconid wackestone with *Calpionella elliptica* Cadisch, *Tintinnopsella carpathica, T. subacuta* (Colom), *T. longa* (Colom), *Remaniela cadischiana* (Colom), *Calpionellopsis simplex* (Colom), *C. oblonga* (Cadisch), *Cadosina fusca fusca* Wanner, *Colomisphaera vogleri* (Borza), *C. heliosphaera* (Vogler), radiolarians, ostracods, clay minerals, pyrite, clastic quartz and glauconite forms breccia clasts in the Butkov- and Nozdrovice section.

MF-e: Nannoconid mudstone with sporadic radiolarians, calpionellids and ostracod fragments. Breccia clasts in the Butkov and Nozdrovice sections.

MF-f: Radiolarian wackestone to packstone with prevailing radiolarians and sporadic sponge spicules, calpionellids and calcareous dinoflagellates. Breccia clasts in the Butkov section.

MF-g: Biodetritic grainstone with crinoid, gastropod, bryozoan, bivalve, algae fragments and foraminifers: *Nautiloculina bronnimanni, Pseudocyclammina lithuus, Acruliammina neocomiana.* Ooids occur sporadically (breccia clasts in the Reváň section Pl. III: Figs. 1-6).

Distribution of the Nozdrovice Breccia Member

The beginning of the Lower Cretaceous sedimentary cycle was affected by a Late Cimmerian bottom denivelization practically in all the sections studied. This influence is traceable in the proximal zones (sections 6, 7) marked by nonsedimentation and erosion. Foot breccias originating along active fault slopes spread laterally through channel fillings (3) and distal fans (1, 2, 4, 5) far into basins. During the latest Tithonian to Early Valanginian, a composite limestone breccia body described as the Nozdrovice Breccia (Borza et

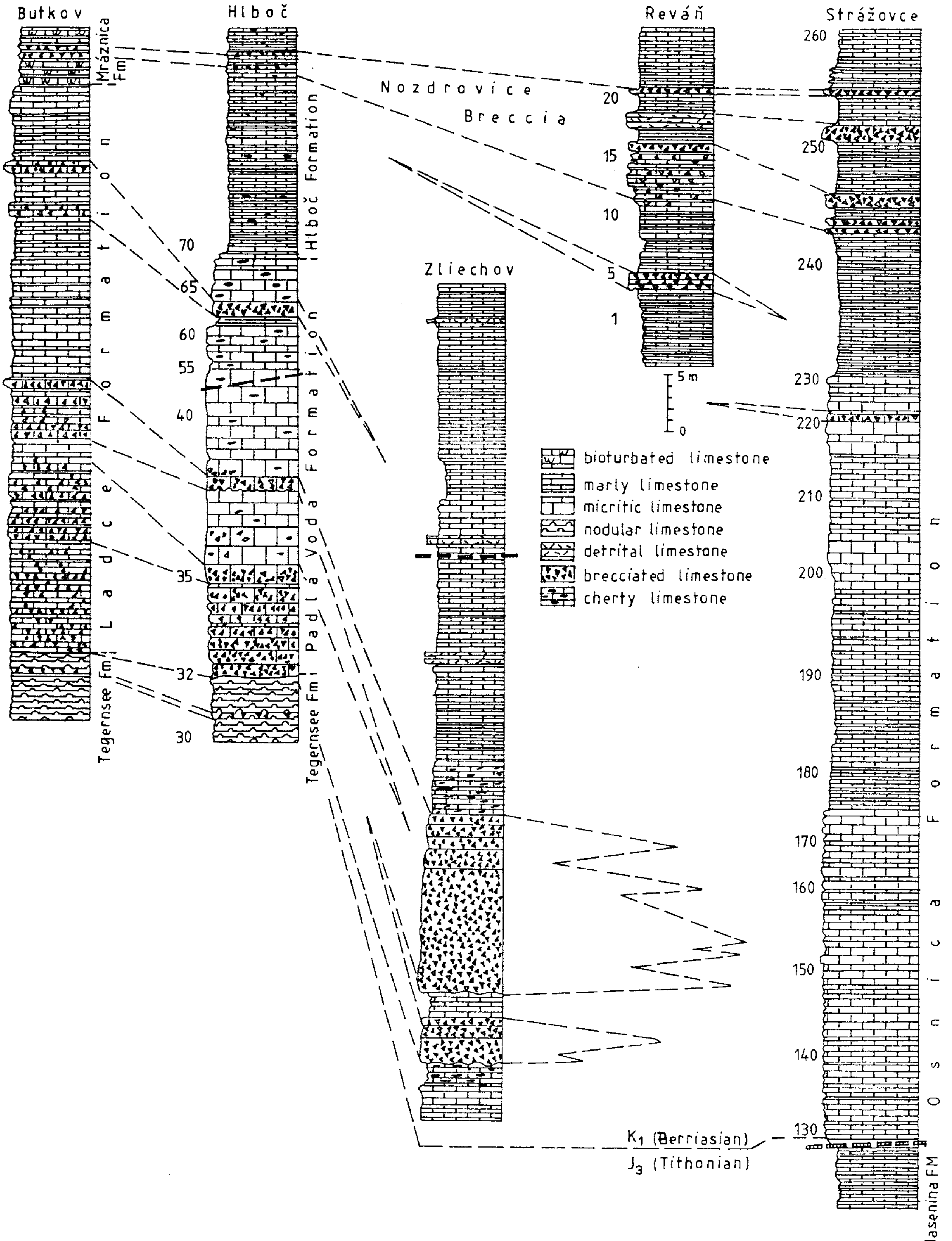


Fig. 3. Litostratigraphical scheme of five Upper Jurassic and Lower Cretaceous sections in the Central Western Carpathians illustrating distribution of breccia horizons. While the brecciated horizons from shallower areas (Butkov, Hlboč sections) contain wide spectrum of limestone clasts (MF-a, -b, -c, -d), the composition of breccia layers in deeper basinal areas is more uniform (MF-b, -c).

al. 1980) with numerous digital apophyses intercalated in the Osnica, Padlá Voda, Ladce and Mráznica Formations (Michalík & Reháková 1994) was formed.

The first carbonate microbreccia layer occurs in the Berriasian Osnica Fm in the **Strážovce** section (1). Biomicrite wackestone (MF-b) clasts (1 to 2 mm in size) were mostly derived from the underlying Jasenina Formation. Breccias to conglomerates with subangular clasts (0.5 to 10 cm) in the lower part of the successive Mráznica Fm come from the Osnica and Jasenina Fms. The clasts consist of crassicolarian, calpionellid and nannoconid wackestones (MF-b, -c, -d).

Six 18-70 cm thick non-graded limestone breccia layers crop out in the middle of nannoconid mudstones of the Mráznica Fm in the **Reváň** (2) section. Four other marly limestone layers (100 to 180 cm thick) contain a lot of dispersed heterogeneous clasts (0.5-15 cm) of crassicollarian and calpionellid wackestone (MF-b, -c). The occurrence of a 12 cm sized subangular clast of biodetrital grainstone (MF-g) is peculiar. Intercalations (50-120 cm) of biodetrital grainstone of turbidite- and grain-flow origin appear in the higher part of sequence. Tiny clasts of MF-c, -d microfacies type occur locally.

Microbreccia packstone intercalation in the **Zrázy** (No. 3) section (Michalík et al. 1993) contains Upper Tithonian micrite clasts (MF-b), clastic quartz grains and echinoderm fragments.

A non-graded brecciated channel filling at the base of the **Zliechov** section (4; Pl. I: Fig. 2) attains 12 m in thickness. Its uppermost layers are distorted by synsedimentary slumping. The limestone clasts (0.2 to 20-60 cm) were derived from Upper Tithonian strata (MF-b; Pl. II: Fig. 2). The matrix consists of biomicrite (MF-c) with microplankton association of the Alpina and Remaniella Subzones. The considerable sedimentary rate (72.7 mm/Ka, equal to five to six time the rate in equivalent sections of neighbourring zones) was caused by accumulation of limestone breccias filling the channel.

Pelagic nannoconid wackestones prevail in the part of sequence belonging to the Elliptica, Simplex and Oblonga Subzones. Several turbidite fine detrital limestone intercalations contain limestone clasts (MF-d) derived from basemental strata. The decreasing sedimentary rate (24.5 mm/Ka) is connected with lower frequency of the clastic components. This rate gradually stabilized (10.8 mm/Ka) with the surrounding sedimentary basins during the Calpionellopsis Zone. Turbidite intercalations (MF-g) amidst pelagic limestones contain limestone clasts (MF-c) coming from the Lower Berriasian Calpionella Zone strata.

A fine brecciated limestone bed (50-60 cm thick) crops out in the Lower Valanginian part of the Mráznica Fm in the **Nozdrovice** (5) section. The clasts attain size of 1 to 5 mm. Nannoconid wackestones (MF-d) and mudstones (MF-e) contain clasts of crassicollarian wackestones (MF-b), calpionellid-globochaete wackestones (MF-c) and nannoconid wackestone (MF-d). Borza in Michalík et al. (1979) noted a striking abundance of limestone clasts belonging to the Elliptica Zone (MF-d). This fact stress the lithological resemblance of the Nozdrovice sequence with the development in the Butkov section.

The breccia layer covering the Tegernsee Formation in the **Hlboč** section (6; Michalík et al. 1990; Michalík & Reháková 1994) consists of Tithonian limestone clasts (10-20 mm; MF-a, -b), which eroded (at least) 12 m of underlying beds. The erosion is also indicated by calculation of the sedimentary rates of the underlying strata: the sediments of the Lower Tithonian Malmica, Borzai and Tithonica Zones attain 450 cm in thickness, which is equivalent to sedimentary rate of 3.5 mm/Ka. Similar rates (3 and 3.7 mm/Ka) are also indicated by the thicknesses of overlying limestones, belonging to Chitinoidella and Praetintinnopsella Zones. If it is assumed that the deposition rate did not substantially change, approximately half of the sedimentary column (2.5 m) would be missing. The breccia character of the Crassicollaria Zone limestones indicates an even higher deposition rate and even larger deficit of the sediment.

Limestone clasts from the base of the massive part of the Padlá Voda Fm (10-30, rarely over 70 mm large) were derived mainly from the Berriasian strata, with smaller share also from underlying Upper Tithonian beds (Crassicollaria, Calpionella Zones; MF-b, -c). The breccias in the Lower Valanginian part of the sequence are exclusively formed by Berriasian limestone clasts. Their origin indicates an erosion of at least 6-9 m of the basemental rock column. Moreover, the calculation of sedimentary rate of the Padlá Voda Fm (7 to 11 mm/Ka) indicates a reduction of its lowermost part, belonging to the Alpina Subzone by erosion of ca. 40-50 % (approximately 4-5 m).

Breccia layers in the higher parts of the Padlá Voda Fm are predominantly formed by limestone clasts of MF-c, -d, indicating erosion of the Berriasian beds (ca. 5-6 m of the rock column). The only intercalation in the lowermost part of the overlying Hlboč Fm also contains clasts derived from the underlying limestone strata (MF-d).

The Ladce Formation in the **Butkov** section (7) starts with a thick sedimentary breccia containing limestone clasts (1 to 40 mm) of Tegernsee and Ladce Fms (Michalík & Reháková 1994). The contours of clasts often merge with the micrite matrix. The composition of breccia beds from the gallery No. 11 (153 m) and No. 12 (170 m) is relatively uniform (MF-c). On the other hand, somewhat younger breccia from the gallery No. 13 (236 m) contains more variegated clasts (MF-b, -c, -d) coming from a deeper eroded source. The breccias from the 13th and 14th level of the Butkov quarry, formed by clasts of MF-a, -b, -d, cover immediately Lower Tithonian nodular limestones, being followed by limestones of the Early Valanginian Calpionellites Zone. If supposed that the breccia was accumulated during the Calpionellopsis oblonga Subzone, its thickness (5-6 m) indicates a sedimentary rate of 9.5 mm/Ka. The lack of Upper Tithonian/Berriasian sediments (Crassicollaria, Calpionella and Calpionellopsis Zones) proves an exposed position of this sedimentary area, which acted as a source of limestone breccias in the adjacent Fatric Basin until the Late Berriasian.

A similar Early Valanginian gap (lack of the Calpionellites Zone) was indicated by Borza (1979) in the marginal Fatric Belá Unit.

Ammonite taxonomy and biostratigraphy

Breccias at the base of the Ladce Formation (13th level of the Butkov quarry) contain undeformed, but reworked remains of cephalopods. This association is dominated by long (Kimmeridgian to Berriasian, resp. Valanginian) ranging ammonites like *Ptychophylloceras ptychoicum* (Quenstedt), *Haploceras* ex gr. *elimatum* (Oppel) and fragments of evolutely coiled Berriasian subgenera of *Berriasella* Uhlig (Pl. IV: Fig. 7) with simple and bifurcated ribs. Upper Tithonian *Durangites* sp. juv. and infrequent fragments of the aptychi *Lamellaptychus beyrichi* (Oppel) occur rarely.

Lower part of the Ladce Formation yielded an ammonite fauna of *Haploceras (N.) salinarium* Uhlig, *Phylloceras (Hy-*

pophylloceras) ex gr. *thetys, Bochianites neocomiensis* D'Orbigny, *Olcostephanus* sp. and aptychus *Lamellaptychus trauthi* Renz & Habicht. The higher part of the sequence contains *Haploceras (N.) grasianum* (D'Orbigny), *Busnardoites campylotoxus* (Uhlig), *Kilianella retrocostata* Sayn, *K. clavicostata* Nikolov, *K.* ex gr. *pexiptycha* (Uhlig) and the aptychi *Lamellaptychus mortilleti* (Pictet & Loriol) (Vašíček & Michalík 1986). The beginning of a continual pelagic sedimentation interrupted by sporadic limestone breccia intercalations is dated by ammonites of the late Early Valanginian Campylotoxus Zone; index ammonites of the older Pertransiens Zone have not been found.

Suborder *Phylloceratina* Arkell 1950
Superfamily *Phyllocerataceae* Zittel 1884
Family *Phylloceratidae* Zittel 1884
Genus *Ptychophylloceras* Spath 1927

Ptychophylloceras ptychoicum (Quenstedt 1849)
Pl. IV: Fig. 6.

1849 *Ammonites ptychoicus;* Quenstedt, p. 219, Pl. 17, Figs. 12 a, b
1976 *Ptychophylloceras ptychoicum* (Quenstedt); Patrulius & Avram, p. 163, Pl. 1, Fig. 8 (cum syn.)

Material: About ten of corroded shell fragments.

Description: Sides of vaulted small involute shells are high, ventral side is rounded, umbilicus narrow, funnel-shaped. Corroded remains of a rosette of short constrictions are visible around umbilicus. They are equivalent to short ventral ribs on the shell perimeter, stressed by shallow constrictions along their posterior sides.

Measurements: The specimen illustrated (BK-13/2) with shell diameter of D = 28.5 mm attains H = 16.0 (0.56), B = 12.9 (0.45).

Distribution: *P. ptychoicum* ranges from Early Tithonian to Valanginian. It spread over the whole Mediterranean including olistolithes of the Tithonian Stramberg Limestone in front of the Outer Carpathian Magura Nappe in Moravia (Vašíček 1983). In the central Western Carpathians in red/olive brown breccia on the base of the Ladce Fm.

Suborder *Ammonitina* Hyatt 1889
Superfamily *Haplocerataceae* Zittel 1884
Family *Haploceratidae* Zittel 1884
Genus *Haploceras* Zittel 1870
Subgenus *Neolissoceras* Spath 1923

Haploceras (Neolissoceras) salinarium Uhlig 1888
Pl. IV: Figs. 1-2.

1888 *Haploceras salinarium* n. sp.; Uhlig, p. 104, Pl. 5, Figs. 1-3
1902 *Haploceras salinarium* Uhl.; Uhlig, p. 28, 65, Pl. 2, Fig. 10
1987 *Haploceras (Neolissoceras) salinarium* Uhlig; Company, p. 99, Pl. 3, Figs. 1-4; Pl. 18, Fig. 3 (cum syn.)

Material: Two molds flattened into a bedding plane. The length of the body chamber attains something between half (ex. BK-13/4) or quarter (BK-13/5) of the last whorl.

Description: Small shells with high less vaulted whorls, relatively narrow umbilicus and distinct keel along the shell perimeter.

Measurements: The larger shell attains diameter (D) 22 mm, the smaller one 21 mm. The latter specimen BK-13/5 with maximum whorl diameter is H = 10.0 (H/D = 0.48) and U = 5.2 (U/D = 0.25). The values measured are influenced by slight lateral deformation.

Distribution: Company (1987) described abundant Early Valanginian (late Pertransiens and Campylotoxum Zones) to earliest Late Valanginian (earliest Verrucosum Zone) occurrences of *H. salinarium* from Spain. He introduced the new Salinarium Zone instead the Campylotoxum Zone. The species is also known from the Austrian Eastern Alps and Roumanian Carpathians. In the central Western Carpathians in the Lower Valanginian part of the Ladce Formation in the Butkov section (Michalík et al. 1994), in Outer Carpathians in the Kopřivnice Lst in Štramberk (Houša & Vašíček 1994) and in several Czech and Polish localities in the Silesian Unit.

Superfamily *Perisphinctaceae* Steinmann 1890
Family *Perisphinctidae* Steinmann 1890
Subfamily *Paraulacosphinctinae* Tavera 1985
Genus *Durangites* Burckhardt 1912

Durangites sp. juv.
Pl. IV: Figs.3-4.

Material: The only fragment of a corroded sculpture mold of a juvenile specimen (BK-13/1).

Description: The width of rounded whorls of evolute shell is slightly larger than their height. The outer flanks are somewhat flattened. The sculpture is mostly formed by simple, slightly proversional, deflected ribs. However, the juvenile section of the preserved quarter of whorl is characterised by thick ventrolateral nodes on each second rib; interribs bear slight nodes. Ventrolateral nodes in the final section are only indicated on several ribs. The ribs are not interrupted: an apparent interruption might be caused by corrosion of the siphonal area. As well as five simple ribs, one inserted rib reaching the umbilical area occurs. Complete shell attains diameter around 17 mm. Although the morphology of the Butkov specimen resembles *Durangites acanthicus* Burckhardt, more precise specification is hampered by its juvenile growth stage and poor preservation.

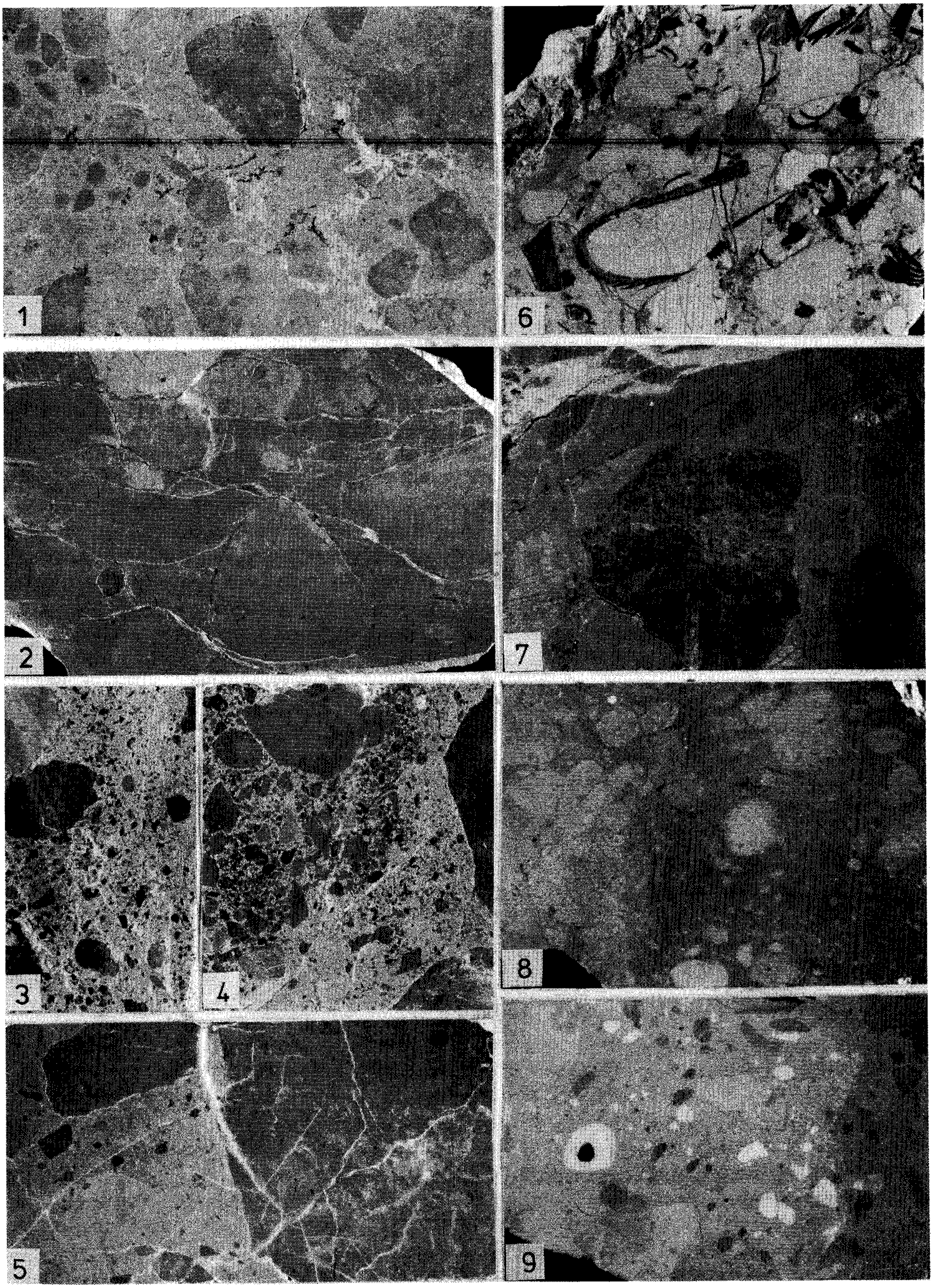
Distribution: According to Tavera (1985), the majority of representatives is typical of the Late Tithonian Durangites Zone. The genus survived into the Early Berriasian. It occurs in basal breccia of the Ladce Formation.

Aptychi

Lamellaptychus trauthi Renz & Habicht 1985
Pl. IV: Fig. 5.

1985 *Lamellaptychus trauthi* new form; Renz & Habicht, p. 399, Pl. 2, Figs. 12, 13

Plate I: Fig. 1. Brecciated limestone bed in the Ladce Formation in the Butkov section - 13th level, magn. 1.7×. **Fig. 2.** Nozdrovice Breccia in the Osnica Formation, Strážovce section, Bed No. 243, magn. 1×. **Fig. 3.** Brecciated bed in the Mráznica Fm in the Reváň section, Bed No. 12, magn. 1.3×. **Fig. 4.** Detto, magn. 1.33×. **Fig. 5.** Brecciated limestone bed in the Osnica Fm in the Zliechov section, Bed No. 9, magn. 1.44×. **Fig. 6.** Brecciated limestone with aptychi fragments, Vigantice, magn. 1.38×. **Fig. 7.** Breciated limestone of the Fasselgraben Fm, Ybbsitz Klippen Belt of the Eastern Alps, Reidl quarry, 1.6×. **Fig. 8.** Detto, Csengőhegy near the Zobák Puszta, magn. 1.1×. **Fig. 9.** Detto, Újbánya Valley, magn. 1.3×.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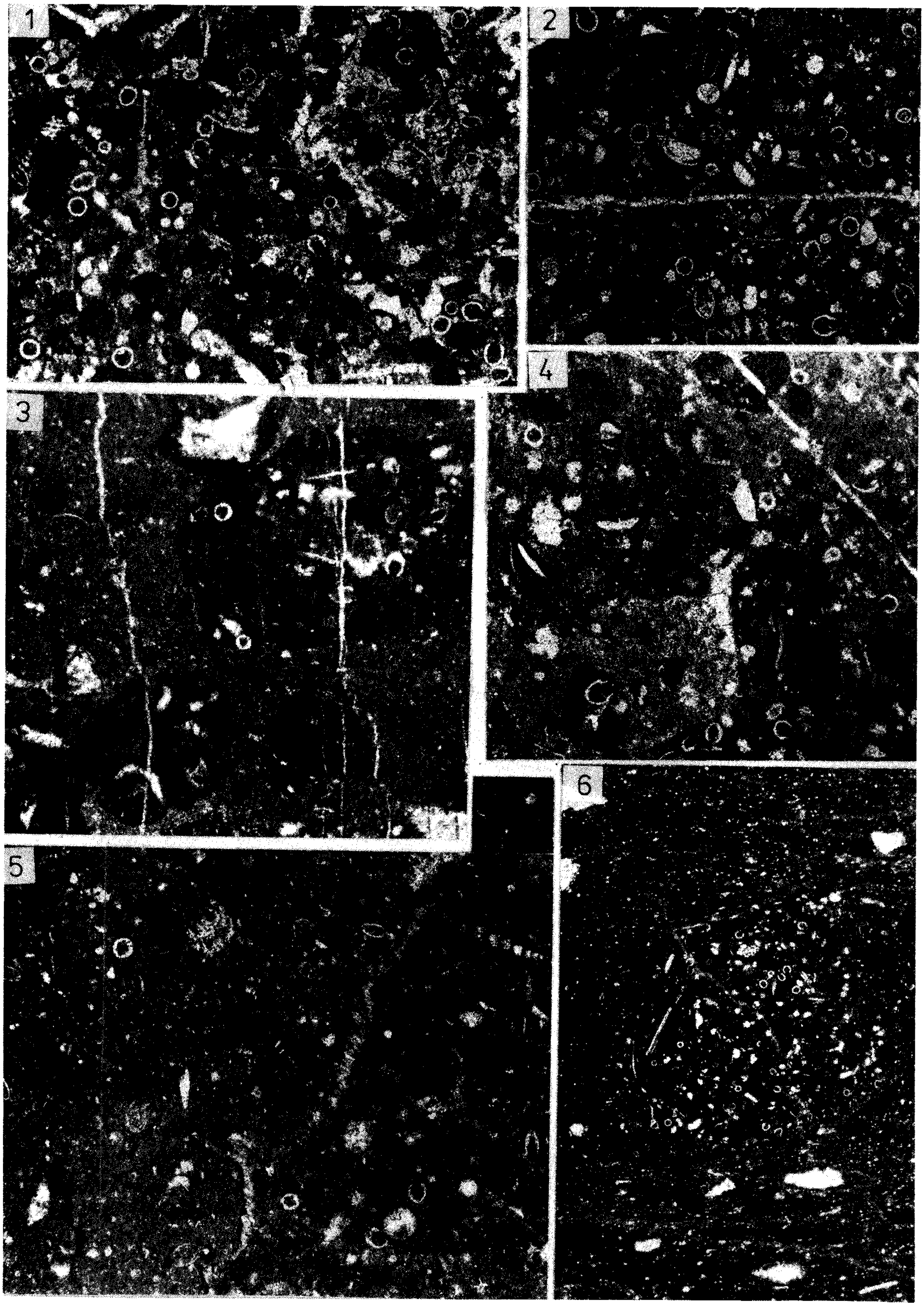
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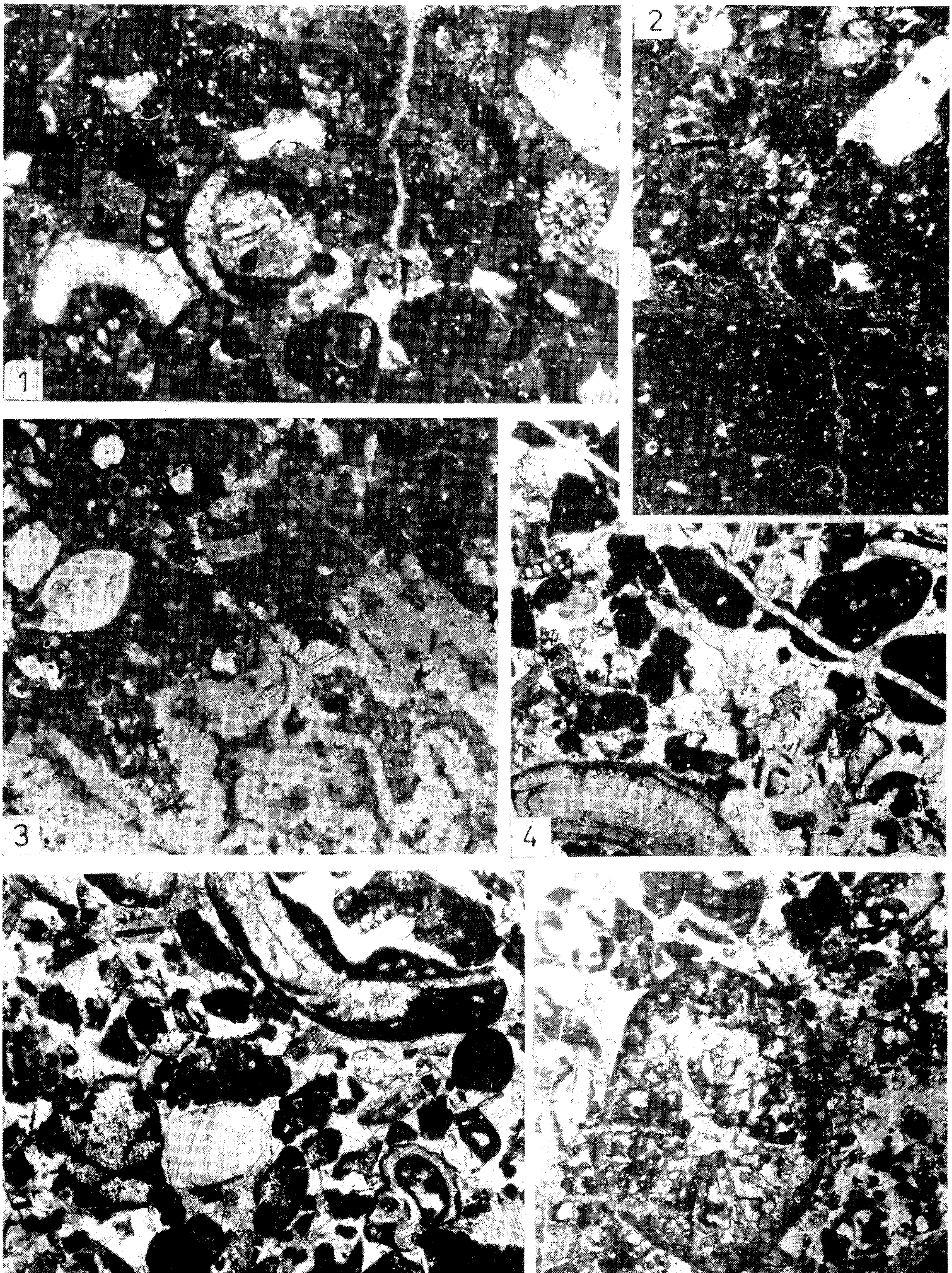
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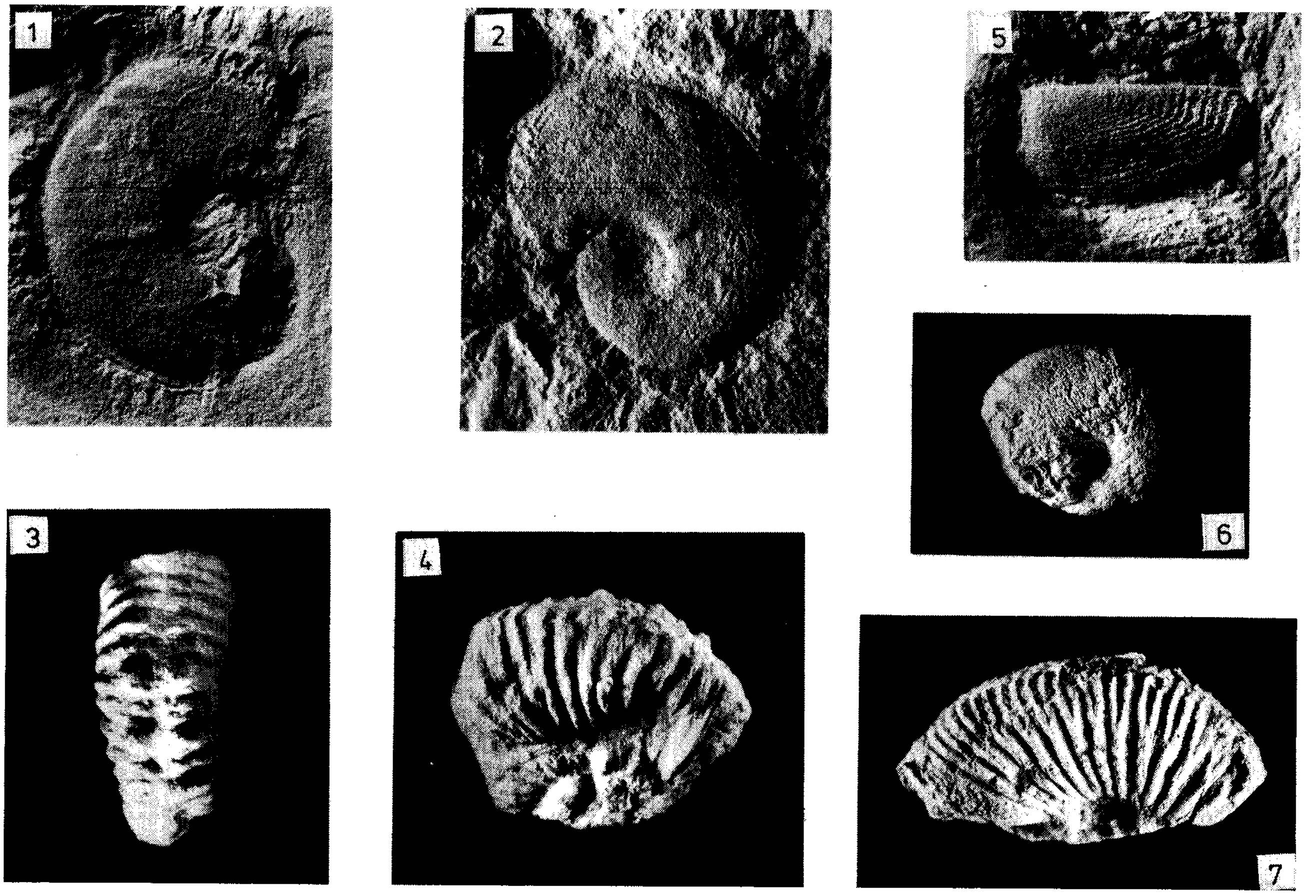

Plate IV: Figs. 1–2. *Haploceras (Neolissoceras) salinarium* (Uhlig), 2×. Spec. BK-13a/4 and BK-13a/5, upper part of Lower Valanginian Ladce Fm, Butkov Quarry, 13th level. **Figs. 3–4.** *Durangites* sp. juv., 3×. Spec. BK-13 br/1. (3-ventral, 4- lateral view). Ladce Fm breccia on Butkov quarry, 13 th level. **Fig. 5.** *Lamellaptychus trauthi* Renz & Habicht, 2×. Spec. BK-13a/8. Upper part of Lower Valanginian Ladce Fm, Butkov Quarry, 13th level. **Fig. 6.** *Ptychophylloceras ptychoicum* (Quenstedt), 1×. Spec. BK-13br/2. Reworked mold of the shell from breccias on 13th level, Butkov Quarry. **Fig. 7.** *Berriasella* sp. indet., 2×. Spec. BK-13br/3. Breccias on 13th level, Butkov Quarry. The specimens were whitened by the ammonium chloride. The shells figured will be deposited in the collection of Slovak National Museum in Bratislava.

Material: One tiny valve (BK-13/8).

Description: 15 mm long valve with very shallow lateral depression. All the ribs in the terminal portion bend at a right angle to the symphysal margin on a relatively wide keel platform. However, just before reaching it, they are arched to the terminal apex.

Distribution: Late Berriasian and Early Valanginian (Switzerland; Renz & Habicht 1985). The only valve found in the Ladce Fm come from its Lower Valanginian part. Incomplete valves also occur in the Lower Valanginian Tlumačov Marls in the Kurovice section.

Discussion

While the Nozdrovice Breccia in the Fatric Zone of the Central Western Carpathians contains exclusively limestone clasts, the compositon of isochronous breccias in the neighbouring areas is more varied.

Pícha & Hanzlíková (1965) described phyllite and gneiss fragments from calpionellid limestone pebbles in the Ždánice Unit. Besides limestone clasts, probably ?Penninic Berriasian limestone breccias known from **Belice** in Považský Inovec Mts. (Fig. 1) contain also fragments of crystalline slates (Plašienka

Plate II: Fig. 1. Microbrecciated limestone of the Osnica Fm. Calpionellids, globochaetes and sponge spicules are enclosed in clasts. Zliechov, 43×. **Fig. 2.** A clast with association of Tithonian microfossils in the Osnica Fm, Zliechov II section, 43×. **Fig. 3.** Brecciated limestone in the Osnica Fm. Matrix with microfossils of the Elliptica Subzone contains clasts of Tithonian and Berriasian calpionellid- as well as biogene limestones. Zliechov -II, 43×. **Fig. 4.** Brecciated limestone bed in the Mráznica Fm. Reváň section, Bed No. 12, 43×. **Fig. 5.** A clast with *Calpionella alpina*, foraminifers and radiolarians in the Mráznica Fm, Calpionellopsis Zone. Reváň section, Bed No. 12a, 43×. **Fig. 6.** A clast with *Calpionella alpina* and sponge spicules in biomicrite matrix with microfossils of the Calpionellopsis Zone in the Mráznica Fm. Reváň section, Bed No. 14, 13.5×.

Plate III: Figs. 1–3. Brecciated limestone bed with rich shallow marine detrite in nannoconid mudstone of the Calpionellopsis oblonga Subzone, Mráznica Fm. Reváň section, Beds Nos. 11, 12, 12 a, magn. 13.5×, Fig. 3: 43×. **Figs. 4–6.** Biodetrite grainstone with *Nautiloculina bronnimanni, Acruliammina neocomiana*, bryozoans, bivalve, gastropod and crinoid fragments. A clast in a breccia bed of the Mráznica Fm. Reváň section, Bed No. 12b, magn. 13.5×.

et al. 1994). Limestone breccias in a small body of Berriasian limestones near **Vigantice** (Reháková et al. 1995) in the Outer Carpathians also contain (besides of lot of aptychi and crinoid fragments) clasts of Tithonian and Berriasian limetones, quartz grains, slate and basic volcanic fragments. Similar brecciated beds are known also from the **Kurovice** section (Vašíček & Reháková 1994) in the Magura Unit.

Berriasian "Aptychenkalk" (Fasselgraben Formation) from **Reidl** quarry in the Ybbsitz Klippen Belt of Eastern Alps contains similar limestone breccia with Tithonian and Berriasian limestone clasts, quartz grains and slate fragments. As well as Upper Jurassic and Berriasian limestone clasts, the brecciated limestones of the Hungarian **Mecsek** Mts. also contain carbonates with Triassic conodonts (S. Kovács, pers. comm.).

The composition of breccia depended on degree of tectonic denivelisation and depth of erosion of the basinal bottom. Therefore, it can be used as a suitable tool for indication of synsedimentary tectonic intensity and for the modelling of Neocimmerian environmental dynamics.

Conclusions

The Upper Jurassic and Lower Cretaceous carbonate basins of the Central Western Carpathians represent a closed depositionary system consisting of three basic groups of lithofacies from carbonate platforms through pelagic ramps with planktogenous carbonate sedimentation to deep basinal sediments deposited under anoxic black shale conditions. At the end of the Tithonian, this system was affected by bottom relief denivelization, local erosion and by the consequent origin of synsedimentary carbonate breccias. Their Late Tithonian to Valanginian age was estimated on the basis of calcareous microplankton occurring in the matrix. On the other hand, this interval is represented by an erosional gap in several sections. As an example, the ammonite fauna from the basal breccias of the Ladce Formation in the Butkov section contains numerous redeposited Tithonian and Berriasian ammonite fragments. The pelagic upper part of the Ladce Formation contains Early Valanginian *Busnardoites campylotoxus* (Uhlig), higher also Late Valanginian indexes *Olcostephanus nicklesi* Wiedmann & Dieni, *Himantoceras trinodosum* Thieuloy, *Criosarasinella furcillata* Thieuloy and *C. heterocostata* (Mandov).

The sedimentary rates of the Berriasian hemipelagic formations (10-12 mm/Ka) depend on the quantity of planktogenous material deposited. Slower sedimentation of Valanginian and Hauterivian formations (to 3 mm/Ka) is connected with decreasing diversity and abundance of microplankton. Eustatic lowering of the sea level caused destruction in the carbonate platform zone as well as transport of material by gravitation mechanisms resulting in calciturbidite layers in the basin. On the other hand, the siliciturbidites could have originated through river transport penetrating from outside the depositional system and carrying terrigenous material from emerged areas. It seems, that the Inner Carpathian zones on the south-eastern margin of the Alpine-Carpathian microcontinent deformed and uplifted by Cimmerian movements were their source area.

Acknowledgements: The paper benefited from critical reading and valuable comments of Prof. M. Mišík and one anonymous reviewer. Authors thank Mrs. C. Michalíková, H. Brodnianska and K. Mezihoráková for photographs, and M. Tinková and E. Kohútová for drawings. The paper contributes to the IGCP Project 362. It was supported by the Grant Agency of the Slovak Academy of Sciences (Grant Project GA 1081).

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