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RHYTHMICITY OF LATE CRETACEOUS CARBONATE SEDIMENTATION IN THE BLACK SEA NORTHWESTERN SHELF

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РИТМІЧНІСТЬ КАРБОНАТНОГО ОСАДКОНАКОПИЧЕННЯ В ПІЗНЬОКРЕЙДОВУ ЕПОХУ НА ПІВНІЧНО-ЗАХІДНОМУ ШЕЛЬФІ ЧОРНОГО МОРЯ

Integrated detail study we conducted for the Upper Cretaceous section of the deep wells drilled within the northwestern shelf of the Black Sea gave us a possibility to recognize a distinct and well traceable rhythmicity of sedimentation in the Late Cretaceous sequence deposited there. In the case of continuous rhythm the section demonstrate full paragenetic set of sequentially changed rocks: biogenic-detrital limestone (biogenic marl) – micritic limestone – chalk – micritic limestone – biogenic-detrital limestone (biogenic marl).
Keywords: sedimentary rhythmicity, Upper Cretaceous, Black Sea northwestern shelf.

Проведені детальні комплексні дослідження верхньокрейдових розрізів глибоких свердловин на північно-західному шельфі Чорного моря дозволили виявити та прослідкувати чітку, добре помітну ритмічність осадконакопичення в накопичених товщах верхньої крейди. У випадку безперервного ритму в розрізі спостерігається повний парагенетичний набір послідовно змінюючихся порід: вапняк органогенно-детритовий (мергель органогенний) – вапняк мікритовий – писальна крейда – вапняк мікритовий – вапняк органогенно-детритовий (мергель органогенний).
Ключові слова: ритмічність осадконакопичення, верхня крейда, північно-західний шельф Чорного моря.

INTRODUCTION

Marine sediments that formed mainly in neritic and partially littoral settings are often characterized by cyclic variability of their depositional features. The most common types of such variability are the rhythms composed by lithologically different limestones and marls. The majority of such rhythms according to modern knowledge are the results of bathymetric setting variations related to movements of the lithosphere or eustatic changes of sea level (Gabdullin, 2002; Naidin, 2004; Naidin, 2005; Einzele, 1985; Arthur et al., 1984; Arthur et al., 1986; Bradley, 1929; Gilbert, 1895; Eicher and Diner, 1989; Paul, 1992; Paul et al., 1994; Schneider, 1964).

Previous studies have shown that, first of all the rhythmicity is developed under influence of uniform astronomical rhythmicity and, secondly, each limestone-marl pair is formed during one precession rhythm (Naidin, 2005; Gilbert, 1895). Precession predetermines the impact of two factors: insolation – the amount and latitudinal distribution of solar radiation over the Earth's surface and geo-eustatic oscillation of the World Ocean caused by nutation of the Earth's rotation axis (Naidin, 2005).

The data on composition of the marl-limestone pair are plentiful and well known by lithological, chemical, paleontological and mineralogical studies. The most important observation says that constituents of a sedimentation pair of marl and limestone differs each form other by form, composition, and $CaCO_3$ content (Naidin, 2005).

Many publications are devoted to formation of the marl-limestone elementary rhythmicity unit based on voluminous data sets (Bradley, 1929; Gilbert, 1895; Schneider, 1964). Rhythmic sequences of the Cenomanian-Turonian sections in North America have obtained particular explanation of a marl-limestone pair nature (Arthur, 1984; Arthur M.A. et al., 1986; Eicher and Diner, 1989). From originally recognized by G. Einzele three cycles – production, dilution and dissolution (Einzele, 1985) only two first ones are supported by modern studies.

According to D. Eicher and R. Diner (Eicher and Diner, 1989) the formation of a limestone-marl sedimentation pair in the Western Interior basin can be explained by two models. First one (dilution cycles) prescribes that marls were deposited in the result of intensive clastic influx during humidic epochs while limestones were formed during epochs of aridization when the transport of clastic material was insignificant. The second model (productivity cycles) assumes that limestones were formed during higher production of carbonate plankton contrary to marls related lower one.

Productivity cycle registered by a marl-chalk (limestone) pair is stipulated by changes of conditions of a «marl sea» by ones typical for a «chalk sea». «Chalk sea» was warmer (by 2°C in average upon isotopic data) that is why its original production of coccolithophores was higher than for «marl sea». Chalk rocks (limestone) were formed faster than marls (Naidin, 2005).

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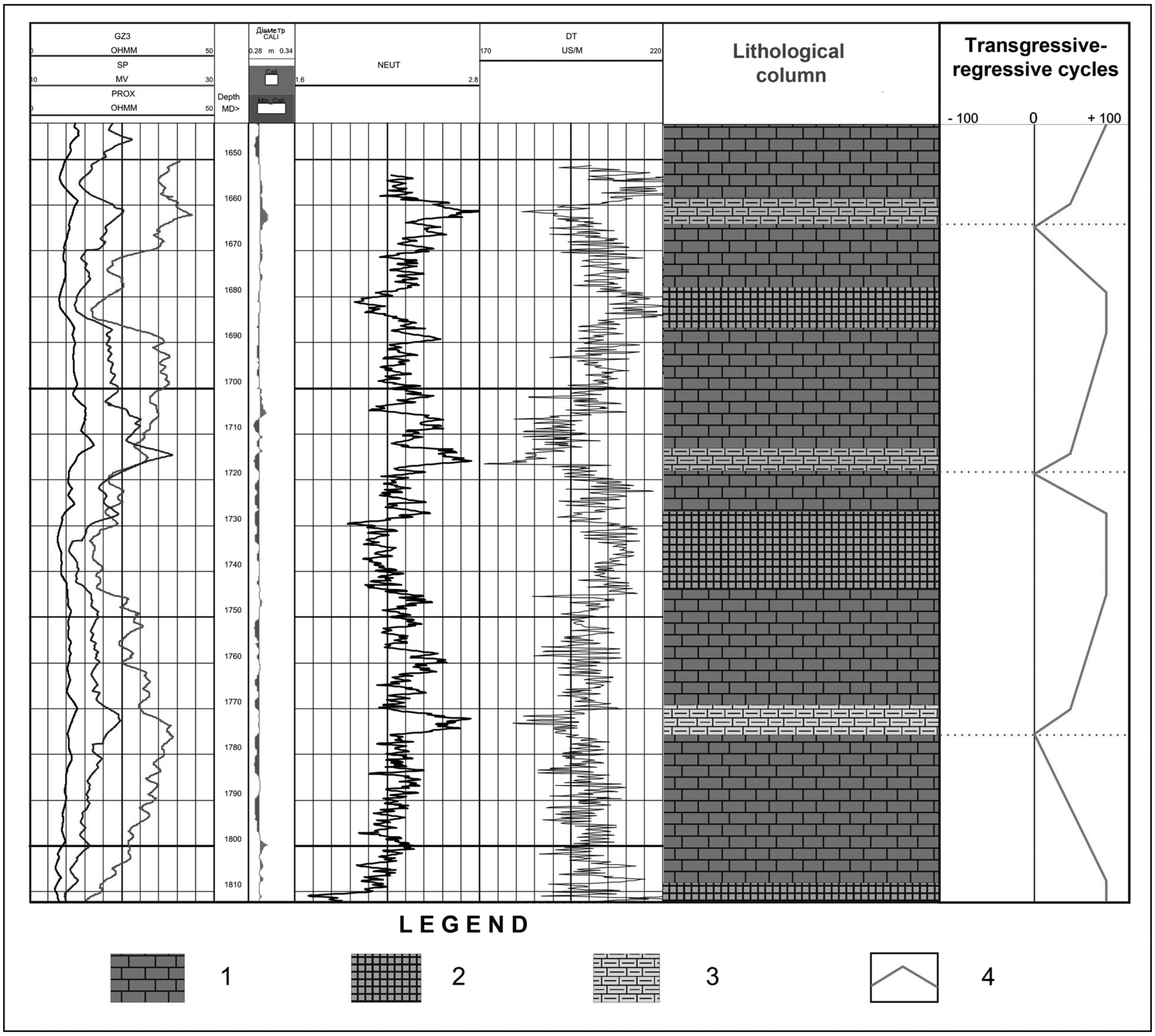

Fig. 1. Rhythmic sequence of the Upper Cretaceous sediments in the Black Sea northwestern shelf (Odessa-2 well, interval 1650-1810 m, early Maastrichtian).
1 – micritic limestones; *2* – chalk; *3* – biogenic marl; *4* – bathymetric curve.

Most of the studied pairs have demonstrated that thickness of the lower constituent (marls) is quite bigger than one of corresponding chalk (limestone) unit.

Fundamentally important data on duration of marl-limestone (chalk) pair deposition were obtained under studying of rhythmic intervals of Cenomanian sequence in the Southern England and Northern France (Paul, 1992; Paul et al., 1994). The British authors have came to conclusion that the each pair has formed during one cycle of precession of 21 000 years long.

The rhythmicity of the Upper Cretaceous sediments was studied by D.P. Naidin (Naidin, 2004), R.R. Gabdullin (Gabdullin, 2002) and others. According to the conception by D.P. Naidin rhythmicity of Cenomanian sedimentation of the European paleo-biogeographical region can be explained by the applying of productivity model. The study of original production of planktonic foraminifers, coccolithofores, and other pelagic biota of mass development with carbonate skeleton can provide significant information on rhythmicity origin for basically planktonic epicontinental sequences. Carbonate production was undeniably a leading process, however, phenomena of dilution taken place as well.

AREA, METHODS AND OBJECT OF STUDY

Area of study is an aquatory of Ukrainian part of the Black Sea northwestern shelf.

Methods of study – lithological, petrographical, geophysical, bio- and lithostratigraphic ones, and paleogeographic restorations.
Object of study – Carbonate sedimentary rocks of the Black Sea northwestern shelf.
Subject of study – rhythmicity of carbonate sedimentation.

RESULTS OF RESEARCHES AND THEIR ANALYSIS
Reasoning from the above the rhythmicity of sedimentation has been recognized and studied mainly in the outcrops. For closed basins such studies are very rare. The detail study conducted for the Upper Cretaceous sections revealed by deep wells drilled within the Black sea northwestern shelf is based on an integrated interpretation of well-log data. It allowed the possibility to uncover and trace a distinct and well distinguished rhythmicity in the accumulated sequence of late Cretaceous age.

An example of recognized rhythmicity is shown on the Figure demonstrating part of Odessa-2 well section within depth interval 1650–1810 m where a distinct and clearly visible rhythmicity is recognized. This part of the section is dated as early Maastrichtian according to paleontological dating.

In case of uninterrupted cycle the section shows full paragenetic set of sequentially changed rocks: ***biogenic marl (biogenic-detrital limestone) – micritic limestone – chalk – micritic limestone – biogenic marl (biogenic-detrital limestone)***.

In our opinion the rhythmic structure of the Upper Cretaceous sequence is the result of depositional conditions change during several distinctly recognized transgressive-regressive cycles caused by oscillated movements of the lithosphere coupling with general subsidence of the area studied. These movements lead to transgressions and regressions of late Cretaceous sea and repeated displacement of its shorelines for significant distance. Amplitude of oscillating movements and their rhythm have defined the completeness of the rhythmic sequences.

The onset of transgression is marked by marl unit or clayey biogenic wackestones, micritic limestones corresponds to further development of transgression, and high system tract during trasgression is marked by chalk formation, beginning and development of regression are marked by micritic limestones with its maximum expressed by hardground at the top of limestones.

Unfortunately, limited recovery of core material and its insufficient investigation do not allow us to speak about detail lithological, chemical, paleontological and mineralogical composition of the abovementioned rhythms as well as about their nature and duration of their formation. These unsolved aspects request additional studies.

CONCLUSIONS
Rhythmical formation of the Upper Cretaceous sequence within the Black Sea northwestern shelf is evidenced.

In case of an interrupted cycle in the section the full paragenetic sets of sequentially changed rocks – biogenic marl (biogenic wackestone) – biomicritic limestone – chalk – biomicritic limestone – biogenic marls (biogenic wackestone).

Rhythmical formation of the Upper Cretaceous sequence is the result of deposition settings change during several distinctly recognized transgressive-regressive cycles caused by oscillating movements of the lithosphere coupling with a background process of general subsidence of the territory studied.

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