

New data about microfacies and stratigraphy of the Late Jurassic Aj-Petri carbonate buildup (SW Crimea Mountains, S Ukraine)

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With 6 figures

KRAJEWSKI, M. & OLSZEWSKA, B. (2006): New data about microfacies and stratigraphy of the Late Jurassic Aj-Petri carbonate buildup (SW Crimea Mountains, S Ukraine). – N. Jb. Geol. Paläont. Mh., 2006: 298–312; Stuttgart.

Abstract: The Aj-Petri carbonate buildup complex has commonly been described as an example of a coral reef. Recent studies indicate that the Aj-Petri sediments include corals occurring mainly in small clusters and that these corals, although sometimes macroscopically visible, do not constitute an important rock component. The principal reef-builders of major portions of the Aj-Petri complex were microencrusters (described for the first time from this area) and stromatoporoids. These formed numerous although small stromatoporoid-*Lithocodium* patch reefs which, together with detrital sediments, constitute a large part of the Aj-Petri massif. The stratigraphic position of the Aj-Petri buildup, previously referred to the Oxfordian and in the upper part to the Early Kimmeridgian, should be modified in the light of the results of new foraminiferal studies. The sediments are dominated by microfauna typical of the Kimmeridgian and Tithonian. Therefore, the Aj-Petri carbonate buildup is younger than hitherto supposed, and its principal part was formed in the Kimmeridgian and Tithonian.

Zusammenfassung: Der karbonatische Aj-Petri-Buildup-Komplex wurde gewöhnlich als Beispiel eines Korallenriffs beschrieben. Neue Untersuchungen zeigen, dass die Sedimente Korallen hauptsächlich in kleinen Flecken enthalten, die zwar zuweilen makroskopisch sichtbar sind, aber dennoch keine bedeutende Gesteinskomponente darstellen. Die Haupt-Riffbildner des Aj-Petri-Komplexes waren Mikroinkrustierer (erstmalig aus dieser Region beschrieben) und Stromatoporiden. Diese bildeten zahlreiche kleine Stromatoporiden-*Lithocodium*-Fleckenriffe, die zusammen mit detritischem Material einen großen Teil des Aj-Petri-Massivs aufbauen. Die stratigraphische Stellung des Aj-Petri-Buildups, zuvor dem Oxfordium und im oberen Abschnitt dem Unter-Kimmeridgium zugerechnet, sollte angesichts neuer

Untersuchungen der Foraminiferen modifiziert werden. Die Ablagerungen werden von typischen Mikrofaunen des Kimmeridgium und Tithonium dominiert. Deswegen muss der Aj-Petri-Buildup jünger datiert werden als bisher; sein Hauptanteil bildete sich im Kimmeridgium und Tithonium.

Keywords: microencrusters, foraminifera, stromatoporoid facies, Late Jurassic buildups, Crimea Mountains, South Ukraine.

1. Introduction

During the Late Jurassic, the Crimea Mountains were situated on the epicontinental margin that formed a wide belt along the northern part of the Tethys (LEINFELDER et al. 1994, GOLONKA 2004). In Europe, exposures of Late Jurassic strata associated with this margin extend from Portugal to the Caucasus. The Late Jurassic sediments in the Crimea Mountains, genetically associated with the Caucasus (NIKISHIN et al. 1998, SAINTOT et al. 1998, ERSHOV et al. 2003, GOLONKA 2004), represent one of the most important

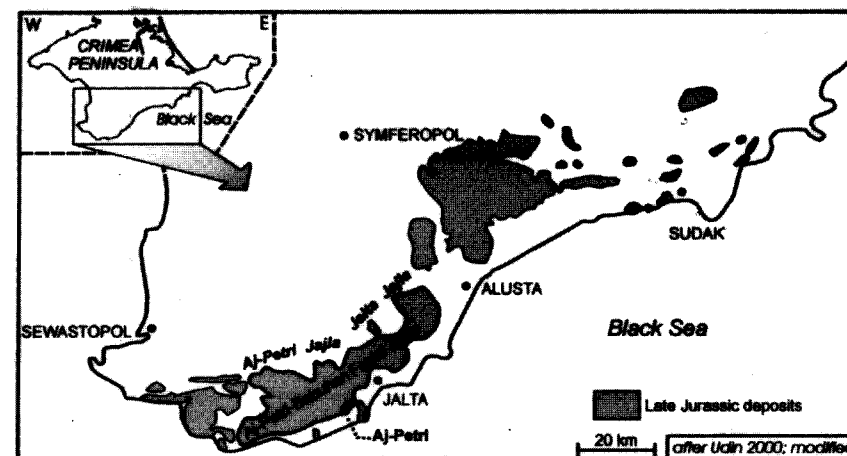


Fig. 1. Location of the study area.

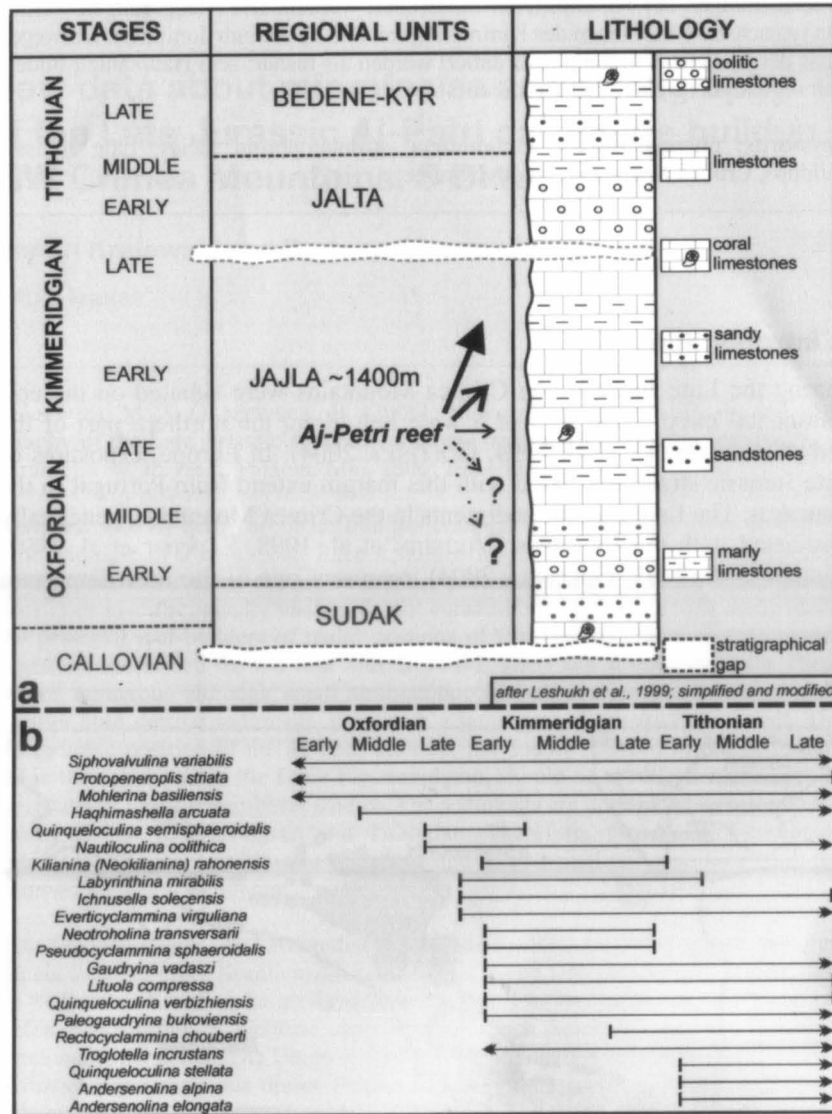


Fig. 2 (Legend see p. 301)

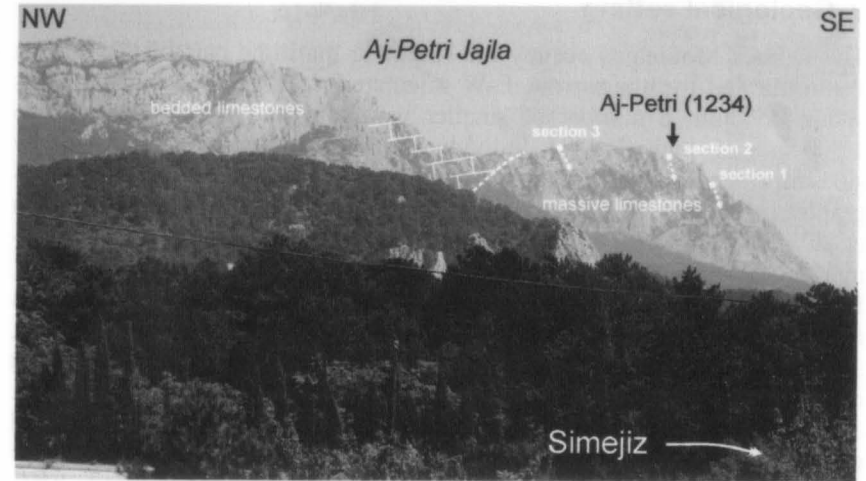


Fig. 3. The southern escarpment of the Aj-Petri Jajla in the study area. Walls are up to 600 m high.

Late Jurassic sections of the northern Tethys margin due to their thickness of up to a few kilometres and good state of exposure. Despite rich Russian and Ukrainian literature (cf. LESHUKH et al. 1999), the properties of the Late Jurassic sediments of the Crimea Mountains are poorly described, particularly in respect to sedimentological microscopic studies, and the published results have seldom been presented and discussed in the European literature.

Based on microfaunal data, this paper presents the results of new studies of the Late Jurassic sediments of the Aj-Petri carbonate buildup.

Fig. 2. Stratigraphic position of Aj-Petri reef. **a** – Stratigraphic subdivision and lithology of Late Jurassic sediments of the Aj-Petri-Babuhan Facies Zone (based on Leshukh et al. 1999; modified). The dotted arrows illustrate stratigraphic position based on literature. The bold arrows illustrate a new interpretation presented in this paper. **b** – Stratigraphic ranges of foraminifers from Aj-Petri reef.

2. Geological setting

The Crimea Mountains occupy the southern, maritime part of the Crimea Peninsula and form a narrow, E-W orientated, 150 km long belt which is subdivided into a number of smaller mountain massifs ("Jajla"), up to 1,500 m a.s.l. high (Fig. 1). Individual massifs, although situated side by side, represent isolated fragments and are characterised by different topography, lithology and stratigraphic position of Late Jurassic strata (LESHUKH et al. 1999, UDIN 2000). Of principal importance are the Oxfordian, Kimmeridgian, and Tithonian deposits (PTCHELINTSEV 1962, PERMJAKOV 1969, PERMJAKOV et al. 1991, LESHUKH et al. 1999), which are subdivided into a number of regional stratigraphic horizons (Fig. 2a). The Aj-Petri massif, situated close to the boundary between Jalta and Aj-Petri Jajla, is a fragment of a larger regional lithostratigraphic unit, called Aj-Petri-Babuhan (Figs. 1, 2a; PERMJAKOV et al. 1991, LESHUKH et al. 1999). According to published data, the Aj-Petri massif is mainly composed of Oxfordian, carbonates which pass at the top into the Early Kimmeridgian (OVIECHKIN 1956, PTCHELINTSEV 1962, MURATOV 1973, and others; Fig. 2a). Inside the massif, there occur limestones and marls assigned to the Tithonian (OVIECHKIN 1956, PERMJAKOV et al. 1991, LESHUKH et al. 1999). The studies of bedded and reef facies in the western Crimea Mountains indicate that the Aj-Petri Jajla massif is built up of oolitic, oncoidal, detrital, coral, and marly limestones, as well as sandy limestones and sandstones (PERMJAKOV et al. 1991, LESHUKH et al. 1999, and others; Fig. 2a). The main part of the Aj-Petri mountain is composed of hard, unbedded massive limestones. These resistant limestones build steep, 600 m high cliffs in the southern part of the mountain, well visible in the topography of the Crimea Mountains (Fig. 3). The Aj-Petri massive limestones gradually pass, both laterally mountainward, into thick- and medium-bedded limestones. Owing to tectonic movements, both massive and bedded limestones are tilted northwards at an approx. 12 degrees (UDIN 2000). Microfacies and microfaunal properties of the Aj-Petri limestones have not been studied in detail until now. Based on coral findings, the Aj-Petri complex used to be described as an example of a coral barrier reef (PTCHELINTSEV 1962, MURATOV 1973, LESHUKH et al. 1999, and others).

3. Methods

This study concerned both central and marginal parts of the Aj-Petri massif. Samples for microscopic examination were collected from three vertical sections and laterally (Fig. 3). In the remaining parts, macroscopic observations were carried out. Considering abundant samples, the first ever micro-

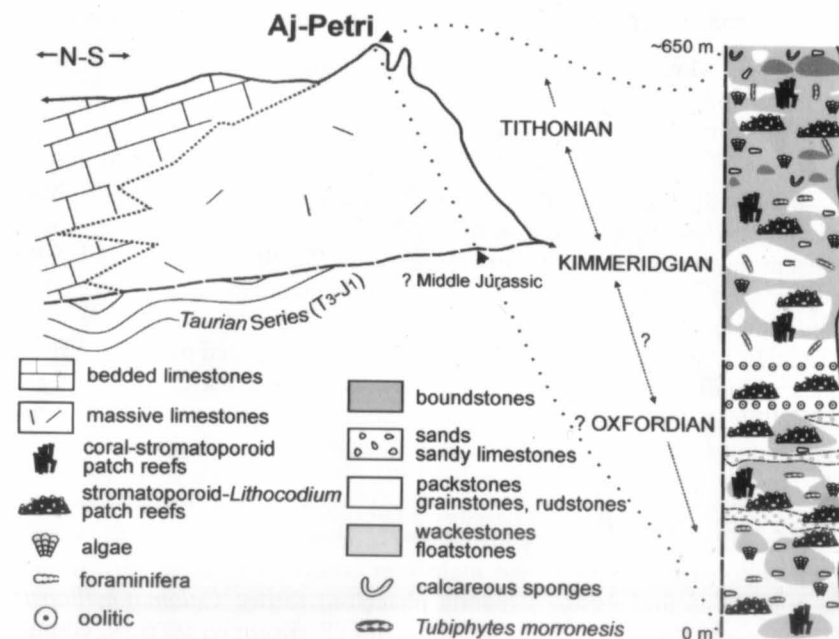


Fig. 4. Lithological sketch of Aj-Petri massive limestones based on sections presented in Fig. 3. The sketch displays the main characteristic and succession of sediments; simplified.

facies study conducted in this massif and the tectonic complexity of the area, detailed microfacies descriptions and palaeoenvironmental interpretations will be presented in a separate paper (KRAJEWSKI, in preparation). The stratigraphic position of the Aj-Petri mountain was determined based on ammonites found in neighbouring areas, and on lithological similarities to other areas of Jalta and Aj-Petri Jajla (OVIECHKIN 1956, LESHUKH et al. 1999; Fig. 2a). As a result of complex fault tectonics of this region, the stratigraphic position of the Aj-Petri sediments is uncertain. Since no ammonites were found in the Aj-Petri limestones, this paper deals with data provided by foraminiferal studies (Fig. 2b). Although stratigraphy based on microfossils

is not as precise as the orthostratigraphic scheme based on ammonites, foraminifers are ubiquitous in the studied sediments, unlike ammonites.

4. Results

The bulk of the Aj-Petri complex is composed of hard, unbedded massive limestones which are more than 600 m thick and ca. 2 km wide (Figs. 3-4). Throughout most of the section, the Aj-Petri massive limestones appear to represent monotonous micritic or detrital rocks. Another picture is provided by microscopic studies which point to differentiated and variable properties of the sediment (Figs. 4-6).

The described part of the Aj-Petri mountain is composed of massive limestones which belong to a stromatoporoid (cf. LEINFELDER et al. 2005) and microbial-algal facies bearing a large amount of grainstones, stromatoporoids, and microencrusters (Figs. 4, 6), frequently of variable proportions and showing either appearance or complete disappearance of some faunal genera. In addition, there also occur oncolithic horizons, between ten and twenty centimetres thick, and infrequent sandstone layers (Fig. 4). Corals, which were supposed to be the main reef constructor, are relatively rare. The studied section includes mainly phaceloid forms: *Calamophylliopsis*, *Latomeandra*, *Stylosmilia*, and *Microphyllia* (E. RONIOWICZ, pers. comm.) which build small, patch reefs, usually 1 m in diameter. Their inner structure is poorly visible owing to considerable or complete recrystallisation of corals.

Stromatoporoids (*Cladocoropsis mirabilis* FELIX) occur much more frequently than corals (Fig. 4, 6). They form small colonial patches which usually develop on hard elements of the substratum. Stromatoporoids occur nearly always with *Lithocodium* (cf. LEINFELDER et al. 2005; Fig. 6). Moreover, quite common are algae (Dasycladacea, rarely Codiacea), small calcareous sponges, fragments of echinoids, bryozoans, and coprolites. The entire studied section includes a frequently occurring, characteristic assemblage of foraminifers and microencrusters (Figs. 5-6).

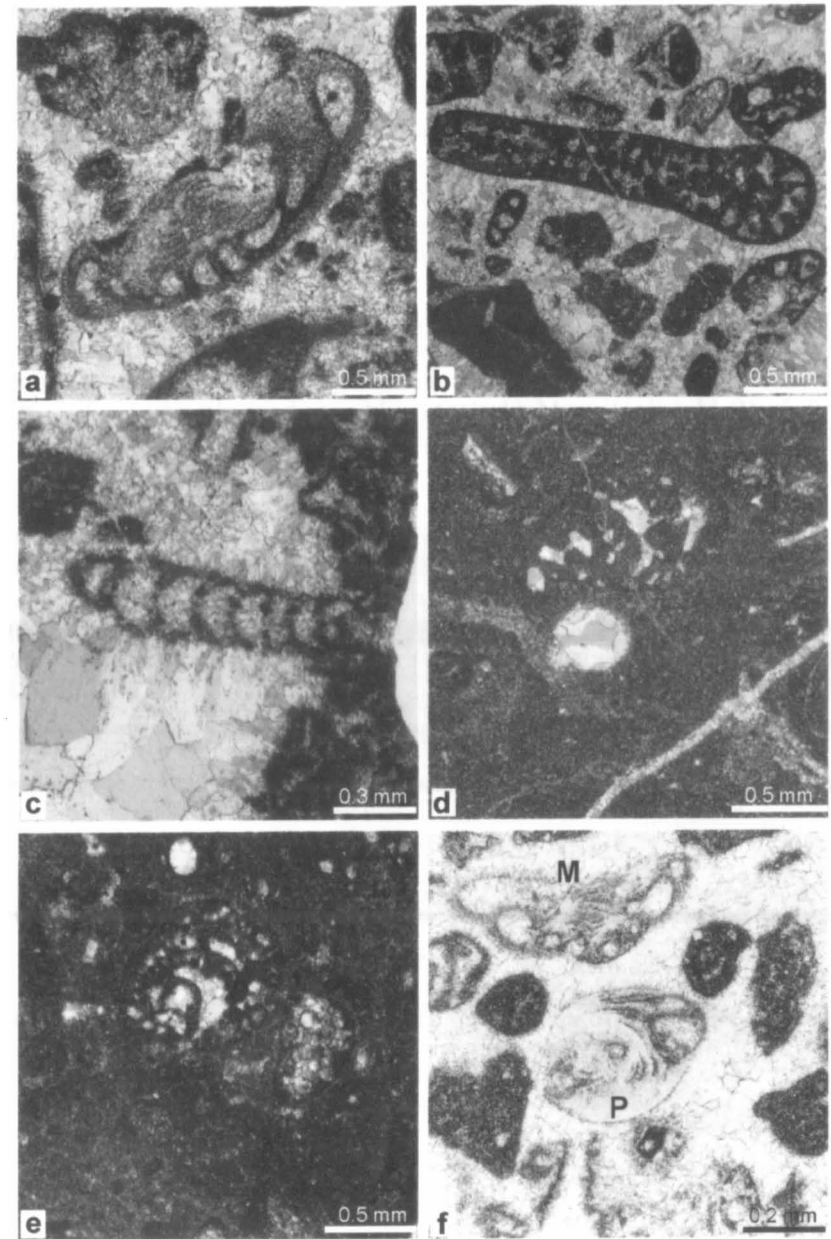


Fig. 5. Examples of foraminifers occurring in the massive Aj-Petri limestones. **a** – *Mohlerina basiliensis* (MOHLER); **b** – *Labyrinthina mirabilis* (WEYNSCHENCK); **c** – *Everticyclammina virguliana* (KOECHLIN); **d** – *Rectocyclammina chouberti* (HOTTINGER); **e** – *Pseudocyclammina sphaerica* (HOTTINGER); **f** – *Protopenneroplis striata* (WEYNSCHENCK) (P) and *Mohlerina basiliensis* (MOHLER) (M).

Foraminifers: The characteristic foraminiferal species found in the studied strata is relatively homogeneous as far as species composition is concerned (Figs. 2b, 5). It includes large, thick-test representatives of the sub-order Loftusiina (KAMINSKI 2004), showing more or less labyrinth-like interiors (*Pseudocyclammina*, *Rectocyclammina*, *Everticyclammina*, *Neokilianina*, *Labyrinthina*). These are very widespread in the Kimmeridgian and Tithonian and characteristic of the inner part of a carbonate platform (SCOTT 1988, SEPTFONTAINE et al. 1991). Representatives of the so-called “small foraminifers”, characteristic of shallow-water carbonate environments (*Mohlerina*, *Nautiloculina*, *Protopenneroplis*, *Siphovalvulina*, *Subbdelloidina*, *Troglotella*, “trocholins”, and “textulariids”) are present as well. Most of these forms prefer an environment of the outer platform and increased water energy. They also colonize organogenic buildups, and some of them (*Subbdelloidina*, *Mohlerina*) could even have played a binding role by encrusting the buildup surface.

Microencrusters: Representatives of encrusting microproblematics, i.e. *Baccinella*, *Lithocodium*, *Thaumatoporella* and *Tubiphytes morronensis* are fairly numerous (Fig. 6). This type of fauna has not yet been described from the Jurassic of the Crimea Mountains. Environmental interpretations of these genera have recently been proposed in numerous studies (SCHMID 1996, SCHMID & LEINFELDER 1996, LEINFELDER et al. 1996, DUPRAZ & STRASSER 1999, 2002, MATYSZKIEWICZ & KRAJEWSKI 2003, SHIRAIISHI & KANO 2004, and others).

The *Lithocodium-Baccinella* association is considered as an assemblage that may help to lithify reef buildups (OURRIBANE et al. 2000). It occurred

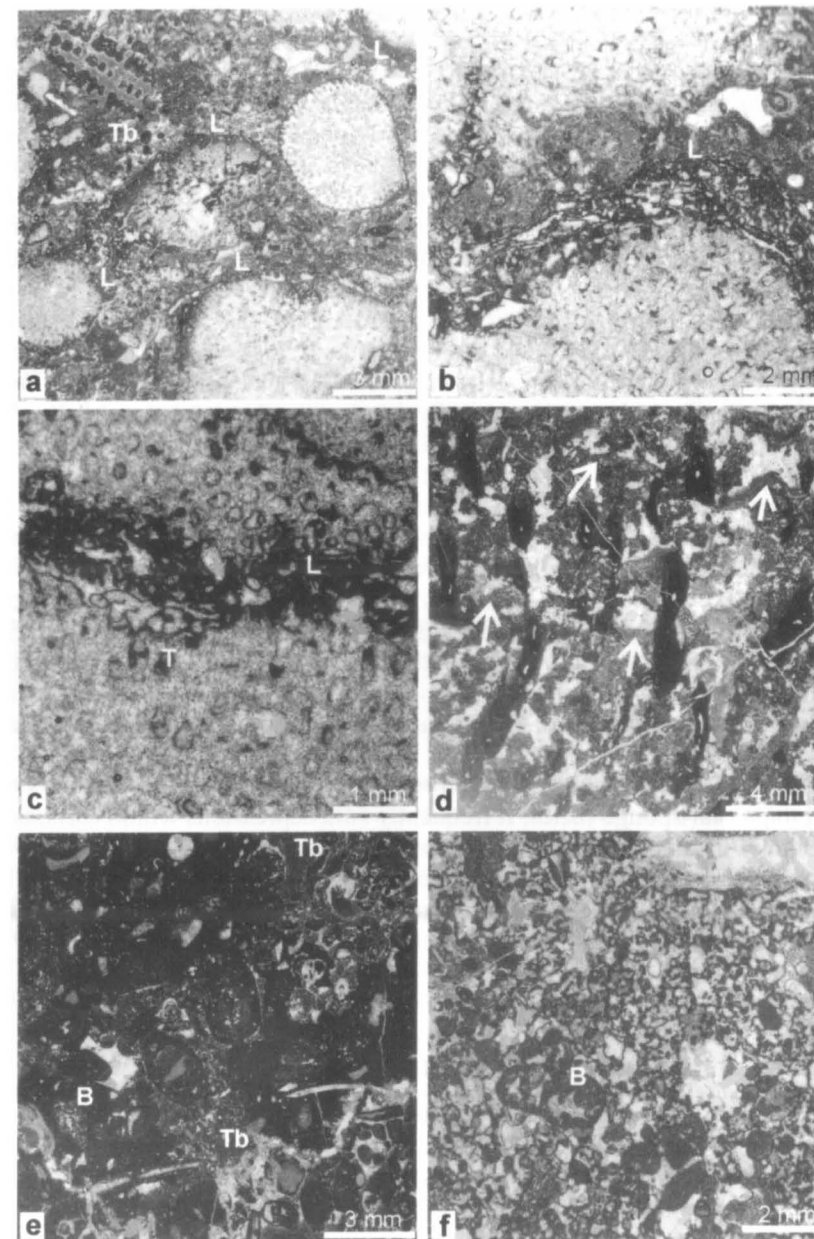


Fig. 6. Examples of microencrusters from the massive Aj-Petri limestones. **a** – Packstone and framestone; numerous stromatoporoids bear *Lithocodium* (L) on their surfaces; packstones include also *Tubiphytes morronensis* (Tb). **b-c** – Framestone and wackestone; space between stromatoporoids frequently filled with *Lithocodium* (L) and *Troglotella* (T). **d** – Framestone; sediment bound by numerous *Tubiphytes morronensis*. The presence of the rigid framework is documented by growth cavities (arrows). **e** – Packstone and grainstone; among intraclasts and microbial structures numerous *Tubiphytes morronensis* (Tb) and *Baccinella* (B) specimens occur. **f** – Packstone and grainstone; in the central part well visible *Baccinella* (B) which fills intra-grain pores and contributes to binding of loose sediment.

in oligotrophic to lowmesotrophic normal marine, lagoon, and reef environments (BERNIER 1984, DUPRAZ & STRASSER 1999, 2002), showing increased water energy (SCHMID & LEINFELDER 1996). *Lithocodium-Bacinella* represents an association which is typical of the so-called inner ramp, developing above the wave base, in a medium to high-energy environment (SCHMID 1996). The occurrence of these organisms is typically related to coral-algal associations (LEINFELDER et al. 1994, 1996, SCHMID & LEINFELDER 1996, DUPRAZ & STRASSER 1999, SHIRAISHI & KANO 2004, and others) and stromatoporoid facies (LEINFELDER et al. 2005), although they have also been reported from thrombolite-sponge associations (KRAJEWSKI 2001, MATYSZKIEWICZ & KRAJEWSKI 2003). In the studied sediments, either *Bacinella* or *Lithocodium* occur mainly within grainstones and wackestones, being frequently accompanied by microbialites and stromatoporoids, and rarely by corals. *Lithocodium* typically develops on the outer parts of skeletal elements, whereas *Bacinella* fills either the inner parts or intra-skeletal pores (Fig. 6). Moreover, *Bacinella* frequently occurs in microbialites or fills intergranular pores in detrital sediments, leading to binding of the latter (Fig. 6).

Less frequent is *Thaumatoporella*, considered to prefer environments more open than those of *Lithocodium* and *Bacinella* (BERNIER 1984, SCHMID 1996). Like *Lithocodium*, *Thaumatoporella* tends to develop on larger bioclasts.

Tubiphytes morronensis occurs in the majority of studied sediments (Fig. 6). It is commonly considered as an organism representing environments slightly deeper than those of the *Lithocodium-Bacinella* association, showing less increased water energy and lesser oxygenation (CHIOCCINI et al. 1986, SCHMID 1996; Fig. 6). *Tubiphytes morronensis* is more common in microbial and microbial-sponge facies; it frequently fills depressions within carbonate buildups, leading to consolidation of the latter (DRAGASTAN et al. 1994, DUPRAZ & STRASSER 1999). Like *Bacinella*, it is capable of binding sediments, leading thereby to formation of the so-called *Tubiphytes* "reef" buildups (MATYSZKIEWICZ & KRAJEWSKI 1996, MATYSZKIEWICZ 1997; Fig. 6).

5. Discussion and conclusions

An overview of environmental requirements of microfauna determined in the Aj-Petri massive limestones indicates that the bulk of this buildup was developing in a shallow-marine environment. Such an environment was extremely sensitive to even minute bathymetric changes that could either isolate or open some parts of the basin, leading thereby to profound changes in environmental conditions (cf. DUPRAZ & STRASSER 1999). This may

explain frequent restriction, appearance or disappearance of microbialites, calcareous sponges, microencrusters, as well as corals or stromatoporoids in some horizons (Fig. 4). Co-occurrence of encrusting organisms, stromatoporoids, and characteristic foraminiferal genera may suggest that we are confronted with a buildup (cf. DUPRAZ & STRASSER 1999, LEINFELDER et al. 2005), which was developing mostly in a shallow-water environment. As far as the studied Aj-Petri sediments are concerned, corals occur in only small clusters in some parts of the buildup and are not important components of sediments. Therefore, the traditional descriptions of the Aj-Petri massif as an example of a coral reef are imprecise and far from reality.

The main reef-builders were microencrusters and stromatoporoids which represented one of the most important and in some parts the most important constructor of small buildups. Microencrusters bound either loose detrital sediment or skeletal elements, forming small stromatoporoid-*Lithocodium* or *Tubiphytes* buildups (Figs. 4, 6). Such buildups, together with detrital sediment compose the bulk of the large and complex construction of the Aj-Petri complex. Moreover, ubiquitous occurrence in some horizons of detrital sediment that compose the carbonate buildup can indicate that in a dynamic, shallow-water environment an important role in the formation of massive limestones, besides microencrusters and microbialites, could have been also played by intensive early diagenetic marine phreatic cementation.

The stratigraphic position of the studied part of Aj-Petri should be modified in the light of recent micropalaeontological studies. Despite numerous regional stratigraphic horizons distinguished in Aj-Petri Jajla, its stratigraphy is poorly recognised (Fig. 2a). Ammonitic fauna has not yet been reported from the Aj-Petri shallow-water reef facies. The temporal extent of characteristic foraminiferal species identified in the examined samples (BASSOULET 1997) indicates that the host sediments are not older than the Kimmeridgian, and the presence of *Rectocyclammina chouberti* HOTTINGER points to a Late Kimmeridgian age of some of the samples. On the other hand, the occurrence of *Quinqueloculina stellata* MATSIEVA & TEMIRBEKOVA and "trocholins", known since the Tithonian, implies that a part of the studied sediments can be of even Tithonian age (Fig. 2b).

The sediments are dominated by foraminiferal fauna typical of the Kimmeridgian and Tithonian. Hence, the boundary between the Oxfordian and Kimmeridgian, previously assigned to the upper part of the Aj-Petri buildup, has probably to be placed in the lower part, and the bulk of the complex belongs to the Kimmeridgian and Tithonian instead of the Oxfordian (Fig. 2).

Acknowledgements

The authors thank the reviewers A. STRASSER and D. SCHMID for their helpful reviews, J. JĘDRYS, J. MATYSZKIEWICZ and E. SZEWCZYK for their suggestions, E. RONIEWICZ for determination of the corals, G. and A. KOSTENKO, B. ROMANYUK (Ukraine) for help in material collection. This research has been financed through statutory funds AGH no. 11. 11. 140.882.

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Manuscript received: November 26th, 2005.

Revised version accepted by the Stuttgart editor: January 27th, 2006.

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