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Sedimentary Records of Early Cretaceous Tectonic Activity in the Alpine-Carpathian Region

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Abstract: Several types of allodapic limestone bodies have been recognized in the topmost Jurassic/Lower Cretaceous pelagic carbonates of the Central Western Carpathians. Limestone breccia layers inserted in monotonous sequences of calpionellid/nannocone biomicrites indicate a distinct relief rejuvenation of the basin bottom by synsedimentary tectonics during this time. These clastics, called Nozdrovice Breccia Beds, are interpreted as talus debris accumulations along active submarine fault slopes.

Key words: sedimentology, paleotectonics, sedimentary breccia, Early Cretaceous, Western Carpathians

1. Introduction

The Berriasian brecciated complex, called "Nozdrovice Breccia Beds," was previously described (BORZA et al., 1980) as an isochronous body produced by a single sea-bottom denivelization event during Late Cimmerian movements.

During sedimentological and microbiostratigraphical study of Upper Jurassic and Lower Cretaceous sequences in the last years, we sampled in detail several tens of Western Carpathian sections. We observed that the brecciated beds built of limestone fragments derived from underlying carbonate formations are a characteristic feature of the majority of Berriasian/Lower Valanginian profiles. Five of the sections (Fig.1) have been selected for closer investigation of the lithological content of these beds, as well as of their time and space relationships.

2. Geodynamic setting

Although the main Neo-Cimmerian collisional zone running meridionally from the Asian Cimmerides terminated in Crimea and Dobrogea, Jurassic east-vergent movement of the "Kreios" and Apulian microcontinents in the Mediterranean also resulted in a collision with the Rhodopean-, Serbian- and Marmarosh microcontinents. The transversal (Teisseyre - Tornquist-, or Pyrenean-) throughs in the cratonic Palaeurope were also re-activated. Traces of Neo-Cimmerian (both tensional and compressional) deformations are recognizable both in the Eastern Alps (TOLLMANN, 1987) and the Western Carpathians (MICHALÍK, 1990).

Oxfordian to Berriasian Ernstbrunn, Štramberk, Vršatec, Raptawicka Turnia and other formations (REHÁKOVÁ,1995) represent products of reef carbonate sedimentation on blocks elevated by tension of the basement (MICHALÍK, 1995). These platforms yielded clasts which supported frequent calciturbidites (Barmstein Limestone) in the slope and basin deposits. On the other hand, some basin infillings (Jasenina Formation of the Fatric Basin) usually do not contain any conspicuous fluxoturbidite intercalations. The wide-spread *Ammonitico Rosso* - type facies was related to hampered or even condensed sedimentation on deeper elevations in pelagic environment. Gradual increase in the sedimentation rate during the latest Jurassic was conditioned by increased carbonate production by benthic (reef building)- as well as by planktonic organisms (by saccocomas, globochaetes, and during the latest Tithonian also by calpionellids).

Neo-Cimmerian deformation of the outer Tethyan shelves changed the eustatic and hydrodynamic regime in the basins (MICHALÍK, 1990). The re-organization of the paleogeographic pattern in wider area of the Mediterranean Tethys, connected with a change of sea current regime, stimulated (brought about) the Berriasian/ Valanginian quantitative "boom" in plankton development. This changes are reflected in the character of the sediments (VAŠÍČEK et al., 1983, 1994, MICHALÍK & VAŠÍČEK, 1989). Isolines of deposition rate of microplanktonic remnants (REHÁKOVÁ & MICHALÍK, 1984) indicate two important revolutions: the first one on passage of the *Crassicollaria*- and *Calpionella* Zones probably resulted from syn-sedimentary tectonic processes, the second one on the *Calpionellopsis*- and *Calpionellites* Zones boundary could have been induced by a change in sea current regime (possible by upwelling).

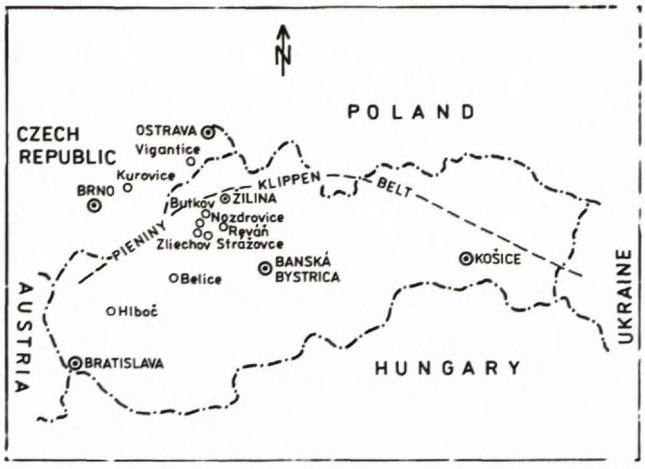

Fig. 1 Localization of the sections and localities mentioned in the text in the frame of Western Carpathians.

Conspicuous Berriasian subsidence supported the facies variability of the sedimentary area (MICHALÍK et al., 1991, SOTÁK, 1989). Reef growth on the margin of Outer Carpathian (Beskydic) carbonate platforms ended, biogene limestones (Olivetská Hora Formation), crinoidal limestones and breccias (Dursztyn Limestone Formation) covered the surface of former elevations. Nannocone biomicrites covered rapidly the area, characterized during Tithonian by pelagic facies. Cherty limestones with marly intercalations were deposited on basin bottoms (Pieniny Limestone Formation). They formed in well-aerated eupelagic environment. Deeper bottom of the Penninic Oceanic Trough, lying below the CCD level, was probably characterized by radiolarite and silicite sedimentation. Basin environments of the Central Carpathians produced biomicrite limestones of "biancone" type (Oberalm-, Padlá Voda- and Osnica Formations, cf. REHÁKOVÁ & MICHALÍK, 1992). They are poor in benthic fossils, rests of nektonic organisms occur rarely, but skeletons of microplanktonic organisms form a substantial part of the sediments. In shallower zones, typical biancone passes into "sublitho-graphic" limestones, as the Butkov section shows (Ladce Formation).

3. Limestone breccia beds in the J/K sequences

3.1. *Butkov section* (Fig.2)

Thick pelagic Kimmeridgian - Barremian limestone sequence belonging to the Central Carpathian Manín Unit was described in detail by BORZA et al. (1987) and by MICHALÍK & VAŠÍČEK (1987).

The oldest breccia beds were identified in the topmost part of the Tithonian red nodular limestones (Tegernsee Formation, parallelized by BORZA & MICHALÍK, 1986, with the Czorsztyn Limestone). The matrix of this breccia consists of brownish marly packstone with abundant *Saccocoma* sp. and *Globochaete alpina* LOMB. and with rare *Crassicollaria intermedia* (DURAND DELGA), *C. parvula* REMANE, and *Calpionella alpina* LORENZ. The clasts (1 to 40 mm in size) were derived from pink grey wackestones containing *Crassicollaria intermedia, C.brevis* REMANE, *C. massutiniana* (COLOM), *Tintinnopsella remanei* BORZA, *T. carpathica* (MURG.& FILIPESCU), *Calpionella alpina*, radiolarians, *Saccocoma* sp., globochaetes, juvenile ammonites, aptychi, crinoid columnalia and fragments of bivalve shells.

Berriasian sequence is strongly reduced by synsedimentary (?) erosion. It is represented by thin (1-5 m) limestone breccia beds capped by thin-bedded pale micritic limestones. The clasts were derived from Upper Tithonian and Lower Berriasian limestones, the matrix is formed of pale wackestone.

The Upper Berriasian - Valanginian Ladce Formation contains a record of the third breccia event. Pale cream to brownish wackestones with marly admixture contain *Calpionella elliptica* CADISH, *Calpionella alpina, Tintinnopsella carpathica, Remaniella cadischiana* (COLOM), *Calpionellopsis simplex* (COLOM), *Calpionellopsis oblonga* (CADISCH), *Cadosina fusca fusca* WANNER, ostracods, radiolarians, crinoids, aptychi, foraminifers and frequent clasts of older (Berriasian) limestones.

The clasts (up to 35 mm large) in the youngest breccia beds were eroded from pale gray biomicrites with clay admixture, pyrite, clastic quartz and glauconite grains, and with abundant nannoconids, infrequent *Calpionella alpina, C. elliptica, Tintinnopsella carpathica, Stomiosphaera echinata* NOWAK, radiolarians and other microorganisms. This association indicates latest Valanginian (or even Early Hauterivian ?) age.

3.2. *Hlboč section* (Fig.2)

This section exposes Callovian – Hauterivian sequence of pelagic limestones belonging to the Vysoká Nappe of Fatric. It was described by BORZA & MICHALÍK (1987, 1988), MICHALÍK et al. (1988, 1990).

Well-bedded reddish nodular limestones (Tegernsee Formation) with an association of Upper Tithonian microfossils (*Crassicollaria intermedia, C. massutiniana, C. brevis, Saccocoma* sp., globochaetes, radiolarians, calcareous dinoflagellates) contain intercalations of brecciated limestones. The

microfossils occurring in their clasts (size of 10–20 mm) indicate Middle- to Late Tithonian age.

The successive Padlá Voda Formation starts with almost massive pale grey limestones (wacke-stones of the *Globochaete (Calpionella* micro-facies) with large cherts. Its base is locally limited by sharp erosive contact followed by thick sedimentary breccia. 10 to 30 (rarely up to 70) mm large limestone clasts came from both Upper Tithonian- and contemporaneous Lower Berriasian strata.

Another breccia bed crops out in the upper (Lower Valanginian) part of the formation. It is com-- posed of grey limestone clasts derived from underlying complexes belonging to the *Calpionella*- (more rarely also to the *Crassicollaria*-) Zones.

3.3. *Nozdrovice section*

Poorly exposed section belonging to frontal nappe slices of the Krížna Nappe in the Strážov Mts (MICHALÍK J. & VAŠÍČEK Z., 1980) exhibits a sole (50 - 60 cm thick) layer of brecciated limestone intercalated in a sequence of Lower Valanginian pale marly limestones. The clasts, attaining the size of several milimeters, contain Berriasian (rarely also Tithonian) microfossil association.

3.4. *Zliechov section (*Fig.2)

The Central Carpathian Zliechov Unit belongs to the Krížna Nappe, which forms several digitations with different facies development (deepening southwards) of their Lower Cretaceous sequences in the Strážov Mts.

A thick (over 100 m) sequence of Berriasian pelagic limestones exposed in the Vápenica digitation by the Rovnianska Valley below the Zliechov village contains huge submarine channel breccia intercalations. They are composed of limestone clasts (0,2–20, more rarely up to 60 cm in size) derived from Upper Tithonian strata characterized by crassi-collarian microfacies. The matrix of the breccias consists of biomicrite with Early Cretaceous microplankton associations of both Alpina and *Remaniella* Subzones. The Upper part of the sequence is built of well-bedded wackestones with occasional submarine slump bodies and with several fine grainstone intercalations of turbiditic origin. The microfauna association indicates appurtenance to the *Elliptica* Subzone.

3.5. *Reváň section* (Fig.2)

The section is located in the area of the Fačkov Pass between the Strážov- and Malá Fatra Mts. A forest road escarpment exposes the Lower Cretaceous sequence of the Zliechov Nappe. Its Berriasian to Valanginian part is built of marly limestones and marlstones with intercalations of limestone breccia. Heterogeneous clasts of wackestones to packstones attain a size of 0,5 to 15 cm. Turbidite- and grain-flow intercalations (50 - 120 cm) of dark grainstones appear in higher part of the sequence.

3.6. *Strážovce section* (Fig.2)

The section exposed by a road escarpment between the villages Zliechov and Čičmany in the central part of the Strážov Mts (BORZA et al., 1980) records well relatively deep pelagic Upper Jurassic and Lower Cretaceous carbonate sedimentation.

The first carbonate breccia beds occur in the Berriasian sequence of thick - bedded calpionellid wackestones (Osnica Formation). They contain 1 to 2 mm large clasts of biomicrite limestones with Crassicollaria derived from the underlying Upper Tithonian Jasenina Formation.

Conspicuous layers of the Nozdrovice Breccia Beds are intercalated in the Lower Valanginian thin-bedded marly wackestones with microfossils of the Calpionellopsis Zone. Their subangular clasts (0,5–10 cm) were derived from both the Berriasian Osnica Limestone- and the Tithonian Jasenina Formations.

Discussion

Nozdrovice Breccia composed of older limestone clasts represents a special type of allodapic deposits occurring in the Tithonian/Valanginian strata. All the breccias mentioned above consist exclusively of limestone clasts. However, Berriasian calpionellid limestone from a unit of probably Penninic origin near Bielice in Považský Inovec Mts contains besides limestone fragments also clasts of crystalline schists.

It is noteworthy that such kinds of breccia occur not only in the Central Western Carpathians, but also in the Outer Carpathian localities. The Berriasian pelagic limestone sequence from Vigan-tice (REHÁKOVÁ et al., 1995) in northern Moravia contains hererogenous breccia intercalations with clasts of Tithonian limestones, dolomites, basic volcanics, crystalline schists, as well as concentrations of crinoidal columnalia and aptychi. Similar breccia beds are known from the Kurovice section located in the Magura Unit.

Berriasian "Aptychenkalk" (Fasselgraben Beds) from Reidl Quarry in the Ybbsitz Klippen Zone of

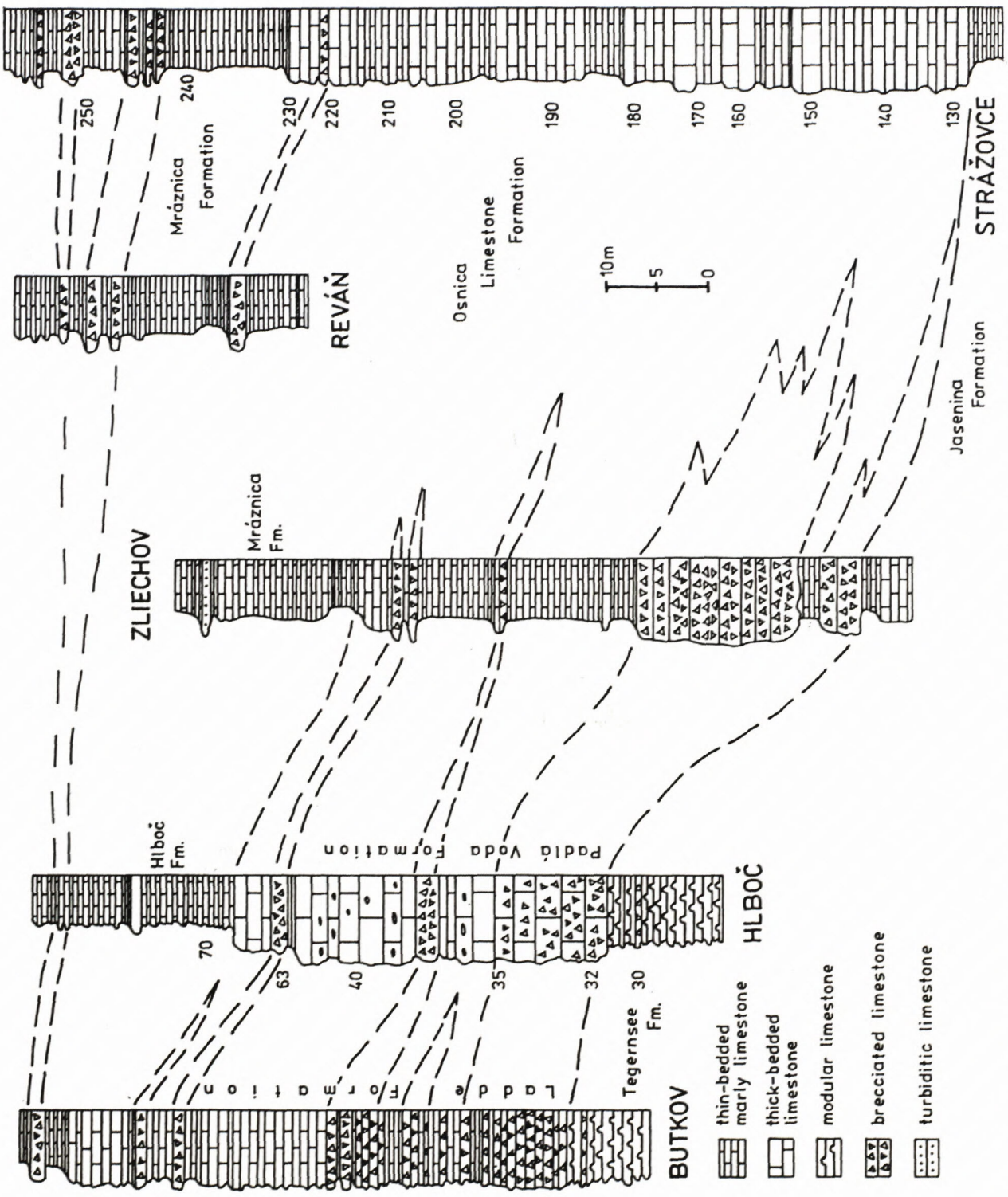

Fig. 2 Lithostratigraphic logs of five sections through topmost Jurassic and Lower Cretaceous deposits from Central Western Carpathians. Correlation of the breccia beds is discussed in the text.

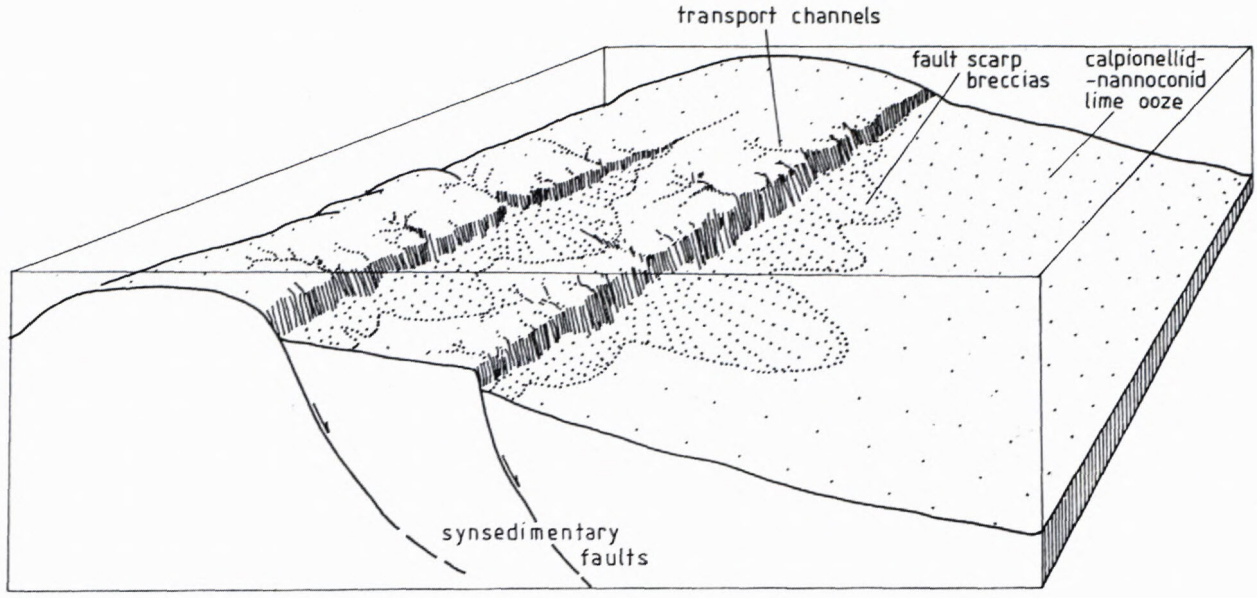

Fig. 3 Genetic model of the Nozdrovice Breccia environment.

Eastern Alps contains similar breccia beds with clasts of Tithonian limestones, vein quartz grains and crystalline pebbles.

Surprisingly, uppermost Jurassic/Lower Cretaceous breccias have been reported also from the Hungarian Mecsek Mts. Moreover, some of these breccias contain not only fragments of Berriasian and Upper Jurassic limestones, but also of Triassic carbonates (dr. S. KOVÁCS, pers. comm.).

Conclusions

A detailed study of Upper Jurassic/Lower Cretaceous carbonate sequences indicates the existence of several types of breccia bodies.

1. Tithonian breccias are usually connected with elevation facies. They occur frequently in slope facies of the "Ammonitico Rosso" nodular limestones. The clasts are derived exclusively from isochronous rocks. It seems that their origin is not closely related to synsedimentary tectonics.

2. Berriasian breccias form huge bodies or intercalations in the Lower part of "Biancone" type limestone complexes. Their material was derived from both underlying Tithonian and isochronous Lower Berriasian pelagic formations.

3. Uppermost Berriasian/Valanginian breccias occur as marked intercalations in marly sequences. They contain clasts of Tithonian- and Berriasian limestones.

The Nozdrovice Breccia indicates distinct relief denivelisation of the basin bottom at the beginning of Early Cretaceous. It was accumulated in talus cones along foot of active submarine fault slopes (Fig. 3).

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