ISSN 0145-8752, Moscow University Geology Bulletin, 2012, Vol. 67, No. 5, pp. 273–281. © Allerton Press, Inc., 2012.
Original Russian Text © V.K. Piskunov, S.V. Rud'ko, E.Yu. Baraboshkin, 2012, published in Vestnik Moskovskogo Universiteta. Geologiya, 2012, No. 5, pp. 3–11.

The Sedimentary Conditions of Middle-Upper Tithonian Limestones of the Demerdzhi Plateau (Mountain Crimea)

V. K. Piskunov[a], S. V. Rud'ko[b], and E. Yu. Baraboshkin[a]
[a] *Faculty of Geology, Moscow State University, Moscow, 119992 Russia*
[b] *Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 119017 Russia*
e-mail: vkpiskunov@gmail.com
Received February 21, 2012

Abstract—As a result of a microfacies analysis of the section of Middle-Upper Tithonian Limestones of the Demerdzhi Plateau (Mountainous Crimea), 12 microfacies types of rocks were distinguished. It has been established that these microfacies types formed in the facies zones of an inner carbonate platform: the littoral, restricted and open marine and sand shoals of the margins of a carbonate platform. The sequence of the microfacies types in the vertical section corresponds to a transgressive trend with minor sea-level fluctuations of the second order. In addition, the communities of microencrusters, which played an active role in sediment stabilization and formation of small bioherms, have been studied. These communities are considered to be evidence of the shallowness of the paleobasin

Keywords: Crimea, Demerdzhi plateau, Upper Jurassic, Tithonian, carbonate platform, sedimentology, microfacies, microencrusters

DOI: 10.3103/S0145875212050067

INTRODUCTION

The Demerdzhi plateau is located in the central part of the First Ridge of Mountain Crimea, between the Chatyr-Dag mountain massif (Chatyr-Dag Yaila) in the west and the Karabi-Yaila in the east. In the north, the Demerdzhi plateau passes into the Tirke Yaila, which, in turn, borders the Dolgorukovskaya Yaila. The Middle-Upper Tithonian Limestones of the Demerdzhi Plateau are considered to belong to the Yalta Formation deposits (Permyakov, Permyakova, and Chaikovskii, 1991), which are widespread within the First Ridge of Mountainous Crimea and compose most of the Crimean Yailas.

Despite the long history of scientific research on Crimea, the Upper Jurassic carbonate deposits of Mountainous Crimea have been studied only in the vicinity of the Yalta and Ai-Petri massifs (Krajewski, 2010) and in the vicinity of Mt. Pakhkal-Kaya (Baraboshkin and Piskunov, 2010). These studies were based on microfacies analysis, the modern approach in carbonate sedimentology (Tucker and Wright, 1990; Flügel, 2010). It is difficult for field geologists to use this approach due to the indistinct macroscopic features (component composition, textural and structural features) in recrystallized limestones.

The limestone section that was studied has a thickness of more than 1.5 km and composes the eastern part of the Demerdzhi plateau and the Tirke Yaila plateau. This article presents the results of a study on only a part of the section, which composes the Demerdzhi plateau (a thickness of 1 km). The age of this section, which was determined on the basis of a study of foraminifera by A.A. Fedorova (Andrukhovych and Turov, 2002), is Middle–Late Tithonian.

The section is separated by fault zones from the Kimmeridgian–Tithonian terrigenous–carbonate deposits that compose the western part of the Demerdzhi plateau. In addition, this section is underlined by Upper Jurassic conglomerates along the gentle thrust fault surface (Piskunov et al., in press) (Fig.1). The extent of the lower beds of the section is limited by a thrust fault and they dip in the northwestern direction. Dip angles are gradually flattened from the southeast (70°–80°) to the northwest (10°–20°). As a result of this research, the sedimentological column (Fig. 2) was compiled and 200 samples were taken. The samples were then studied under the microscope.

Microfacies Types and their Interpretation

Microfacies were distinguished based on their component composition, as well as textural and structural features. Similar and associated microfacies of rocks were combined into microfacies types (MTs) that correspond to certain sedimentary conditions and the facies zones (FZ) of a rimmed carbonate platform (Flügel, 2010). The facies zones are widely distributed and they were distinguished on the basis of study of associating microfacies zones, which are sparely distributed. The pattern of carbonate platform develop-

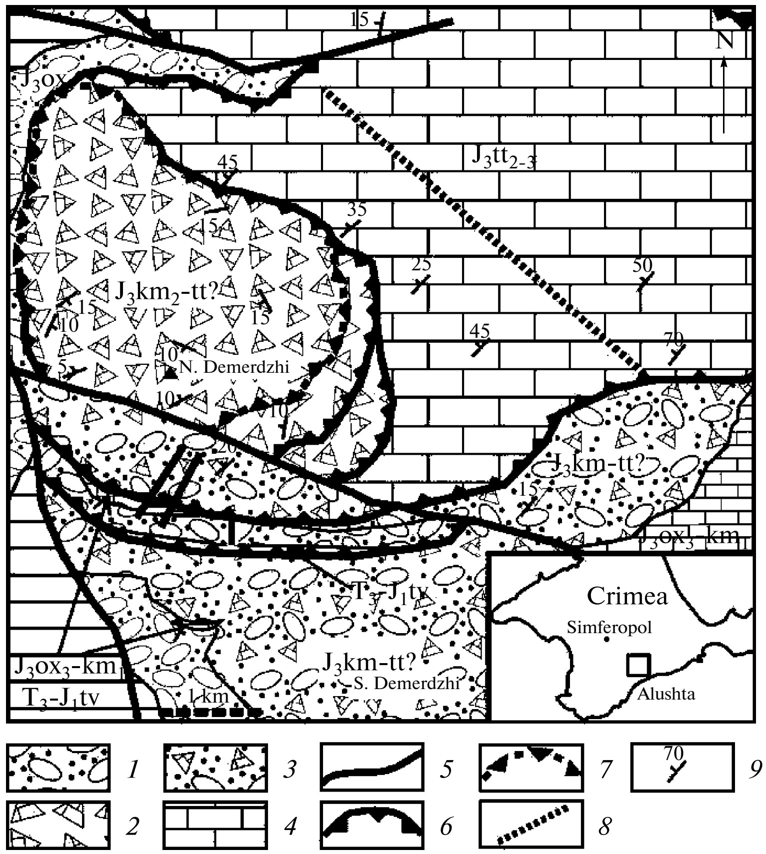

Fig. 1. Geological Scheme of the area of the Demerdzhi plateau. *1*, conglomerates; *2*, carbonate breccias; *3*, conglomerate breccias; *4*, limestones; *5*, subvertical faults; *6*, thrusts; 7, proposed thrusts; *8*, the studied section; *9*, the dip and strike.

ment is based on the distribution of microfacies and regional geological data. According to the latter, the occurrence of shelf carbonate deposits in the Tonas River area and the prevalence of shallow-water components in the Tithonian calcium-turbidites in the environs of the town of Feodosiya indicate that a similar surrounded carbonate platform existed in Tithonian time in Crimea (Guzhikov et al., 2012).

As a result of our research, the following microfacies types were distinguished (Fig. 2):

MT 1. Bindstones and pack-bindstones with fenestra (Fig. 3a). This microfacies type is characterized by numerous cavities in the form of fenestra, viz., "bird's eye" structures and stromatics, which are characterized by an ordered arrangement. Bindstones are composed of dark micrite; pack-bindstones are of algal peloids or pelmicrite. Sometimes calcispheres, small benthic foraminifera (miliolids and textulariids), and blue-green and green algae occur. In addition, geopetal structures in stromatics with vadose silt occur frequently.

Similar microfacies are formed under littoral conditions within the algal marches (Tisljar et al., 2002; Martini et al., 2006; Flügel, 2010). Initially, the microfacies was represented by bacterial and algal mats, which created the framework that overgrew and bounded interlayers of micrite, peloids, and bioclasts. Fenestra are primary cavities in the framework, which formed as a result of dissolving organic material (Flügel, 2010). Vadose silt, as a component of geopetal structures, formed due to diagenetic transformation of the sediment that filled the lower parts of primary cavities in the vadose zone, and sparite, which filled the remaining space formed in the vadose or phreatic zone (Flügel, 2010).

MT 2. Floatstones, rarely rudstones with predominance of micritic and spongiostromate oncoids (Fig. 3b). This microfacies type is characterized by the predominance of micritic oncoids with poorly developed bedding and rarely spongiostromate oncoids, as well as by an occurrence of whole benthic foraminifera with the predominance of large lituolids. Associate grains are as follows: bioclasts, gastropods, bivalves (including rudists), micritic and concentric (tangential) ooids, cortoids, and extremely rarely micritized intraclasts and porostromate oncoids. Geopetal structures with vadose silt are rarely observed. MT 2 often alternates with MT 1.

Micritic layers of oncoids formed as a result of the binding and deposition of micrite by microorganisms (Vedrine, Strasser, and Hug, 2007; Flügel, 2010). Good roundness and an absence of microencrusters in sponge-stromatic and micritic oncoids indicate that

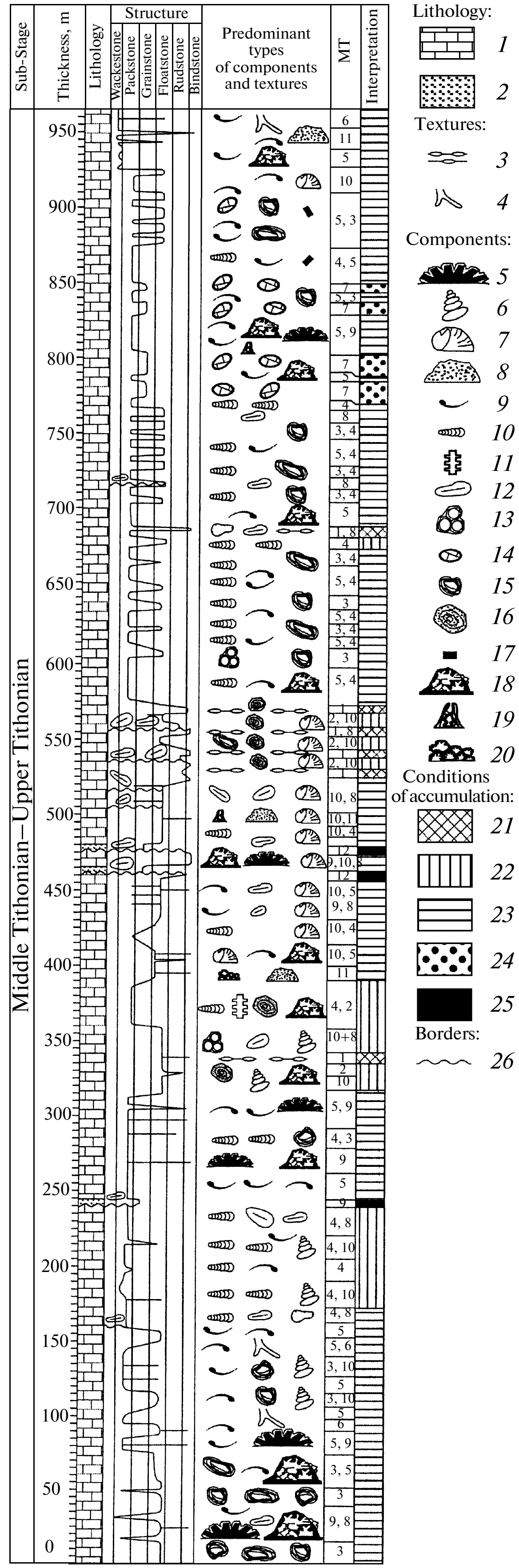

Fig. 2. The section of the Middle–Upper-Tithonian limestone section of the Demerdzhi plateau. *1*, limestones; *2*, sandstones and gravellites; *3*, fenestra; *4*, bioturbations; *5*, coral and sponge bioherms and biostroms; *6*, gastropod banks; *7*, rudist banks; *8*, trombolites; *9*, bioclasts; *10*, foraminifera; *11*, dasycladales algae; 1*2*, intraclasts and lithoclasts; *13*, grapestones; *14*, cortoids; *15*, spongiostromate and porostromate oncoids; *16*, micritic and spongiostromate oncoids; *17*, carbonaceous detritus; *18*, community *Lithocodium bacinella*; *19*, community *Crescrentiella morronensis*; *20*, community *Koskinobullina socialis*; *21*, littoral; *22*, restricted marine FZ; *23*, open marine FZ; *24*, shoals; *25*, channels; *26*, erosion boundaries.

MT 2 formed under high hydrodynamic conditions. The depleted composition of the fauna, the presence of geopetal structures with vadose silt and frequent association with MT 1 indicate that MT 2 formed within an restricted marine FZ above the normal wave base level.

MT 3. Floatstones, rarely wackestones and packstones with numerous oncoids of mixed types and bioclasts (Fig. 3c). This microfacies type is characterized by the predominance of porostromate and spongiostromate oncoids. Porostromate crusts are often represented by communities of microencrusters: *Lithocodium aggregation–Bacinella irregularis* (Fig. 4c). Bioclasts are represented by whole foraminifera, rare fragments of crinoids and dasycladales algae, single fragments of bivalves, gastropods, corals, algae, and brachiopods. The occurrence of a community of microencrusters (*Lithocodium–Bacinella*, sometimes with *Taumathoporella parvovesiculifera*) (Fig. 4c), and coated grains (cortoids, bahamite-type peloids, and micritized intraclasts) are a characteristic feature of MT 3. Foraminifera are represented by large (lituolids), and small benthic species.

A predominance of porostromate oncoids in microfacies over other oncoids, not infrequent formation of beds by the microencruster community of *Lithocodium–Bacinella*, as well as the presence of the mixed-type oncoids are evidence that the sedimentation occurred in an open marine FZ (Vedrine, Strasser, and Hug, 2007) at a low sedimentation rate under the oligotrophic conditions of the sublittoral zone (Leinfelder et al., 1996; Rameil et al., 2010; Shiraishi and Kano, 2004; Flügel, 2010). The occurrence of a large amount of micrite, large oncoids with non-uniform shells, and whole foraminifera indicates moderate or weak hydrodynamic conditions, while disintegrated bioclasts indicate that the clastic material was supplied from areas with active hydrodynamic regime (Flügel, 2010).

MT 4. Packstones with the predominance of foraminifera (Fig. 3d). MT 4 is represented predominantly by packstones, rarely wackestones with the predominance of benthic foraminifera. In addition, large lituolids, miliolids, and textulariids dominate; other small benthic foraminifera are less common. The associate grains are represented predominantly by peloids and green algae (including, dasycladales

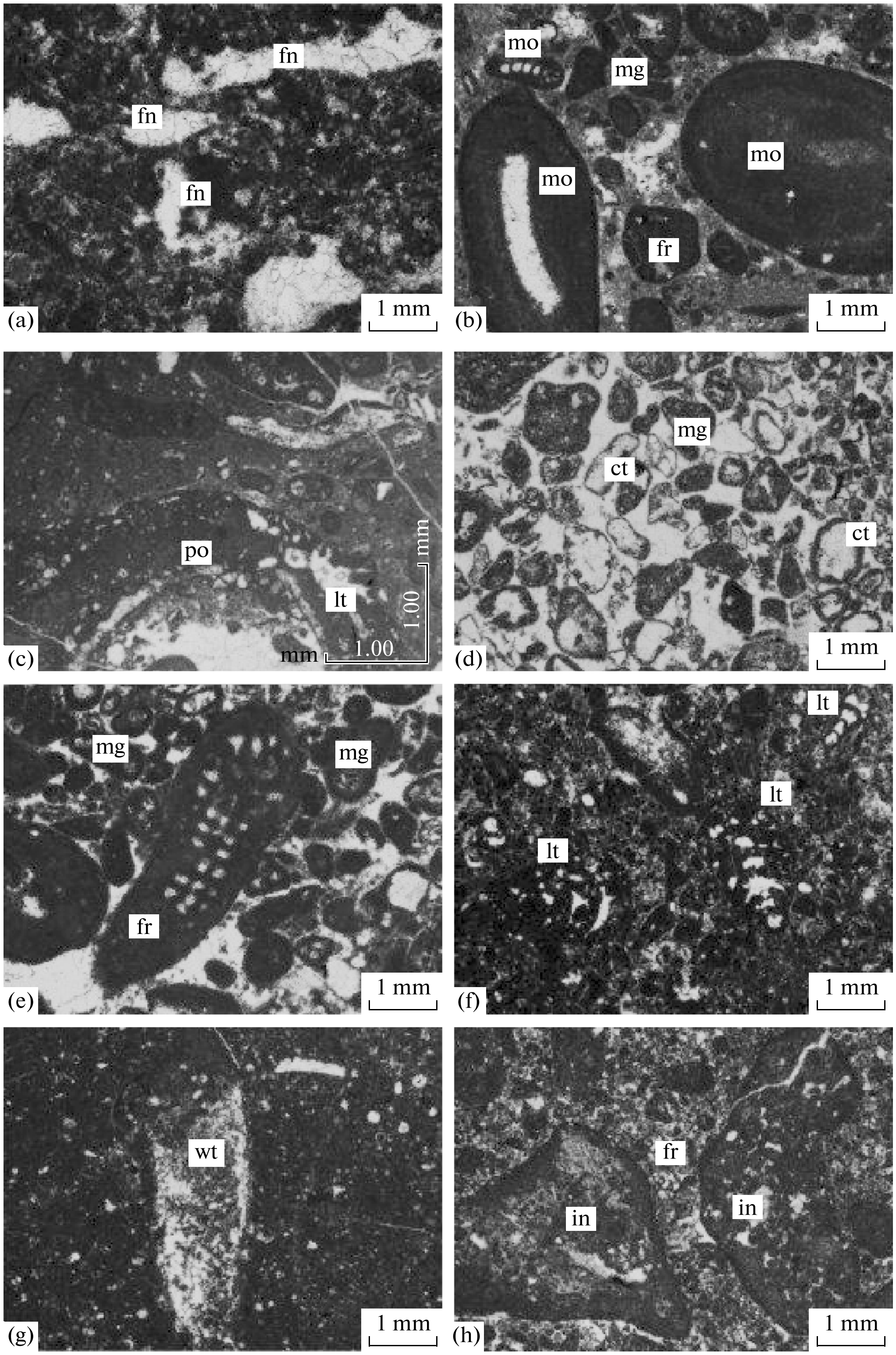

Fig. 3. The main microfacies types (MT): (a) MT 1, peloid pack-bindstone with fenestra (fn); (b) MT 2, packstone with micritic oncoids (mo), foraminifera (fr), and micritized grains (mg); (c) MT 3, floatstone with porostromate oncoids (po) with *Lithocodium aggregatum* (lt) in the shell, bioclasts and micritized grains; (d) MT 7, grainstone with cortoids (ct) and micritized grains (mg); (e) MT 5, grain-packstone with micritized grains (mg), including foraminifera (fr); (f) MT 4, packstone with lituolids (lt); (g) wackestone with burrows (wt); (h) MT 8, pack-floatstone with micritized intraclasts (in) and foraminifera (fr).

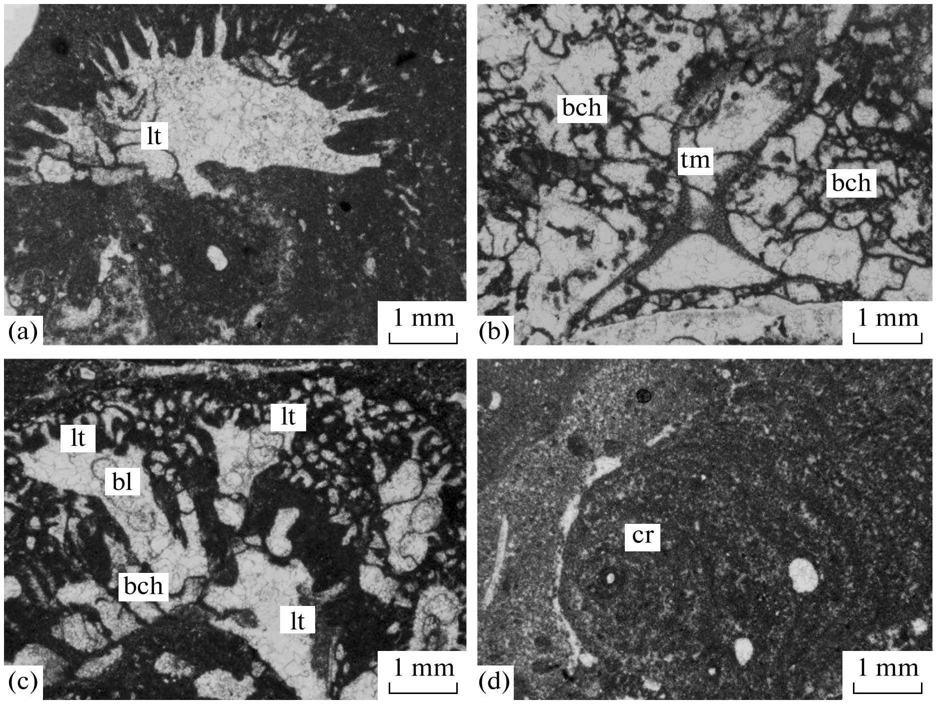

Fig. 4. The main microencrusters: (a) *Lithocodium aggregatum* (lt); (b) *Bacinella irregularis* (bch) and *Taumathoporella parvovesiculifera* (tm); (c) the community *Lithocodium aggregatum* (lt)-*Bacinella irregularis* (bch) with *Bullopora* sp. (bl); (d) *Crescrentiella morronensis* (cr).

algae); bioclasts of bivalves and gastropods, crinoids, cortoids, micritic oncoids, micritized intraclasts; single porostromate oncoids are less common. Sometimes, carbonaceous detritus is noted. In addition, rare algae *Lithocodium aggregatum* (Fig. 4a) are found in their lifetime position and allochtonous *Taumathoporella parvovesiculifera*.

Similar microfacies formed in restricted (Di Stephano et al., 2002) and open marine FZ (Flügel, 2010; Kastner et al., 2008). Based on the poor composition of the fauna and the occurrence of micritic oncoids, one can suggest that these microfacies types formed in the restricted marine facial zone (Vedrine, Strasser, and Hug, 2007). However, patterns of the formation of MT4 occur in the open marine FZ below the normal wave base level (Kästner, Schülke, and Winsemann, 2008), which was confirmed by their association with the MT that is typical of the open marine FZ, in the deposits that were studied. The occurrence of a significant amount of micrite and the predominance of whole bioclasts are evidence of moderate or calm hydrodynamic conditions.

MT 5. Packstones with micritized bioclasts and grains (Fig. 3e). This microfacies type is represented by packstones, very rarely wackestones. MT 5 is composed of bioclasts, peloids, and rare intraclasts. *Lithocodium aggregatum*, *Bacinella irregularis*, *Crescentiella morronensis* (Fig. 4d) and *Taumathoporella parvovesiculifera* are common species. Bioclasts are not infrequently abraded or destroyed, rounded and coated by micritic crust, which can be presented by crusts (cortoids) or it can penetrate to the central part of a bioclast. In the latter case, crusts are often represented by bahamite-type peloids (less than 0.5 mm) or intraclasts (more than 0.5 mm). Foraminifera shells are well preserved, rarely coated by micrite. Among the bioclasts, benthic foraminifera and echinoderms dominate; corals, brachiopods, bivalves, gastropods, blue-green and green algae are less common.

The distribution of the microencrusters we listed, the common marine fauna, and intense micritization of grains allow one to suppose that the microfacies we studied formed in the open marine facial zone (Kabanov, 2000; Leinfelder et al., 1993/1996; Rameil et al., 2010; Shiraishi and Kano, 2004). Grains were micritized by endolithic algae and microborers under shallow-water conditions at a depth that varies from a few meters to the first tens of meters (Kabanov, 2000). The occurrence of micrite, as well as abraded and destroyed bioclasts, indicates that they formed under moderate or active hydrodynamic conditions.

MT 6. Bioclastic wackestones, often with bioturbations (Fig. 3f). This microfacies type is represented by bioclastic wackestones, rarely mudstones and packstones with bioturbations. Bioclasts are represented by foraminifera (small benthic forms dominate), algae, echinoderms, whole or slightly abraded gastropods, bivalves, brachiopods, single *Lithocodium aggregatum* and *Bacinella irregularis*, which encrust large shells. Not infrequently there is a significant amount (up to

70% of all bioclasts) of small indeterminable detritus (up to 0.3 mm). Associate grains are rare intraclasts.

Bioturbations are represented by vertical tubes (up to 4 mm in diameter and first centimeters in length), filled usually by pelsparite or intraclast-peloid pack- or grainstones.

Similar microfacies formed under calm hydrodynamic conditions below the fair weather wave base (Kästner, Schülke, and Winsemann, 2008) in the open lagoon or open shelf facial zones. The occurrence of a community of microencrusters (Leinfelder et al., 1996; Rameil et al., 2010; Shiraishi and Kano, 2004) allows one to suggest that this MT formed in an open lagoon. Fine detritus formed in areas with active hydrodynamic regimes; later it was redeposited (Flügel, 2010).

MT 7. Grainstones, rarely grain-packstones with coated grains (Fig. 3g). This microfacies type is represented by well-sorted grain- and grain-packstones with cortoids and intensively (sometimes completely) micritized intraclasts, bioclasts and bahamite-type peloids. Cortoids usually are bioclasts, coated with micrite. Among bioclasts, the fragments of crinoids, gastropods, brachiopods, bivalves; whole foraminifera and dasycladales algae dominate.

Associate grains are represented by ooids, spongiostromate oncoids and rare carbonaceous detritus. Microencrusters occur, such as *Crescentiella morronensis* with a diameter of more than 1 mm.

Widespread micritization is an evidence of the extreme shallow-water conditions of sedimentation (Kabanov, 2000); the small amount of micrite is evidence of its removal under active hydrodynamic condition (Tucker and Wright, 1990; Flügel, 2010). MT 7 most likely corresponds to high-energy shoals of the platform margin, as these shoals are characterized by good sorting of sand material and a significant thickness of deposits. This is indirectly confirmed by alternation of the benches of grainstones of MT7 and MT 3, 4, 5 and 9, which formed in an open marine FZ.

MT 8. Intraclastic lithoclastic packstones and rarely grainstones and rudstones (Fig. 3h). In MT8, intraclasts of surrounding microfacies types dominate. Among them are bioherms, microencrusters, or microbial formations, including bindstones with fenestra, etc.

Intraclasts are often micritized to varying degrees and rounded. MT 8 not infrequently contains bahamite-type peloids and abraded or destroyed bioclasts of foraminifera, bivalves, gastropods, brachiopods, corals, sponges and algae. Bioclasts are often micritized. In some cases, lithoclastic rudstones compose single layers with a thickness of the first 10 centimeters with intraclasts (first centimeters) as large and/or elongated micritic grains. In the neighboring microfacies, cavities are often observed.

Intraclasts formed as a result of short breaks in sedimentation or a decrease in the rate of sedimentation during strengthening of hydrodynamics that lead to erosion. Microfacies types are not infrequently the product of destruction of bioherms under the destabilization of conditions of sedimentation (Krajewski, 2010) and are located close to bioherms. The micritization of grains indicates that the MT formed under shallow-water conditions and grains were at the water-table boundary for a long period of time (Kabanov, 2000), as shown by their rounded shapes.

The occurrence of interlayers of lithoclastic rudstones with elongated micritic lithoclasts in MT8 is evidence of exposure of deposits and the coastal karst development (Flügel, 2010).

MT 9. Coral and sponge framestones and bafflestones are represented by single structures with a diameter of less than 1 m and a height of first 10 centimeters or biostroms. These structures are encrusted by *Lithocodium aggregatum*, *Bacinella irregularis*, rare *Taumathoporella parvovesiculifera*, *Koskinobullina socialis*, and *Bullopora* sp. The latter is often associated with *Lithocodium aggregatum* (Fig. 4c), which developed on the surface of corals and sponges. *Bacinella irregularis* occurs in the space between corals and sponges, binding the matrix and intraclasts (Fig. 4c).

Such microfacies can be formed in different predominantly shallow-water zones that surrounding a carbonate platform. The occurrence of microencrusters is evidence of shallow oligotrophic conditions with a low sedimentation rate (Leinfelder et al., 1993, 1996; Rameil et al., 2010; Shiraishi and Kano, 2004).

MT 10. Rudist and gastropod float- and rudstones. This microfacies type is represented by accumulations of allochtonous and sub-allochtonous large shells of rudists or gastropods (including nerineids). They are often encrusted by foraminifera (including *Troglotella*) and the community of *Lithocodium-Bacinella* with the predominance of *Lithocodium aggregatum*. The matrix in MT9 is bioclastic wacke- and floatstones; the components of the matrix are often bound by *Bacinella irregularis*.

MT 10 is represented by rudist and gastropod banks. Gastropods and rudists are organisms that are adapted to restricted conditions (Wilson, 1975; Waite and Strasser, 2010). The binding of deposits by *Lithocodium aggregatum*, *Bacinella irregularis* u *Taumathoporella parvovesiculifera* indicates that sedimentation was under shallow oligotrophic conditions (Leinfelder et al., 1996; Rameil et al., 2010; Shiraishi and Kano, 2004). This MT corresponds to the inner zone of a carbonate platform. In this case, specific facies zones are distinguished on the basis of associate microfacies types.

MT 11. This microfacies type is represented by trombolites and microbial formations with lumpy structures, which are represented by peloid pack- and bindstones. They are often associated with encrusted corals and sponges. Grains are represented by microbial and rarely bahamite-type peloids with rare small

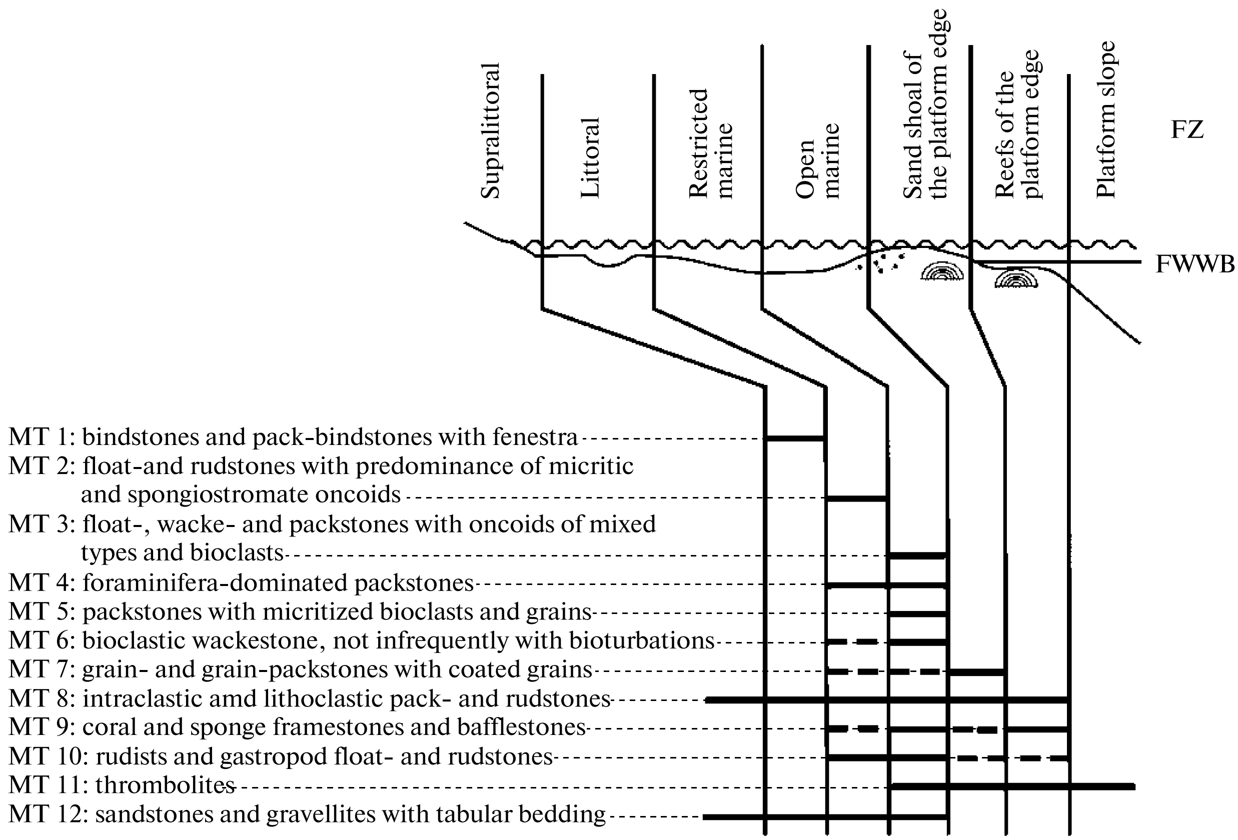

Fig. 5. Distribution of distinguished microfacies types in the facies zones that surround a carbonate platform (after (Flügel, 2010) as amended). Dashed line, the potential distribution of the MT in the FZ; solid line, the reliable distribution of the MT in the FZ. FWWB, Fair Weather Wave Base.

benthic foraminifera; the matrix is represented by pelmicrite. In addition, this MT is characterized by the development of fenestra filled with sparite.

Thrombolites, as other microbialites, are formed by the microbial community in the form of biofilm. In general, they are cyanobacteria and other bacteria, rare algae and fungi, which begin to precipitate carbonate under certain conditions. Thrombolites in the Jurassic period could exist in different zones of carbonate platforms (Leinfelder et al., 1996). As a rule, their development is connected with low-oxygen eutrophic conditions (Leinfelder et al., 1996). Thrombolites of MT 11 are not numerous and are associated with the faces zones of open, restricted marine FZ corals, and sponges. Therefore, a decrease in oxygen content and/or the development of eutrophic conditions was manifested in local areas, and probably it was connected with the peculiarities of the bottom topography.

MT 12. This microfacies type is represented by sandstones and gravellites, which occur in lenses ranging from 0.4 to 1.5 m within the carbonate deposits in separate normal-graded terrigenous beds. The terrigenous material is fine to medium-grained and exhibits good to very good sorting. Tabular cross-bedding is often observed; trough cross-bedding is noted rarely. MT 12 is made predominantly of quartz grains; the content of carbonate grains, which are large intraclasts, ranges from 0 to 50%.

This microfacies type is considered to belong to deposits of megaripples of tidal channels (Leeder, 1982).

Sedimentary Conditions

As a result of the microfacies analysis, the distribution of the microfacies zones that were distinguished was established for facies zones, as well as their sequence on the platform (Fig. 5). The thickest interval of the section we studied is considered to belong to the open-marine facies zone. In the lower and middle parts of the section are intervals that are associated with the formation of the facial zones of restricted marine and littorals that correspond to periods of shallowness. The interval of 575–625 m, where oncoid floatstones (MT 2) of the restricted marine FZ alternate with fenestra pack- bindstones (MT 1) of the littoral FZ is the most informative. Here, the sea level fluctuations (or seasonal tides?) resulted not only in the formation of the shallowness, but in the dewatering of a coastal area. This is confirmed by the presence of layers with lithoclasts, which appeared due to the development of the coastal karst (MT 8), and geopetal textures with vadose silt (MT 1 and rarely MT 2).

In the upper parts of the section there are intervals that correspond to the shallow FZ of the platform margin (MT 7). They alternate with benches, where MT5 of intensively micritized rocks of the open marine facial zone dominates. The movement of the platform margin to the coast can be explained by transgression that resulted in the formation of unusually vast and unstable surrounding sand shoals. The overlying open marine facies zone formed at the sea level high stand, which led to the restoration of the basin configuration and movement of the platform margin to its initial position.

The occurrence of relatively deep wackestones and clays at the borders of the Tirke and Demerdzhi plateaus are indirect evidence of the closeness of the platform margin to the facies, which correspond to the terminal parts of the section we described. Thus, this section corresponds to the main transgressive trend with the minor sea-level fluctuations. At the time intervals that correspond to the lower and middle parts of the section, these fluctuations resulted in the shallowness of open marine and the formation of the facies zones of an restricted marine and littoral zone. During the time interval that corresponds to the upper parts of the section, these fluctuations resulted in the formation of sand shoals that surround a carbonate platform. At the same time, temporary and occasional underwater currents (MT 12) were manifested. Judging by the large thickness (more than 1 km) of the section we studied and the wide distribution of Tithonian shallow-water limestones in Mountainous Crimea (Permyakov, Permyakova, and Chaikovskii, 1991), a vast and significant transgression occurred in this area.

The Paleogeographic Significance of Microencrusters

Microencrusters occur widely in both the deposits of the section we studied and in other Upper Jurassic shallow-water carbonate deposits of the Crimea (Krajewski, 2010). The most common species are *Lithocodium aggregatum*, and *Bacinella irregularis*; *Taumathoporella parvovesiculifera* and *Crescentiella morronensis* are less common. In addition, there are single finds of *Koskinobidlina socialis*.

Microencrusters are of great importance for the reconstruction of paleogeography and paleoecology. So, *Lithocodium aggregatum*, *Bacinella irregularis* and *Taumathoporella parvovesiculifera* and their communities (Figs. 4b, 4c) are an evidence of shallow-water oligotrophic conditions of the inner platform and its margin and the low rates of sedimentation (Leinfelder et al., 1996; Rameil et al., 2010; Shiraishi and Kano, 2004). In the microfacies studied, *Lithocodium aggregatum* encrusts bioclasts and bioherms, or in the outer parts of oncoids (Fig. 4a). Algae of *Bacinella irregularis* mostly occupy the intraframe space. Together with *Lithocodium bacinella*, they stabilize and strengthen the sediment, creating a microframework. In the same way, these microencrusters often took part in reef formation (Leinfelder et al., 1993; Krajewski, 2010; Shiraishi and Kano, 2004). *Taumathoporella parvovesiculifera* was associated “in situ” with *Bacinella irregularis* in the microfacies we studied (Fig. 4c). This alga occurs independently only in the form of detritus. Due to this, its paleoecological significance is probably similar to that of *Bacinella irregularis*.

The occurrence of *Koskinobullina socialis* is evidence of shallow-water conditions of sedimentation (Leinfelder et al., 1993), which is confirmed by its not infrequence occurrence together with *Bacinella irregularis* in these deposits. At the same time, its association with *Crescrentiella morronensis* is considered as an indicator of relatively calm conditions below the normal wave base level (Flügel, 2010; Lienfelder et al., 1996).

The most important paleogeographic criterion for *Crescrentiella morronensis* (Fig. 4d) is its diameter, which is a function of depth (Leinfelder el al., 1996). The outer shell, the main part of a microencruster, is the product of cyanobacteria activity, whose activity is proportional to the amount of incoming light. However, if microencrusters grew in kryptons of reefs or there were other barriers to light penetration, their diameter (usually small) cannot serve as a criterion for determining the depth. A relatively large diameter of *Crescrentiella morronensis* (about or more than 1 mm), as noted in the section, is evidence of shallow-water conditions.

CONCLUSIONS

As a result of our research work, 12 microfacies types were distinguished. They correspond to a littoral, an restricted marine, an open marine FZ, and the sand shoals of a carbonate platform. Based on their sequence in the vertical section, a transgressive trend in the sedimentation is supposed to exist. Judging by the thickness of the section (more than 1 km) and the wide distribution of Tithonian shallow-water limestones in Mountainous Crimea (Permyakov, Permyakova, and Chaikovskii, 1991), a vast and significant transgression occurred in this area.

Communities of microencrusters, which stabilized and bounded the sediment, played an important role during sedimentation and took a part in the reef formation.

ACKNOWLEDGMENTS

This work was supported by the Russian Foundation for Basic Research (projects nos. 11-05-00405, 10-05-00276, and 10-05-00308).

We are grateful to V.S. Mileev for consultations concerning the geological structure of the region, and

Yu.O. Gavrilov and A.V. Tevelev for their help in collection and treatment of the materials.

REFERENCES

Andrukhovich, A.O. and Turov, A.V., Comparative Characteristics of Tithonian—Berriasian Deposits of Karabi-yaily and Demerdzhi-yaily (Mountain Crimea), *Izv. Vyssh. Uchebn. Zaved., Geol. Razved.*, 2002, no. 2, pp. 29–39.

Baraboshkin, E.Yu. and Piskunov, V.K., The Structure and Formation Conditions of the Upper Jurassic Succession in the Area of Mount Pakhkal-Kaya (Crimea), *Moscow Univ. Geol. Bull.*, 2010, vol. 65, no. 1, pp. 1–16.

Flügel, E., *Microfacies of Carbonate Rocks: Analysis, Interpretation and Application*, Berlin: Springer, 2010, 2nd ed.

Guzhikov, A.Yu., Arkad'ev, V.V., Baraboshkin, E.Yu., Bagaeva, M.I., Piskunov, V.K., Rud'ko, S.V., Perminov, V.A., and Manikin, A.G., New Sedimentological, Bio-, and Magnetostratigraphic Data on the Jurassic—Cretaceous Boundary Interval of Eastern Crimea (Feodosiya), *Stratigr. Geol. Correl.*, 2012, vol. 20, no. 3, pp. 261–294.

Kabanov, P.B., Micritization of Paricles as a Facies Indicator in Shallow Water Marine Carbonate Rocks, *Byull. Mosk. O—va Ispyt. Prir., Otd. Geol.*, 2000, vol. 75, no. 4, pp. 39–48.

Kästner, M., Schülke, I., and Winsemann, J., *Facies* Architecture of a Late Jurassic Carbonate Ramp: the Korallenoolith of the Lower Saxony Basin, *Int. J. Earth Sci.*, 2008, vol. 97, no. 5, pp. 991–1011.

Krajewski, M., *Facies, Microfacies and Development of the Upper Jurassic-Lower Cretaceous of the Crimean Carbonate Platform from the Yalta and Ay-Petri Massifs (Crimea Mountains, Southern Ukraine): Dissert. Monographs 217*, Krakow: Wydawnictwa AGH, 2010.

Leeder, M.R., *Sedimentology: Process and Product*, London: Allen & Unwin, 1982.

Leinfelder, R., Nose, M., Schmid, D.U., and Werner, W., Microbial Crusts of the Late Jurassic: Composition, Paleoecological Significance and Importance in Reef Construction, *Facies*, 1993, vol. 29, pp. 195–229.

Leinfelder, R.R., Werner, W., Nose, M., Schmid, D.U., Krautter, M., Laternser, K., Takacs, M., and Hartmann, D., Paleoecology, Growth Parameters and Dynamics of Corals, Sponge and Microbolite Reefs from the Late Jurassic, in *Global and Regional Controls of Biogenic Sedimentation. I. Reef Evolution, Res. Rep.*, Reitner, J., Neuweiler, F., and Gunkel, F., Eds., Göttingen: Geol. Inst., Georg-August Univ. Göttingen, 1996, vol. Sb2, pp. 227–248.

Martini, R., Cirilli, S., Saurer, C., Abate, B., Ferruzza, G., and Cicero, G. L., Depositional Environment and Biofacies Characterisation of the Triassic (Carnian To Rhaetian) Carbonate Succession of Punta Bassano (Marettimo Island, Sicily), *Facies*, 2006, vol. 53, no. 3, pp. 389–400.

Permyakov, V.V., Permyakova, M.N., and Chaikovskii, B.P., A New Stratigraphic Scheme of the Jurassic Deposits of Mountain Crimea, *Preprint of the Institute for Geological Sciences, Academy of Sciences of the Ukrainian Soviet Socialistic Republic*, Kiev, 1991, 91–12.

Rameil, N., Immenhauser, A., Warrlich, G., Hillgartner, H., and Droste, H.J., Morphological Patterns of Aptian Lithocodium-Bacinella Geobodies: Relation To Environment and Scale, *Sedimentology*, 2010, vol. 57, no. 3, pp. 883–911.

Shiraishi, F. and Kano, A., Composition and Spatial Distribution of Microencrusters and Microbial Crusts in Upper Jurassic-Lowermost Cretaceous Reef Limestone (Torinosu Limestone, Southwest Japan), *Facies*, 2004, vol. 50, pp. 217–227.

Di Stefano, P., Galácz, A., Mallarino, G., Mindszenty, A., and Attila Vörös, A., Birth and Early Evolution of a Jumssic Escarpment: Monte Kumeta, Western Sicily, *Facies*, 2002, vol. 46, pp. 273–298.

Tišljar, J., Vlahović, L., Velić, I., and Sokać, B., Carbonate Platform Megafacies of the Jurassic and Cretaceous Deposits of the Karst Dinarides, *Geol. Croatica*, 2002, vol. 55, pp. 139–170.

Tucker, M.E. and Wright, V.P., *Carbonate Sedimentology*, Oxford: Blackwell, 1990.

Vedrine, S., Strasser, A., and Hug, W., Oncoid Growth and Distribution Controlled by Sea-Level Fluctuations and Climate (Late Oxfordian, Swiss Jura Mountains), *Facies*, 2007, vol. 53, no. 4, pp. 535–552.

Waite, R. and Strasser, A., A Comparison of Recent and Fossil Large, High-Spired Gastropods and Their Environments: the Nopparat Thara Tidal Flat in Krabi, South Thailand, Versus the Swiss Kimmeridgian Carbonate Platform, *Facies*, 2010, vol. 57, pp. 1–26.

Wilson, J.L., *Carbonate Facies in Geologic History*, New York: Springer, 1975.