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CARBONATE MICROFACIES OF UPPER JURASSIC DEPOSITS IN THE WEST AND SOUTH OF UKRAINE

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КАРБОНАТНІ МІКРОФАЦІЇ ВІДКЛАДІВ ВЕРХНЬОЇ ЮРИ ЗАХОДУ ТА ПІВДНЯ УКРАЇНИ

The results of investigations of carbonate microfacies of Upper Jurassic deposits in the South and West of Ukraine are represented. The greatest diversity of microfacies types are observed in Ukrainian Precarpathians (19 types of Standard microfacies), much less of ones are in Pre-Dobrogea depression (11) and Southeastern Crimea (8). The belonging of these sediments to standard facies zones of carbonate shelf are determined. 11 Standard microfacies types are identified in Upper Jurassic deposits in Yalta Amphitheatre (Mountain Crimea). The features of sedimentary conditions in different parts of paleobasin are characterized.
Keywords: Upper Jurassic, Ukraine, reefs, microfacies

Представлено результати досліджень карбонатних мікрофацій у відкладах верхньої юри Заходу та Півдня України. Найбільше різноманіття спостерігається в Українському Передкарпатті (19 типів стандартних мікрофацій), менше – в Західному Причорномор'ї (11) та Південно-східному Криму (8). Визначена належність цих відкладів до стандартних фаціальних поясів карбонатного шельфу. У верхньоюрських відкладах Ялтинського амфітеатру (Гірський Крим) ідентифіковано 11 типів стандартних мікрофацій. Виявлено особливості умов седиментації в різних частинах палеобасейну.
Ключові слова: верхня юра, Україна, рифи, мікрофації.

INTRODUCTION

In world practice, one of the main methods used in comprehensive studies of carbonate strata is the analysis of carbonate microfacies. It was initiated by J. Cuvillier in the early 50›s of the 20th century (Cuvilier, 1951).

Microfacies analysis together with sequence-stratigraphy are often a key tool for paleogeographic and paleoecological reconstructions, as well as the correlation of different parts of paleobasin (Schlager, 1992). It is widely used for detailed stratification and correlation of thick carbonate strata of different ages – e.g. Triassic and Upper Jurassic of Western and Central Europe (Austria, Germany, Romania, Slovakia) (Flügel, 1982, 2004; Mišik, 1966, and other), Cretaceous of Mexico and South India, and is especially applied in the oil and gas regions, including the Middle East (Saudi Arabia, Yemen etc.).

Carbonate sedimentation is the result of biochemical processes, mainly in the sea environments under the influence of two main factors – the absence of terrigenous material and high biological productivity of basin. Biological productivity and as a result sedimentation of carbonates, are controlled by many factors – depth of basin, water temperature, salinity, oxygen saturation, hydrodynamic regime, etc. Most of carbonate material forms in situ and is of organic origin – either direct, i.e. skeletal material, or indirect, as a product of vital functions of some organisms. Autochthonous origin of most of carbonate sediments allows reconstructing the sedimentary conditions with high reliability (Wilson, 1975, etc.).

In 1975, J.L. Wilson proposed the model of distribution of carbonate sediments what is expressed as a sequence of facies – standard facies zones (belts) of carbonate shelf. He has distinguished nine standard facies zones from deep basin to coastal. Depending on specific conditions these zones change in width and length. They are more narrow on steep shelf, and wider on sloping shelf. This sequence is stable enough and may be used as a criteria for stratification, correlation, and paleogeographic reconstructions in different regions (Wilson, 1975).

Later the Wilson's model had been improved and completed (Flügel, 1982, 2004, Schlager, 1992, etc.). Thus, 10th facies zone (continental conditions) was distinguished, and carbonate ramp model has been proposed as an alternative (Flügel, 2004).

Every standard facies zone is characterized by a specific set of standard microfacies that can be formed only under specific conditions, and differ by the composition of organic remnants depending on the age and conditions in the basin. 24 types of standard microfacies (SMF) were identified (Wilson, 1975). In further studies the list of SMF was supplemented with two more types and standard microfacies of carbonate ramp were allocated by different researchers as well (Flügel, 2004, and other).

MATHERIALS AND METHODS

Analysis of carbonate microfacies (biolithomicrofacies) is one of the main research methods used for a detailed partition of carbonate strata, including the Late Jurassic complex formed at the periphery of the Tethys and widespread in Europe and the Middle East (fig. 1). In Ukraine, the Upper Jurassic carbonate deposits outcrop in the Crimean Mountains and locally in the Ukrainian Carpathians and in the Basin of Dniester River (Volyno-Podolia), and were opened by numerous wells in the Ukrainian Precarpathians, Western Black Sea Coast (Pre-Dobrogea depression) and Southeastern Crimea.

We studied microfacial composition of rocks of Upper Jurassic deposits of the South and West of Ukraine for detailing the stratigraphic, paleographic and correlative constructions. Samples from the Upper Jurassic deposits of the Ukrainian Precarpathians, Western Black Sea Coast, Southeastern Crimea and Yalta Amphitheatre (Mountain Crimea) were used as the research material. Microfacies types have been identified and classified according to the Wilson' Standard Microfacies (SMF).

RESULTS OF INVESTIGATIONS

The greatest diversity of microfacies have been found in the territory of Ukrainian Precarpathians (19 SMF types). There are full sequences of standard facies zones of carbonate shelf – fore-reef (open shelf and slope), reef, back-reef deposits at three stratigraphic levels – Oxfordian, Kimmeridgian and Tithonian-Berriasian, and sediments of evaporite lagoon at Lower Kimmeridgian level (fig. 2). The facies zones extend almost submeridionally and replace from deep-water environments in the west to shallow-water in the east.

Sediments of the 5th (reef) facies zone of Oxfordian are the separate knoll build-ups (Dulub et al, 2003, Zhabina, 2003) with the same vertical zonation: at the bottom they are composed of sponge limestones and spongolites, higher of coral-algal bioherm limestones (mainly grapestones) and at the top – of oncolitic limestones (oosparites) and somewhere of stromatolites. Sediments of this facies zone of Kimmeridgian are represented by sponge-algal stratal bodies in the thickness of micritic shelf limestones. At the Tithonian-Berriasian level, the sediments of the 5th facies zone are two varieties: Opary barrier reef and numerous small mollusk-algal bioherms that situated in back-reef area. To the west the reef zone is replaced by fore-reef formations of the 2nd–4th standard facies zones, to the east – by the sediments of the 6th–8th zones of Oxfordian, Kimmeridgian and Tithonian-Berriasian, and sediments of evaporite lagoon (the 9th facies zone) occur at Lower Kimmeridgian. The formation of 1th standard facies zone (deep basin sediments) in Precarpathians are not discovered. They are present in allochthonous occurrence in outcrops in the Ukrainian Carpathians (Rehakova et al, 2010).

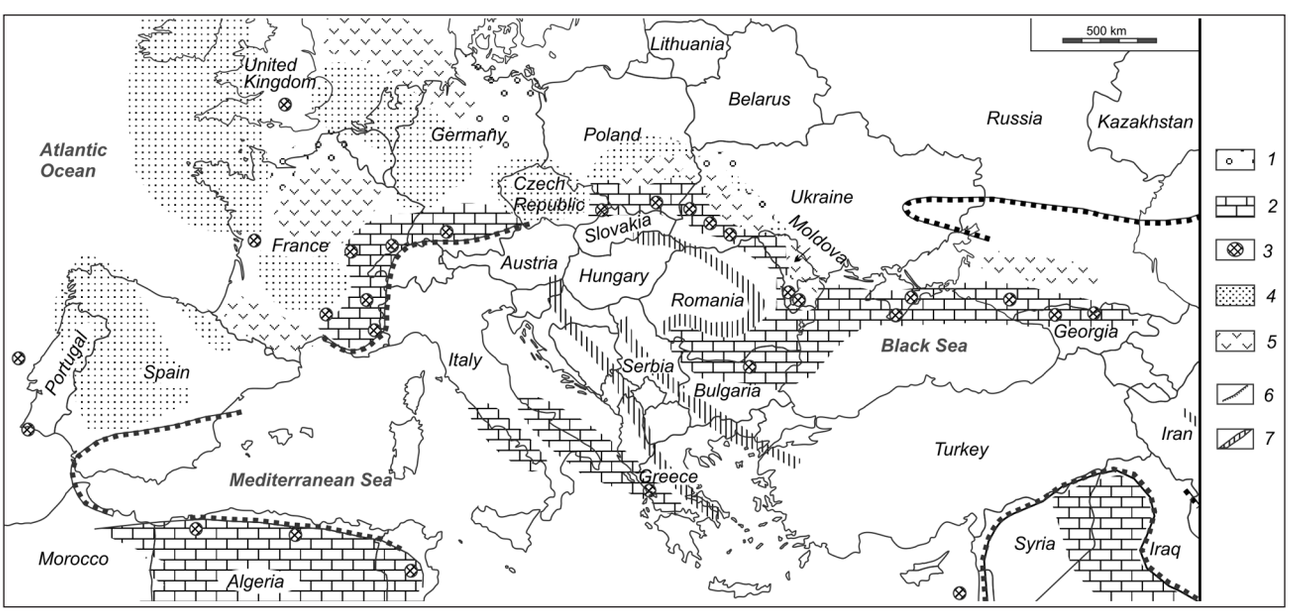
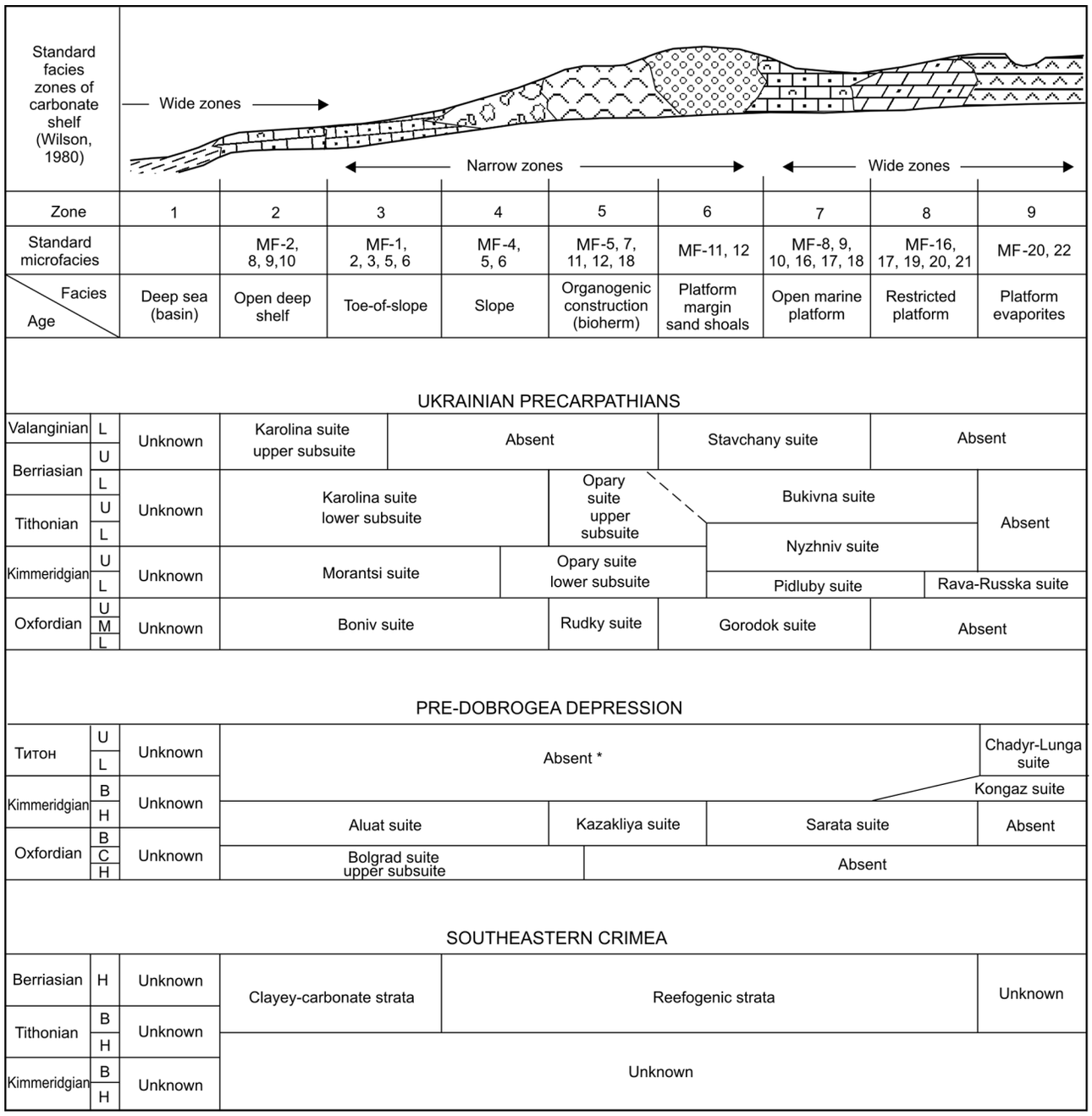


Fig. 1. Northern part of Tethys in Late Jurassic. After J.L. Wilson (1975), modified.

1 – shallow (formation of granestones and oolites); *2* – shelves (sedimentation of shelf limestones with small reef interlayers); *3* – reefs; *4* – shallow-water shelves with islands; *5* – evaporite and saline lagoons; *6* – border line between deep-water radiolarian and shelf facies; *7* – boundaries of mobile blocks.



* Upper Kimmeridgian and Tithonian sediments in Pre-Dobrogea (Kongaz and Chadyr-Lunga suites) are lagoon-evaporite and continental formations of 9 and partly 8 facies zones, and they overlay the sediments of Lower Kimmeridgian in a whole region

Fig. 2. Upper Jurassic sediments of West and South of Ukraine according to standard facies zones of carbonate shelf.

There are much less of microfacies types in the Pre-Dobrogea depression and Southeastern Crimea. It is due to specific conditions in different parts of paleobasin, and partly depends on the completeness and preservation of sections.

In Pre-Dobrogea region 11 SMF types have been identified. Here, the sequence of standard facies zones appears only at Oxfordian and partly Lower Kimmeridgian levels. The sediments of Upper Kimmeridgian and Tithonian are mainly formations of evaporite lagoon (Slusar, 1971, Romanov, 1973, Polukhtovich et al, 1984, 1985, Leschukch et al, 1999). The Oxfordian 5th (reef) standard facies zone extends as an arc from northwest to southeast and represented by deposits of barrier reef with frame reef-builders in the northwestern part, and predominantly by microbial-algal formations in the south. To the southwest, they are replaced by fore-reef sediments of the 2nd–4th standard facies zones, by back-reef sediments of the 6th–8th facies zones to the northern east.

In Southeastern Crimea, only the Tithonian-Berriasian sediments were opened by drilling. There are identified 8 SMF types, which characterizing fore-reef, reef and back-reef facies, but correct succession of facies zones was broken by the subsequent tectonic events (Zhabina, Mintuzova, 2000).

In outcrops in Yalta Amphitheatre and Iograf Ridge (Mountain Crimea) the Oxfordian reef facies (4 SMF types) are overlapped by shelf sediments of Kimmeridgian (3 SMF types). Tithonian shallow-water shelf sediments with small bioherms (4 SMF types) outcrop in Yalta Yaila, Bedenekir and Ai-Petri Mounts. The reconstruction of detailed paleogeographic situation here, as well as in the whole of Mountain Crimea, is extremely difficult due to the complex tectonic history.

CONCLUSIONS

Having compared conditions in different parts of paleobasin on the base of analyzing data of previous investigations by B.S. Slusar, L.F. Romanov, B.M. Polukhtovych, A.D. Samarsky, E.V. Samarska, R.J. Leschukch, Y.V. Turkevych, V.V. Permyakov, V.G. Dulub, N.M. Zhabina, B. Olszewska, M. Krajewski and other, and own researching of microfacies the following conclusions can be done:

Since the Upper Jurassic sediments in West and South Ukraine were formed in a common paleobasin, belonging to the North Tethys periphery, they have much in similar, but there are differences too due to the specific conditions in different parts of the basin.

The belt of bioherm constructions stretched along all Ukrainian segment of northern periphery of Tethys since Middle Oxfordian and till Middle Berriasian. The existence of Early Oxfordian bioherms, formed by siliceous sponges in relatively deep environments (about 100 m) is proved only in Ukrainian Precarpathians.

Oxfordian bioherms in Precarpathians are the separate dome buildups (knolls), in Pre-Dobrogea most researchers (Polukhtovich et al., 1984, 1985, Leshukh et al, 1999, and other) believe that the Oxfordian constructions are the barrier reef.

The sponge limestones and spongolites and also silicification of rocks characteristic for lower part of Oxfordian bioherms in Precarpathians, were not found in Mountain Crimea, and lower part of biogerms is unknown. In Pre-Dobrogea basement of reef is the Lower Oxfordian clayey-carbonate deposits.

Bioherm deposits of Middle-Late Oxfordian are presented everywhere by coral-algal formations with a high content of microbial aggregates; in the southern part of Pre-Dobrogea it sometimes reaches 50%.

Oxfordian bioherms in Precarpathians show the certain vertical zonation and tendency to shallowing basin; in Oxfordian deposits of Pre-Dobrogea and Mountain Crimea this zoning is shown less.

Dark pelagic micrites with aptychi are present among the bioherm and oncolitic limestones in Iograf Ridge, and stromatolites that are typical for upper part of Oxfordian bioherms in Precarpathians are absent. It indicates relatively bigger depth of forming Middle-Upper Oxfordian deposits in Mountain Crimea, so the deepest part of paleobasin was there at that time.

Signs of regressive processes at the Oxfordian-Kimmeridgian boundary are various in different regions:

– In Precarpathians the Oxfordian bioherms are overlapped by mottled carbonate-terrigenous shallow-water and continental formations of Lower Kimmeridgian. Together they formed a barrier that turned the eastern part of basin to isolated evaporite lagoon.

– In Pre-Dobrogea the regression led to increasing the area of dry land, which, according to most researchers (Polukhtovich et al, 1984, Leshukh et al, 1999, and other), was farther to the south, and to isolating part of paleobasin. The strip of reef bodies divided it into two separate lagoons, where evaporite and halogen-evaporite formations accumulate.

– The signs of break in sedimentation on the boundary of Oxfordian and Kimmeridgian are not observed in Iograf Ridge (Mountain Crimea), they are changed gradually. Only oncolitic shallow-water limestones at the top of the Oxfordian deposits indicate the shallowing of basin at the end of Oxfordian.

Because of transgression in Kimmeridgian, bioherm deposits of Oxfordian in Iograf Ridge were overlapped by thickness of relatively deeper-water shelf limestones of Kummeridgian and Lower Tithonian.

Low differentiated relief of sea bottom and gentle slope of shelf in these regions were during the Kimmeridgian. This is confirmed by shape of Kimmeridgian bioherms in Precarpathians and their almost absence in Mountain Crimea.

Tithonian deposits were formed under the influence of periodic small regressive-transgressive processes, what is indicated by non-rhythmic changing of limestones formed in normal-marine and lagoon (stagnant) conditions.

Reef formations of Tithonian and Tithonian–Berriassan in Ukraine present in the Ukrainian

Precarpathians, the Southeastern Crimea, and, according to many researchers (Polukhtovich et al, 1984, etc.) are correlated with deposits of Mount Agarmysh.

Unlike Precarpathians where in Tithonian coral barrier reef existed, Tithonian bioherm formations at the Mounts Ai-Petri and Bedenekir are mainly composed of oncolitic, algal and bioclastic limestones without typical reef microstructures. This opinion have also been expressed by Krajewski and Olszewska (Krajewski, Olszewska, 2006), who considered bioherms of Mount Ai-Petri as patch-reefs. In general, vertical zonation of Tithonian bioherm at Ai-Petri indicates a gradual shallowing of the basin characteristic for Precarpathians as well.

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