Dominant autogenic control on the formation of peritidal cycles in the Olenekian carbonate succession of NW Bulgaria

Доминиращ автогенен контрол върху образуването на перитайдълни цикли в Оленекската карбонатна последователност от СЗ България

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The formation of small-scale shallowing-upward sequences in carbonate peritidal settings can result from allocyclic (allogenic) and/or autocyclic (autogenic) processes (Strasser, 1991). Allocyclic controls are independent from the depositional environment and include orbitally-driven eustatic sea-level fluctuations, or repeated synsedimentary fault movements, that generate changes in the accommodation space. Autocyclic processes operating within the sedimentary basin involve progradation and aggradation of sedimentary bodies (tidal flats, shoals, delta lobes), or lateral migration of tidal channels, without being related to extrinsic factors such as tectonics and eustatic sea-level changes. The relative influence of allocyclic and autocyclic processes is difficult to estimate as they commonly interact (Burgess, 2006).

Meter-scale asymmetric cycles in the Olenekian part of the carbonate ramp succession (Opletnya Mb of Mogilata Fm) exposed in the Western Balkanides show shallowing-upward trend, i.e. transition from subtidal to intertidal and locally supratidal facies (Chatalov, 2000). The subtidal facies include dm-thick, commonly cross-bedded basal lags of intraclastic, ooidal or bioclastic grainstones, packstones or rudstones, and overlying dm- to m-thick bedsets of calcimudstones and bioclastic wackestones. The intertidal/supratidal facies is represented by massive or laminated dolomudstones and microbial dolobindstones with desiccation cracks, tepee structures, and bird's-eye fenestrae. Dolomitic flat-pebble conglomerates (dolorudstones) occur in the topmost part of only few cycles and probably indicate formation in supratidal setting. The transgressive basal lags have erosional lower bed surfaces and locally contain intraclasts derived from penecontemporaneously dolomitized intertidal/supratidal facies of the underlying cycle. The cycle boundaries correspond to subplanar discontinuity surfaces produced by erosion related to marine flooding.

The origin of the meter-scale cyclicity can be best studied in the southern part of the Western Balkanides where the well-exposed Olenekian–Anisian peritidal succession shows maximum and persistent thickness. New field data collected from eight sections of the Opletnya Mb allow tracing the cycle numbers, boundaries, thicknesses and stacking patterns, plus the intracycle facies distributions and lateral facies heterogeneity. Tectonic origin of the peritidal cycles should be considered unlikely taking into account the regional setting of passive continental margin, the lacking evidence for repeated fault movements, the relatively large area with cyclic peritidal sedimentation, and the absence of cycle type variability and great thickness variations of the sections. Although the influence of low-amplitude, high-frequency eustatic oscillations during the Olenekian cannot be ruled out, there are clear implications for dominant autocyclic control on the formation of the peritidal cycles. Most important is the lack of evidence for subaerial exposure, erosion, or vadose diagenesis in the subtidal facies (i.e., reflecting sea level fall), which suggests that eustatic sea-level fluctuations played minor role in the development of peritidal cyclicity. In contrast, short-lived subaerial exposure is indicated only by the intertidal and supratidal facies forming the cycle tops which are bounded by the flooding surface of the next cycle. Moreover, the lack of supratidal facies directly superimposed on subtidal facies (indicative of abrupt shallowing), or muddy lagoonal deposits directly overlying intertidal/supratidal facies (indicative of abrupt deepening), is not consistent with the assumption of overriding eustatic control. Other features of the studied sections that likewise imply dominant autocyclic mechanism include the different numbers of cycles and great variability in the cycle thicknesses. Also, common lateral facies heterogeneity is revealed by the highly variable thickness ratio between the subtidal and intertidal/supratidal facies, as well as between the transgressive basal lags and lagoonal mudstones/wackestones. Taken together, these characteristics result in very poor correlation of the peritidal cycles even over short distances of several kilometers. Other reliable evidence against a prevailing eustatic control is the absence of ordered hierarchical organization of the cycles, such as distinctive upward trends of decreasing or increasing cycle thicknesses, and thinning or thickening intracycle bed thicknesses. During greenhouse times such as the Triassic period autocyclic processes would be expected to override the reduced forcing potential of high-frequency low-amplitude eustasy resulting in relatively high levels of randomness in the facies occurrence and in the cycle stacking patterns. However, the simple operation of autocyclic processes (i.e., shoreline progradation) to produce disordered stacking pattern was challenged by Burgess (2006), who demonstrated by forward modelling that changes in stochastic processes such as carbonate production rate and sediment transport direction are necessary to generate random stratal patterns. Therefore, other factors inherent to the depositional system (e.g., carbonate productivity, accumulation rate, depositional topography, or hydrodynamic conditions) may have also contributed to the variable cycle thicknesses, lateral facies heterogeneity, and disordered stacking pattern in the peritidal succession.

The assumed dominant autocyclic mechanism was effective on a local scale because the occurrence of peritidal cyclicity is not known from Olenekian shallow marine carbonate successions outcropping in other regions of the country (e.g., exposures and boreholes from the adjacent Moesian Platform, Fore-Balkan, Central Balkanides, Western Srednogorie Zone and Kraishte Zone) even within strata of the same lithostratigraphic unit (Opletnya Mb of Mogilata Fm). Also, the absence of such documented cyclicity on a broader regional scale (i.e., in platform carbonates deposited around the Olenekian–Anisian boundary across the NW Tethys shelf area) further supports the hypothesis for dominant autogenic control on the formation of peritidal cycles in the carbonate depositional system during the early stage of ramp retrogradation.

The influence of relative sea level changes on the formation of third-order depositional cycles in the ramp succession is another debatable issue. For example, five mesocycles of "allogenic origin", corresponding to third-order cycles (0.5–3 Ma), were distinguished in the Olenekian–Anisian peritidal succession by Ajdanlijski et al. (2004). Each mesocycle consists of four submesocycles which in turn include four to five elementary cycles. According to Ajdanlijski et al. (2004), the elementary cycles have different thicknesses and are dominated by different lithofacies (allochemic limestones, micritic limestones and dolostones) in the lower, middle and upper part of each mesocycle, respectively. In general, third-order sequences are depositional cycles bounded by exposure surfaces and consist of lowstand, transgressive and highstand system tracts. While their origin has been related to both climatic and tectonic influences, orbitally forced climate changes have been recently demonstrated to be the main control via glacioeustasy, thermoeustasy and/or other processes (Boulila et al., 2011). New field observations in the study area show that the individual thicknesses, intracycle lithofacies distribution and stacking patterns of the elementary cycles (sensu Ajdanlijski et al., 2004) do not outline any particular trend upsection, and hence, these cycles cannot be grouped into third-order depositional sequences. Furthermore, boundary surfaces indicated by long-term subaerial exposure (i.e., karstification, pedogenesis, brecciation, black pebbles) are not recognized as separating the presumed mesocycles. Therefore, eustatically-controlled third-order depositional sequences, such as those known from other Western Tethys and Peri-Tethys basins (e.g., Götz, Török, 2008), cannot be convincingly detected in the Triassic carbonate ramp succession of the Western Balkanides.

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