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PRE-FLYSCH OLISTOSTROMES IN CENTRAL WESTERN CARPATHIANS BARREMIAN – APTIAN OF KRÍŽNA NAPPE, SLOVAKIA

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Abstract: The paper presents brief information on olistostrome accumulations (thickness up to 70 *m*) in the Lower Cretaceous of the Krížna Nappe (Fatricum, allochthonous unit) within the Central Western Carpathians in the W and NW of Slovakia. Olistostromes are part of sequence deposited in the Zliechov trough with subcontinental crust type in the Jurassic and Cretaceous. They occupy the position between (above) Lower Cretaceous micritic limestones and (below) Albian - Lower Cenomanian sequences (Poruba Flysch Formation, Jablonský 1988). The main accumulations of olistostromes are farther inside than the main accumulations of the overlying flysch. The origin of the olistostromes is associated with tension tectonics during the remodeling the Zliechov area into a flysch trough before the shift of nappes. It is characteristic of olistostromes that they are poorly sorted, matrix-supported and their material is of intraformational origin. Cleavage of matrix depends upon the clay content. Certain criteria indicate plastic sedimentary deformations, boudinage and textural transition from slides into olistostrome. Olistolites of the 1st and 2th generations (clasts composed of earlier olistostromes) are distinguished.

Key words: sedimentology, olistostrome, sediment gravity flows, Lower Cretaceous stratigraphy, basin analysis and dynamics, pre-flysch stages and paleogeography.

Introduction

Olistostromes are less common in the Cretaceous of the Central Western Carpathians than in the more external units of the Western Carpathians, namely the Klippen Belt (see Marschalko & Samuel 1977; Marschalko 1986) and the Manín unit (Marschalko & Kysela 1980; Michalík & Vašíček 1984). They also show a different character, tectonic position and origin. So far they are only known to occur in the Krížna Nappe. Fig. 1 and Fig. 2 show the position of olistostromes in the bed sequence. They are named the "Vlkolinec Breccia" by Jablonský (1988b). Their main occurrence falls chronologically within the time interval of Late Barremian - Late Aptian (Jablonský 1978, 1984). Lefeld (1974) reported Urgonian bioolistolites attaining the size of 5 - 40 *cm* from uppermost parts of 30 *m* thick position of marlstones of Early Aptian age from the Belianske Tatry Mts. The first occurrences of similar sediments are referred to already from the Lower Valanginian (Nozdrovice Breccia Bed., Borza et al. 1980).

Olistostromes from the Krížna Nappe show neither the character of precursors of compression tectonics nor they are associated with the emplacement of nappes. They record long diachronic synsedimentary sliding and resedimentation on the slope of the Zliechov trough. Therefore the tectonic position of these olistostromes is similar to that described by Naylor (1981) from the Casanova area of the northern Appennines.

Geological setting

The Krížna Nappe represents an allochthonous unit of the Central Western Carpathians (a part of the Fatricum in the sense of Andrusov, Bystrický & Fusán 1973) lying on an (para?) autochthonous unit - the Tatricum. It is covered with the overlying Choč Nappe (Hronicum). The units were thrust over each other by the end of the Middle Cretaceous outwards from internal parts of the geosyncline (to the N). The polyfacies character of the Krížna Nappe (Fatricum) is indicative of a paleogeographically variable sedimentation area. A substantial part of the area was represented by the Zliechov trough during the time of most extensive oceanization of the Western Carpathians in the epoch of the Jurassic and Early Cretaceous (Maheľ 1983). It is filled up with deep-water Jurassic and Lower Cretaceous overlying the shallow-water and lagoonal Triassic. The Middle Cretaceous is represented by a flysch sequence (Poruba Formation). The end of sedimentation after the Cenomanian is associated with the commencing of folding and nappe shift.

The most extensive olistostrome accumulations overlie the Lower Cretaceous sequence, mostly consisting of pelagic limestones and marlstones with subsidiary organodetrital limestones, rare occurrences of the Nozdrovice breccia and volcanoclastics (a detailed stratigraphy of the Lower Cretaceous in the Strážovské vrchy Mts. was elaborated by Borza et al. 1980). According to recent observations the overlying flysch sequence, is thinner, in the area of the main olistostrome accumulations and the flysch has the character of thin-bedded turbidites. Thicker flysch accumulations (with coarser-grained turbidites) appear in more external parts. The character of olistostrome's contact with underlying and overlying sequences whether sharp had not been contact, or a difuse transition precisely known before.

Olistostromes were recorded in a belt attaining to 30 *km* in width, and 150 *km* in length (Fig. 3). The main occurrences are near Homôlka (1) and the villages Zliechov (2), Čičmany (3),

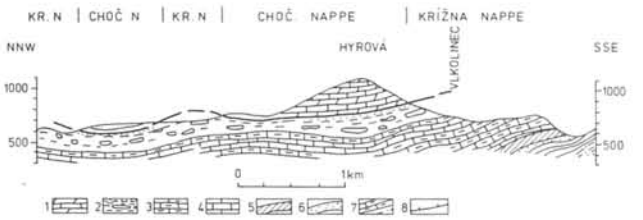

Fig. 1. Simplified geological section through the area of olistostrome occurrences around Vlkolinec-Hrabovo.
Legend: Choč Nappe: 1 - Middle-Upper Triassic dolomites, 2-7 - Krížna Nappe: 2 - olistostromes and flysch (Barremian-Albian); 3 - marlstones and marly limestones (Berriasian-Hauterivian); 4 - aptychi - saccocoma and calpionella limestones (Oxfordian-Tithonian); 5 - Doggerian radiolarites; 6 - spotty marlstones, shales, sandy limestones (Liassic); 7 - limestones, dolomites, variegated shales (Middle and Upper Triassic); 8 - thrust plane of Choč Nappe.

Zbýňov (4) in the Strážovské vrchy Mts., Zázrivá and Medziholie (5) in the Malá Fatra Mts., Vlkolínec and Hrabovo near Ružomberok (6) in the Veľká Fatra Mts., Jasenová (7) in the Chočské vrchy Mts. and in the Belianske Tatry Mts. (8).

Characteristics of olistostromes

We used the term olistostrome to denote sedimentary deposits resulting from the downslope movement of consolidated and unconsolidated (older) stratigraphic successions of the same basin, controlled by gravitation. They consist of the matrix and of chaotically distributed rock blocks representing all sizes. The size of olistostromes reach tens of sqkm and their thickness, hundreds of metres.

All olistostromes studied show the common interformational origin of olistolites (endolistolites), exclusively Early Cretaceous age, nearly synchronous (penecontemporaneous) somewhat

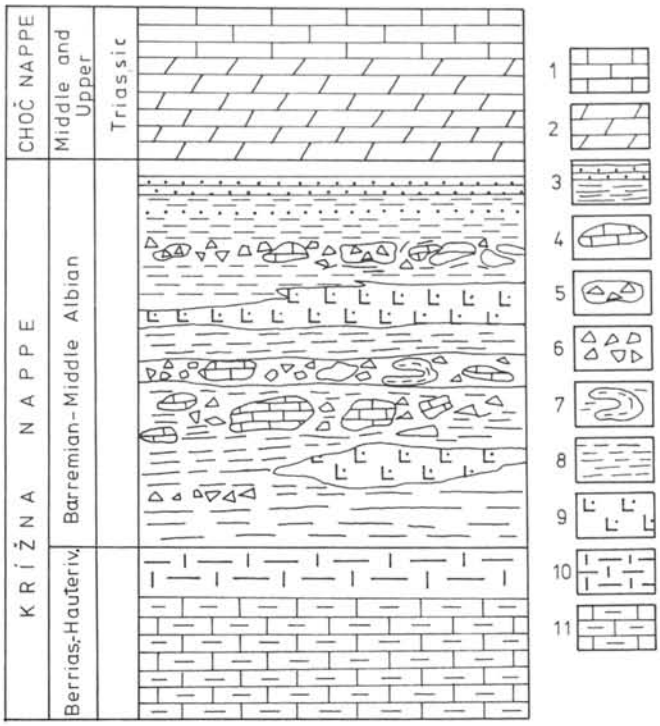

Fig. 2. Lithostratigraphic column showing position of olistostromes and of flysch in Krížna Nappe (Zliechov succession).
Legend: 1 - limestone; 2 - dolomite; 3 - turbidites of lower part of depositional fans (distal flysch); 4 - 1st generation olistolites; 5-2nd generation olistolites; 6 - small intraclasts associated with larger olistolites; 7 - synsedimentary deformations of semiconsolidated marls; 8 - marly shales; 9 - massive biomicrite limestones (with chaotic marlstone intraclasts at base); 10 - marlstones; 11 - marly limestones.

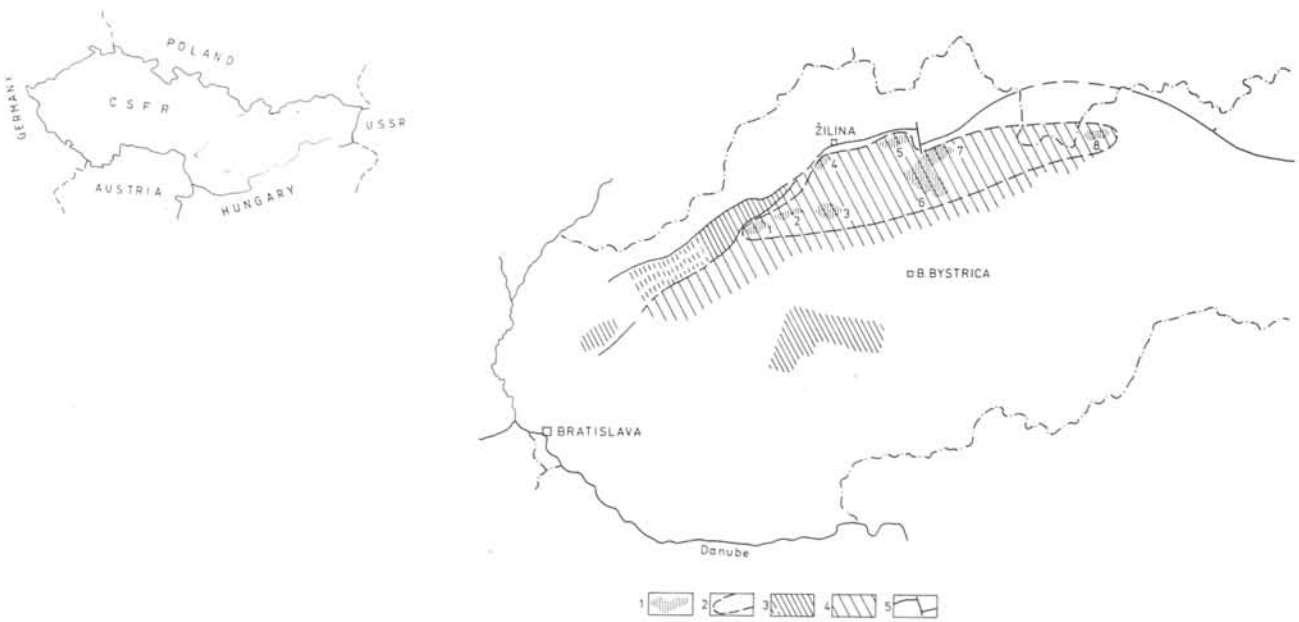

Fig. 3. Scheme of olistostrome distribution in basement of Albian-Cenomanian of Zliechov succession (Krížna Nappe).
Legend: 1 - Barremian-Aptian olistostrome occurrences: numbers denote localities (see text); 2 - presumable area of olistostrome distribution; 3 - area of Albian proximal flysch; 4 - area of Albian distal flysch; 5 - southern border of Klippen Belt (northern border of Central Western Carpathians).

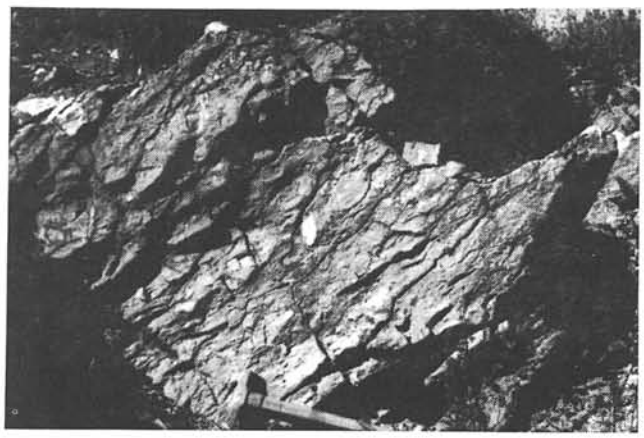

Fig. 4. Calcirudites with biomicrite matrix prevailing over intraclasts of sparite limestones. So both components consists of limestone. Uppermost Aptian of Krížna Nappe, Strážovské vrchy Mts., locality Čičmany, 200*m* east of church. Photo Jablonský.

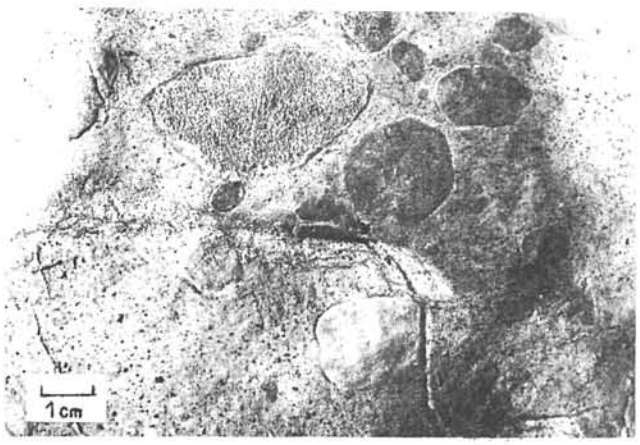

Fig. 5. Calcirudite with biointramicrite matrix. "Variegatedness" of intraclasts shows that slumping mixed clasts originated from different parts of basin. Interesting are rounding of clasts and absence of clayey component in matrix. Rock is part of large (several *m*) block (older olistostrome) embeded in calcareous claystones (matrix) of younger olistostrome. So it is second generation olistolite. Barremian-Aptian of Krížna Nappe of Veľká Fatra Mts., locality Hrabovo in forest road dump, natural size. Photo Jablonský.

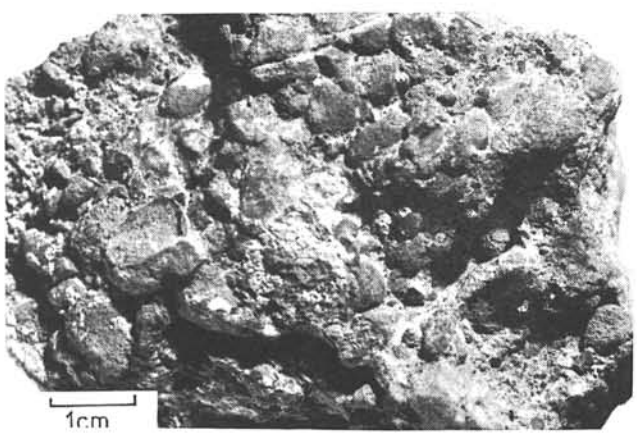

Fig. 6. "Conglomerate" of limestone clasts forming block (second generation olistolite) in Barremian-Aptian resediments (Vlkolinec breccia) of Krížna Nappe. It is evidence of repeated processes of olistostrome forming (downslope sliding), including formerly formed and lithified breccia in slumping. Saddle 1 *km* NW of Vlkolinec. Photo Osvald.

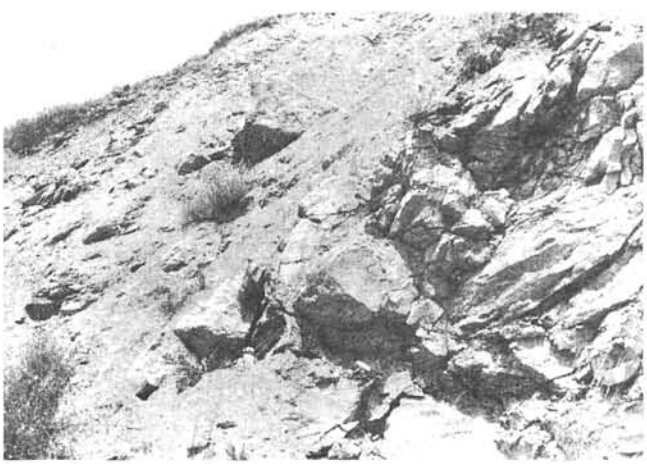

Fig. 7. Dark micrite limestones beds of the upper part of lower Cretaceous deformed into *m* order slump folds (in centre of photograph). Northwestward paleoslope was derived from axis fold orientation and from torn limbs. Locality Jasenová in Chočské vrchy Mts. S of Dolný Kubín. Photo Jablonský.

older than the age of olistostromes, and a chaotic distribution. Composition, shape and size of clasts, as well as the character of the matrix vary from place to place. At some localities belemnite rostra are more frequent.

Olistolites (clasts): They range in size from several millimeters into blocks attaining the maximum size of 40 x 10 *m*. Most frequently they consist of dark (layered) biomicritic limestone (sparse to packed biomicrite and poorly washed biointrasparite) and marly limestones. Clasts only formed by sparitic limestones can be found at the locality Čičmany (Fig. 4) and in the Belianske Tatry Mts. (Lefeld 1974). At other localities clasts (olistolites) are mixed and biomicrites dominate.

The breccia and carbonate analogues of conglomerates with matrix predominant, analogues of coarse-grained sandstones and of massive sandstones (Figs. 5 and 6), found at the localites Hrabovo and Vlkolinec in the form of olistolites are indicative of the repeated olistostrome generating processes. Such blocks of redeposited consolidated breccia are denoted as the second--generation olistolites. Plastic deformations of marlstone blocks and marly limestone beds were recorded at the localities Jasenová (Figs. 7 and 8) and Medziholie (Fig. 10). The shape of olistolites is most variable: from rounded isometric "pebbles" to irregular sharp-edged fragments and plastically deformed and boudenaged layers of (marly) limestones. Armoured blocks of limestones were also found. The shape of clasts reflects the lithification degree during the formation of olistostromes and also the intensity, velocity, form and length of the down-slope sliding. Downslope sliding is also represented by coherent and incoherent slump,

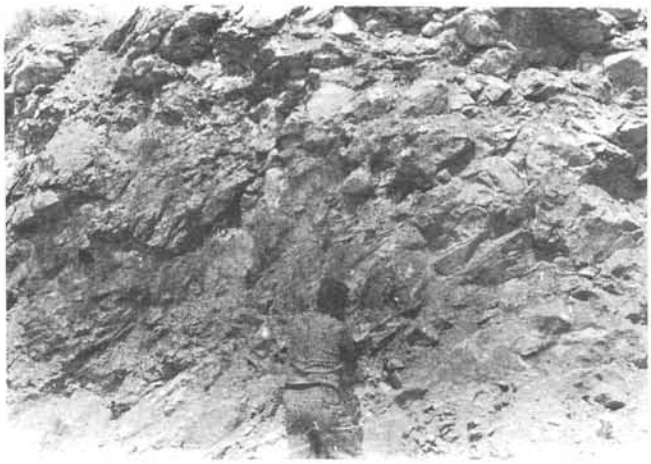

Fig. 8. Besides plastic deformation also braking of banks and their partial mixing with surrounding pelites are destinct. Locality as in preceding photos.

Fig. 9. Mounting current-ripple lamination with primary sedimentary deformation (bending of upper part of cross laminae) downslope indicative of northward dip of paleoslope. Biomicrite calcarenite of Vlkolinec breccia, Upper Aptian (?Lower Albian) of Krížna Nappe of Strážovské vrchy Mts., locality Čičmany, 200 *m* east of church. Photo Osvald.

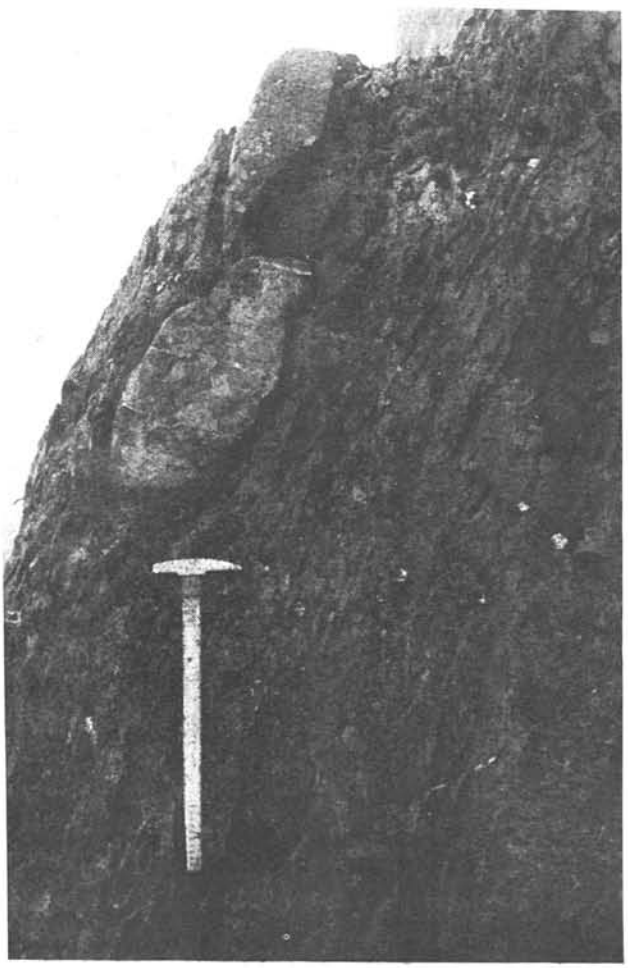

Fig. 10. Block of fragmented limestone bank in resediments of upper part of lower Cretaceous of Krížna Nappe in Malá Fatra Mts. Surrounding matter consists of plastic-deformed shreds of marlstone plates and calcareous-claystone matrix (hammer length is 50 *cm*). Locality Medziholie. Photo Jablonský.

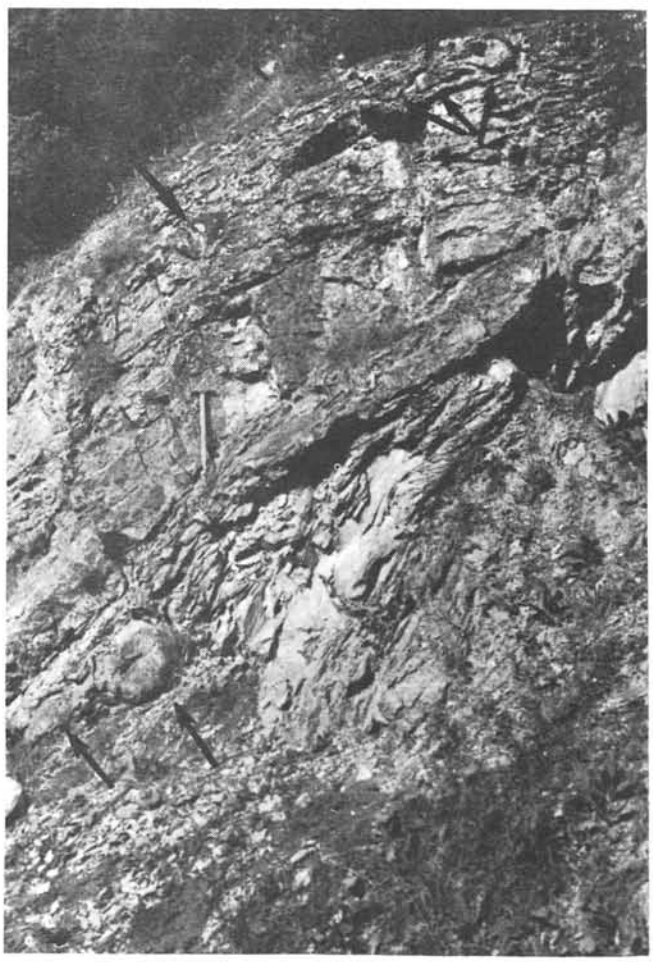

Fig. 11. 1 - 70 *cm* blocks of rounded and angular micrites and biosparites embeded in markedly predominant calcareous-claystone matrix. Middle of exposure is crossed by bank (80 *cm* thick, uneven) of carbonate breccia with higher amount of calcareous component in matrix (like in rest of olistostrome) resulting in its less extensive cleavage (higher competence). Arrows denote blocks of clasts. Krížna Nappe, Aptian of Malá Fatra Mts., locality Zázrivá. Photo Jablonský.

somewhat older lithified dark-grey biomicrite beds and laminated marls with the metre-order folds (Fig. 7).

Matrix: composed of non-lithified clay, marl, lime mud and carbonate sand. The matrix was generated in the process of olistostrome formation. The presence of these components in matrix strongly varies in different places. Biointramicritic matrix is associated with sparitic clasts and indicates a common place of origin prior to redeposition in the same way as the marly matrix supporting marlstones clasts (Fig. 4). When the marl-stone and claystone matrixes mostly contain sparitic limestone clasts (Fig. 11), different places of original deposition should be supposed. Positive correlation between clay content in matrix and cleavage grade is evident. The cleavage follows the surface of clasts or it is sharply interrupted by the clast surface (cf. Abbate et al. 1970, p. 533).

Associated rocks and structures

Olistostrome bodies are accompanied by thicker bodies (up to 40 *m*) of lime claystones and shales as well as gradded parallel and current laminated and massive biolitocalcarenites (Fig. 9). The rocks show close relations to the processes of olistostrome formation.

Discussion and conclusion

The concept of olistostrome origin from gravity flows of high density - debris flows at the foot of slopes of sea basins is today universally accepted. In accordance with this concept, Cretaceous olistostromes of the Krížna Nappe are regarded as accumulations formed at the foot of the Zliechov trough slopes. They are sandwiched between Lower Cretaceous deep sea sediments and Albian - Lower Cenomanian flysch, and contain only marine fauna. Their marine origin is also supported by glauconite dispersed in matrix.

Yet the problem dip of slope on which they had originated, has not been solved so far. On one side, the Zliechov trough formed a more internal zone than the units with well-known Urgonian limestone (the Vysoké Tatry Mts. unit and the Manín unit).

Olistolites of Urgonian limestones are rare. According to one alternative explanation of the source on the external (northwestern) side of the Zliechov trough (Jablonský 1984), the absence of the higher Lower Cretaceous (Hauterivian? - Aptian) in the Tatricum of the Strážovské vrchy Mts. and of the Považský Inovec Mts. is caused by their down-slope slumping into Zliechov area during the formation of the olistostrome. On the other hand, the internal origin and source of olistostromes might be indicated by the following facts: the main accumulations of olistostromes are in the inner parts of the Zliechov area. Sporadic measurements of slump fold axis vergencies (Jasenová, Figs. 7, 8) and ripple cross current lamination (locality Čičmany Fig. 9 sf. Jablonský 1978) are indicative of the paleoslope dipping from the southeast-south to the nortwest-north. Plašienka (1983, p. 226) also considers the alternative.

Different endolistolites of the 1st generation (from shallow-water Urgonian limestones to dark micrites), high content and the character of matrix indicate that the processes of sliding, fragmentation and flow also included partly soft and partly (at different grade) lithified sediments of the shelf and of the slope of the Zliechov trough.

The age range and although limited occurrence of 2nd generation olistolites are indicative of long repeated processes. The accumulation of smaller conglomerate bodies (the Nozdrovice breccia;, Borza et al. 1980; Michalík & Vašíček 1984) proceeded in Earlier Cretaceous stages and is not particularly significant.

The generation of the Barremian - Aptian olistostromes in a delimitated SW-NE extending zone, 30 *km* wide and 150 *km* long, with the tendency of the body volume to increase, is a particular feature of the Zliechov area. Olistolites of local origin were not transported by debris flows known from marginal nappe structures of Manín Zone (Borza et al. 1979; Marschalko & Kysela 1980), and they cannot be associated with that genesis, so the transport from these sources may be ruled out.

The Barremian - Aptian olistostrome facies are associated with the zone which in later Middle Albian time represented the deposition area for the external parts of turbidite fans (Fig. 3). The bathymetric topographic axis with the greatest water depth ran across the zone. This is why extensive change of the paleogeographical infrasctructure is presumed from the Barremian to the Albian when the northwestern margins were uplifted and proximal turbidite rims arose.

The interformational origin of olistostrome material (of Vlkolinec Breccia), its position not immediately below the base of the upper nappe, as well as a long time gap between the origin of the olistostrome and the formation of the nappe structure, suggest that their origin should be connected with other processes than that of nappe shift. We associated them with processes resulting in the formation of a new paleogeographic infrastructure - the flysch trough. The tension character of tectonic activity is indicated also by contemporary occurrences of alkaline basalt hyaloclastites (Hovorka & Sýkora 1979).

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