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Lagoonal-peritidal sequences in the Fatra Formation (Rhaetian): an example from the Veľká Fatra Mountains (Western Carpathians)

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Abstract. Meter-scale lagoonal-peritidal sequences occur in the Fatra Formation (Rhaetian) on the Bystrô locality (Veľká Fatra Mountains, Western Carpathians). The lowermost part of sequences is formed mostly by well-sorted calcarenitic grainstones. The middle part is represented by subtidal facies – fossiliferous marly floatstones, biopelmicritic wackestones or biointramicritic packstones. In the uppermost part intertidal and supratidal dolomitized facies with laminites and fenestral pores are mainly preserved, usually with an unconformity on the upper bedding plane.

Key words: Upper Triassic, Western Carpathians, lagoonal-peritidal sequences, carbonate microfacies

Introduction

The Rhaetian Fatra Formation represents a product of shallow-water carbonate sedimentation in the Fatric Unit, in the Central West Carpathians (Michalík 1973, 1974, 1977). It overlies the Carpathian Keuper Formation of Norian age. On the Triassic/Jurassic boundary, the sedimentary regime has significantly changed and the Fatra Formation was replaced by clastic sediments of the Kopienec Formation. In the Upper Triassic, central Western Carpathians belonged to the NW margin of the North European shelf.

In order to obtain data about facies development of the Fatra Formation several sections in the Veľká Fatra Mountains have been studied. Michalík (1974) described 6 basic facies cycles from biostromatic-lagoonal development of the Turiec facies zone of the Fatra Formation, based on correlation of several lithological sections.

This paper gives short description of sequences from the Bystrô locality near Ružomberok. The sequences were provisionally designated by numbers (they do not correspond to 6 basic cycles of the Fatra Formation). The locality was reported by Stur (1859) for the first time. Michalík (1985) described lithological section from this locality and pointed to characteristic cyclic development with dolomites and fossiliferous marls.

Description of cycles

1. cycle. Underlying bed of the 1. cycle is formed by dolobiomicritic mudstone to wackestone (bed no. 2) with abundant ostracods. Fenestral texture with shrinkage pores is preserved, in upper part passing into irregular sheet cracks. This bed was probably deposited in intertidal to supratidal environment (tidal flats or tidal islands). Uneven upper surface of this bed is overlained by the 1. cycle.

The basal facies is represented by low-energy restricted lagoonal deposits. They are formed by light-grey fine-grained biopelmicritic and biomicritic wackestones with dispersed fragmented and moderately to well-sorted bioclastic debris (0.1 - 2 mm) and with scarce micritic intraclasts (bed no. 3). The main components are represented by recrystallized, commonly micritized and bored bivalve fragments (5 - 30%) and echinoderm ossicles (5 - 7.5%). Locally, involutinid and glomospirellid foraminifers are abundant (5%). Algae (*Acicularia*) and brachiopod valve fragments are less frequent. Oval and circular well-sorted peloids (0.3 - 0.5 mm) are common (10 - 25%). Bioclasts are commonly bioeroded and micritized, locally also impregnated with Mn-Fe oxides.

This facies is horizontally and vertically replaced by relatively well-sorted packstones and partly also by grainstones with micritized, rounded and fragmented bioclasts (echinoderms, gastropods, bivalves) and intraclasts. They were deposited in relatively higher-energy environment.

In the overlie, biopeloomicritic and biointramicritic wackestones occur (bed no.4 in Bystrô 1). They indicate transition again toward relatively more restricted lagoonal environment. Locally textural inversion is observable - redeposited abraded, micritized and bored bioclasts represented by well-sorted crinoid (2.5 - 5%) and bivalve (5%) fragments and small intraclasts and pseudopeloids are present. Autochthonous macrofauna is not frequent - only brachiopod valves and shells with geopetal sparite infillings occur in some places. Algal rests, ophiuroids and sessile and glomospirellid foraminifers are also present. Up-section, the bed no. 5 is represented by dark-grey biomicrites with fine very well-sorted bioclastic debris, locally passing into coquinal biomicrites (floatstones) with micritized and rounded fragments of bivalves and brachiopods. This part of cycle represent a subtidal environment.

Fig. 1. The upper part of the 1. cycle formed by intertidal to supratidal dolomite (bed no. 6) bounded by disconformity. Next 2. cycle start with calcarenitic bed at the base, follows with bioclastic limestone and ends with biooosparitic grainstone in the uppermost part (bed no. 9).

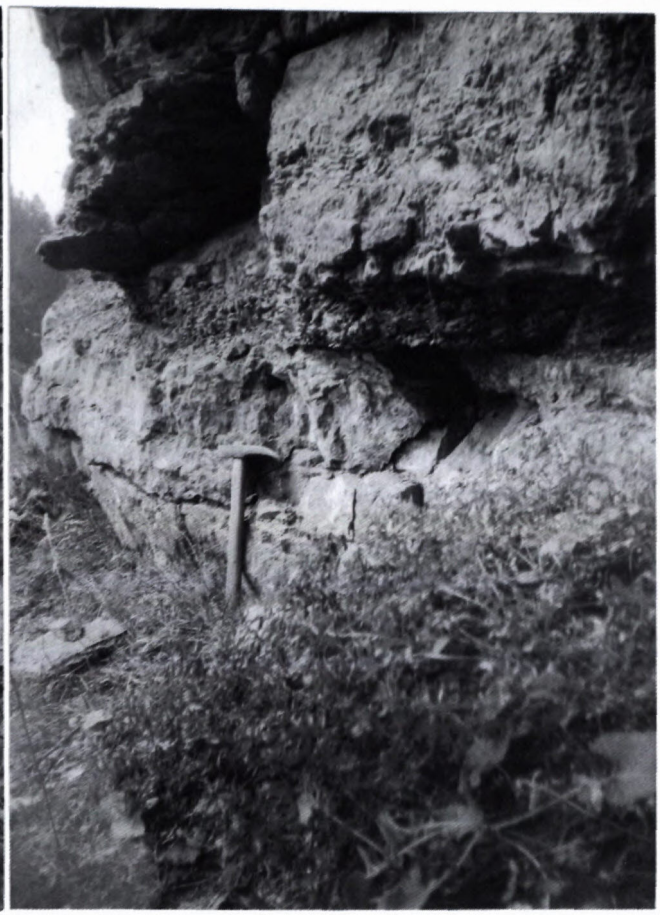

Fig. 2. Coquinal calcareous marls and marlstones with abundant brachiopods and bivalves in the middle part of the 3. cycle.

Locally, thin microlaminated fine-grained limestone, representing probably deposit of intertidal environment, overlies the bed no. 5. Capping facies (Fig. 1) of this cycle is formed by intertidal and supratidal dolomicritic mudstone (bed no. 6), in the basal part with wavy stromatolitic (algal mat) lamination. In the upper part of this bed fenestral loferitic texture is developed with shrinkage pores with partial internal sediment infilling. Local relicts of lamination were observed. Upper boundary of the bed No.6 formed by irregular bedding plane can represents erosive disconformity.

2. cycle. This cycle (Fig. 1) is characterized by sediments deposited in more exposed shallow subtidal environment with more dominant wave and current activity. It begins with 10 cm thick residual calcarenitic bed with clast-supported structure and very well-sorted abraded and encrusted redeposited echinoderm and bivalve fragments and other allochems. Local cross-stratification is observable. Up-section, 150 cm thick complex of well-bedded dark-grey bioclastic limestones (beds no.6.3 to 9) occur, indicating shallowing upward trend in their upper part (from low-energy to high-energy setting). In the eastern part of the section, calciruditic beds consist of poorly sorted bioclasts in different degree of preservation, with abundant fragments of megalodonts, corals, sponges, brachiopods, gastropods, echinoderms and recrystallized bivalves. Bioclasts are commonly micritised, encrusted, bored and abraded and have no preffered orientation. The mud and fine bioclastic debris is mostly winnowed.

In the western part of the section, micritic mud occurs in higher proportions and bioclasts are loosely-packed and relatively better preserved that in eastern part of section. In the basal part (bed no. 6.3) calciruditic coquinal limestone bed is preserved with concentrations of well-sorted fragmented coated bioclasts (mainly bivalves) and winnowed micritic mud. Up-section (beds no. 7-8), biopelintramicrites and biopelmicrites (floatstones, in lower part matrix-supported, in upper part clast-supported) occur, with abundant brachiopod fragments and shells with partial micritic infilling (10-15%), echinoderm ossicles (10-30%), rounded, micritised and encrusted bivalve fragments (10-25%)(with encrusting *Thaumatoporella*), algal remnants (10%), ostracods and foraminifers and well-sorted pseudopeloids and small intraclasts (0.05-0.25 mm). Shallowing upward trend is indicated by upward increasing of significance of clast-supported structure, mud-winnowing, high-energy components and allochem sorting.

The uppermost part of this cycle is represented by biooointrasparitic grainstones and rudstones (Fig. 1) withrelatively well-sorted (1 - 5 mm) packed washover bio-

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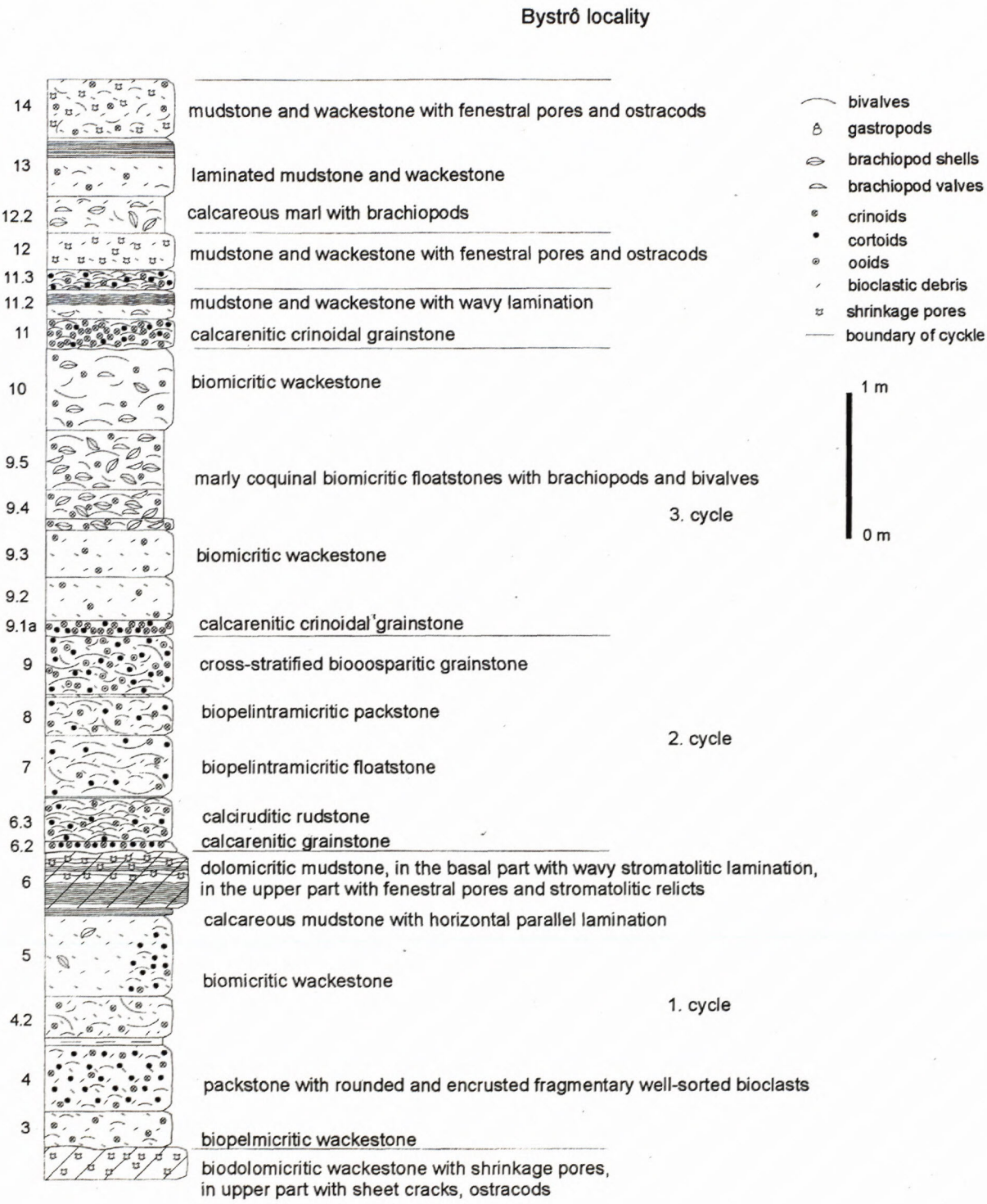

Fig. 3. Lagoonal-peritidal sequences in the Fatra Formation – Bystrô locality near Ružomberok (part of lithological section).

clastic debris (bivalves, crinoids), locally with cross-stratification. They were deposited on calcareous sand bars.

3. cycle. This cycle starts with crinoidal well-sorted calcarenitic crinoidal limestone at the base. In the overlie, this bed passes into the fine-grained muddy limestone beds with dispersed crinoid and bivalve fragments. About 120 cm thick complex consisting of bioclastic and coquinal marly limestones and marls overlies these beds and represents shallow subtidal low-energy environment with normal marine salinity and good oxygenation. In the lower part, benthic assemblage is relatively more diversified and consists mainly of brachiopods (*Rhaetina gregaria, Rh. pyriformis, Zugmayerella uncinata, Discinisca suessi, Austrirhynchia cornigera*), bivalves (*Atreta intusstriata, Lopha haidingeriana, Modiolus sp.)* and crinoids (Fig. 2).

The diversity decreases and *Rhaetina gregaria* is dominant in the higher part, corresponding probably to a start of the shallowing upward trend. In the uppermost part, biomicritic wackestones occur (bed no. 10) with up-

per uneven bedding plane. Preservation and abundance of bioclasts significantly decreases. This complex is sharply overlained by basal grainstone of the next cycle.

Higher cycles

Up-section, the complex consisting predominantly of intertidal to supratidal capping deposits is preserved. They represent probably several stacked cycles. Cycles normally begin with well-sorted calcarenitic or calciruditic coquinal limestone bed with redeposited crinoid and bivalve fragments, with winnowed mud and clast-supported biofabric. Locally, dark-grey and light-brown calcareous claystones underlie intertidal laminated facies. They were deposited in low-energy shallow subtidal lagoonal environment with normal salinity. *Rhaetina gregaria* is dominant in the benthic assemblage. Faunal association with brachiopods and echinoderms then pass upward into more restricted ostracod associations.

The overlie is formed by intertidal dolomitized bioturbated biomicritic mudstones and wackestones with fine dispersed bioclastic debris, in the upper part with horizontal wavy lamination. Upwards, they pass into supratidal dolomitized biopelmicritic mudstones and wackestones with strongly bioturbated and pelletized matrix, with local lamination relicts. Fenestral texture with shrinkage pores is typical. Ostracods are dominant in very restricted fossil assemblage. The complex of well-bedded oolitic limestones is in the overlie, with poor cyclicity indications.

From microfacies analysis and sedimentologic and paleoecologic knowledges, it is possible to infer that sequences on the Bystrô locality belong to lagoonal-peritidal cycles.

Comparison

Meter-scale lagoonal-peritidal sequences are well-known from the Upper Triassic carbonatic sediments of Northern Calcareous Alps, Southern Alps or Transdanubian Central Range. Lofer cycles forming extremely thick complexes were deposited on wide carbonate platforms, where carbonate accumulation was able to keep pace with intensive subsidence (Haas 1991). In the Western Carpathians, Lofer cycles were described from the Dachstein Formation in the Silicic Unit (Borza 1977).

An idealized symmetrical sequence bounded by disconformities consists of reworked paleosol (member A), transgressive tidal-flat laminite (B), subtidal carbonate (C), regressive tidal flat dolomite (B´) and in situ paleosol (A´). The architecture of sequences is commonly assymmetric becauses lack of several members. Balog et al. (1997) concluded that these sequences were formed as a response to precessional sea-level fluctuations of roughly 20 k..y. duration. Howewer, there exist also different interpretations of these cycles (tectonic cycles, autocycles, cf. Goldhammer et al. 1990, Strasser 1991, Satterley 1995).

The Fatra Formation sequences from the Bystrô locality differ from a typical Lofer cycle. The thickness of this formation is relatively small in comparison with formations with Lofer cycles, attaining only about 20 to 50 m. From the point of view of facies composition (Fig. 3), the basal facies of sequences on the Bystrô locality is usually formed by residual calcarenitic bed. Paleosol horizons were not observed on this locality. The middle part of sequences is represented by biopelmicritic and biomicritic wackestones with restricted fossil assemblages, biopelintramicritic packstones and floatstones with partially redeposited bioclasts or biomicritic coquinal floatstones with abundant brachiopods, bivalves and crinoids. They correspond to subtidal facies formed in an environment with changeable influence of open sea (fluctuations in salinity, water-energy, rate of sedimentation etc.). The capping facies of sequences is mainly formed by intertidal and supratidal facies with lamination and fenestral pores, usually with an unconformity on the upper bedding plane. In some cases this facies type does not occur and the uppermost part of cycle is formed by subtidal facies.

The cycles always end with shallowing upward trend on the Bystrô locality.

Lagoonal-peritidal sequences in the Fatra Formation were deposited in different sedimentary and geotectonic regime than sequences belonging to Lofer cycles. The sedimentation took place in an intraplatform shallow basin with restricted connection to open sea.

In order to recognize controls and causes of cyclicity in the Fatra Formation, lateral cycle continuity have to be studied and detail comparison and correlation of lithologic section have to be done.

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