Late Triassic to Late Jurassic evolution of the Adriatic Carbonate Platform and Budva Basin, Southern Montenegro

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Abstract

Southeastern Montenegro is the only part of the Adriatic Carbonate Platform (AdCP) that bears record of its evolution from a ramp, through a distally steepened ramp to a platform. In this paper we present the sequence stratigraphy of the Late Triassic to Late Jurassic rocks from this part of Tethys for the first time in the literature. We discovered and described three new facies: hardground and cerebroid oolites of the Livari Supersequence, and black pebble conglomerate of the Tejani Supersequence. The mid-ramp and lower ramp cherty oolite, wackestone and mudstone facies of the Livari Supersequence, as well as Oolite Conglomerate facies of the Stari Bar Supersequence were partially or completely reinterpreted.

The Middle and Late Triassic rifting separated the AdCP from the other South Tethyan carbonate platforms and created the intraplatform Budva Basin. The AdCP evolved through three morphologic stages: a detached ramp (Livari Supersequence; Rhaetian–Early Toarcian), a distally steepened ramp (Tejani Supersequence; Early Toarcian–Middle Callovian) and an accretionary rimmed platform (Stari Bar Supersequence; Oxfordian to Neogene). The Rhaetian regression is marked by a regional unconformity surface that represents a type S sequence boundary at the base of the Livari Supersequence. Lowstand Wedge of the Halobia Limestone was the oldest sediment in the Budva Basin. TST and HST of the Livari Supersequence include: supratidal and intertidal inner ramp sediments, ooid shoals, and cyclic shallowing-up parasequences of the mid-ramp. Sedimentation rates were high in the inner ramp, while Budva Basin received relatively thin accumulation of siliceous plankton. A brief exposure of supratidal flats and ooid bars represents a type P sequence boundary between the Livari and the Tejani Supersequences, which was flooded by the Early Toarcian transgression. TST and HST of the Tejani Supersequence consist of supratidal, lagoon, and shoal sediments in the inner ramp, and deeper water carbonates of the mid- and outer ramp. Highstand shedding of the sediment from the steepened ramp left thick deposits in the Budva Basin. The Bathonian regression is marked by a regional unconformity that represents a type S sequence boundary between the Tejani and Stari Bar Supersequences. Stari Bar Oolite Conglomerate is a Lowstand Wedge of the Stari Bar Supersequence. The Middle Callovian transgression induced aggradation of ooid shoals deep into the platform interior. Oxfordian coral reefs created a rimmed platform and restricted export of the shallow carbonates into the Budva Basin.

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1. Introduction

Ever since the Budva–Cukali zone was recognized (Bukowski, 1926) the Dinaric Carbonate Platform was considered different from the Adriatic Carbonate Platform. Over several years other names (High Karst, Outer Dinaric belt and Dalmatian–Herzegovinian zone) were used to describe the Dinaric Carbonate Platform. Recently, Vlahović et al. (2002, 2005) proposed that all shallow and deeper water carbonates exposed along the eastern Adriatic coast belong to a single, Adriatic Carbonate Platform (AdCP). In this paper we will use AdCP acronym for the extensive, Bahamian type, south Mediterranean carbonate platform. The Late Triassic events in various Mediterranean platforms (Bosellini, 1984; Čadjenović, 1987; Burchell et al., 1990; Čadjenović and Mirković, 1992; Čadjenović and Vuisić, 1995; Blendinger et al., 2004) indicate a different evolution of the separate platforms. Thus, we propose that the SE part of the AdCP, now exposed in Montenegro, began its
evolution in the Late Triassic, rather than in late Early Jurassic, as suggested by Vlahović et al. (2005).

The focus of this paper is the southeastern part of the AdCP, which experienced unique evolution with respect to other parts of the AdCP. We recognize three major cycles of sedimentation from the Late Triassic to the Late Jurassic. The cycles are named Supersequences based on their duration (14–29 Ma) as suggested by Sarg et al. (1996). Two older Supersequences, Livari and Tejani, were completely described, and only the basal part, the Transgressive System Tract (TST), of the youngest, Stari Bar Supersequence is analyzed. In this paper we will demonstrate that the AdCP evolved from a detached ramp (Read, 1982; Schlager, 2005) (Early Jurassic) to a distally steepened ramp (Read, 1982) (Middle Jurassic), and only since the Late Jurassic became a carbonate platform (accretionary rimmed shelf of Read, 1982).

The study area is located in southern Montenegro, between the Adriatic Sea to the south, and Lake Skadar (Scutari) to the north (Fig. 1). We measured and described three stratigraphic sections (Fig. 2) that indicate three depositional environments: 1) AdCP interior; 2) the transitional zone of ramp/platform margin; and 3) Budva Basin. The chronostratigraphy (Fig. 3) is based on the fossil assemblages and regional correlation with other Tethys facies and unconformities. Two hundred samples were collected, classified in field (Dunham, 1962; Embry and Klovan, 1971) and made into thin sections. Microfacies analyses (Flügel, 2004) were combined with outcrop descriptions to define 23 carbonate facies (Wilson, 1975; Read, 1985), whose arrangement indicates stacking in three Supersequences.

2. Platform foundation

The loferite facies (Bešić, 1975; Radojičić, 1982, 1987; Obradović et al., 1985; Čadjenović and Mirković, 1992) of the Upper Triassic dolomite is the basal unit of the AdCP. The facies
is made of 0.5–1.5 m thick incomplete and seldom complete lofer cycles (Fischer, 1964; Flügel, 2004). While only the uppermost 50 m of the loferite facies is exposed in the shallow parts of the AdCP, over 1 km of its exposure is in the Budva Basin, near the town of Stari Bar (Čadjenović, 1987; Čadjenović and Mirković, 1992), as a result of Neogene thrust faulting during the Dinarides development (Obradović et al., 1985; Čadjenović et al., 2005).

The basal parts (C member of Fischer, 1964) of the complete regressive succession loferite cycles are massive, dark grey, 0.1–0.5 m packstones and wackestones. Large (10 cm) megalodontid bivalves make up the packstones while benthic forams, gastropods, and peloids float in the matrix of the wackestones. The abundance and diversity of fossils suggest that the packstones and wackestones were deposited in a shallow subtidal environment.

The mudstones and wackestones of the B member (Fischer, 1964) are usually the thinnest (0.1–0.2 m) in the loferite cycles (Fig. 4A) and made of alternating light tan dolomitic, and dark grey micritic laminae and/or stromatolites with a fenestral fabric. Rare fossils found within the B member wackestones include ostracods, gastropods and benthic forams. Laminated mudstones represent deposition in the intertidal zone with fluctuating water salinities that were inhospitable for tropical marine life. The A member (Fischer, 1964) massive mudstones are lightest in color and usually the thickest (0.3–0.6 m) part of the loferite cycles (Fig. 4A). These massive dolomites contain abundant bird’s-eye and fenestral structures, black pebble conglomerates, mudcracks, and intraformational conglomerates/breccias, paleokarstic pockets with speleothems, Neptunian dikes, limonite crusts, and bauxite (Čadjenović, 1987) representing a supratidal environment which was frequented by storms.

The cyclic deposition of peritidal and subtidal sediments on the Triassic carbonate platforms has been recognized in many other parts of the Mediterranean (Fischer, 1964; Bosellini, 1984; Zappaterra, 1994). Some loferite buildups have been reinterpreted as deeper water sediments (Blendinger et al., 2004), or as erratic, storm induced autocycles (Satterley, 1996). However, many other loferites contain a Milankovitch signature of precession (~20 kyr) driven low-amplitude sea-level oscillations (Goldhammer et al., 1990; Hinnov and Goldhammer, 1991; Pretto et al., 2001; Pretto and Hinnov, 2003). We found exposure surfaces with Neptunian dikes and speleothems on many subtidal cycle members which support allocyclic (Pretto and Hinnov, 2003) rather than autocyclic (Satterley, 1996) loferite facies origin.

3. Livari Supersequence facies

3.1. Early Budva Basin — packstone

Halobia Limestone (Degnan and Robertson, 1998) is the oldest unit overlying the Middle Triassic volcanic rocks in the Budva Basin. About 60 m thick purplish gray packstones (Dunham, 1962) occur in massive banks or thin beds that are intercalated with thin cherty layers or lenses (Crne et al., 2006). Within the banks, the packstones are parting in thin (5–10 cm)
coquina layers along the wavy surfaces. The main allochems are very well preserved delicate shells of Halobia bivalves which show no indication of transport (Table 1). Carbonate mud is trapped on the underside of the delicate shells (Fig. 5C) while the rest of the pore space is filled with spar. The Late Triassic (Rhaetian) age (Goričan, 1994) of this facies is based on conodont assemblage (Misikella hernsteina, M. posthernsteini, and Epigondolella bidentata).

Halobia packstone represents sediments of the early Budva Basin, which began opening in the Middle Triassic as one of the secondary rifts (aulacogens) of the major rift that separated the South Tethyan Megaplatform from Africa. Budva Basin was still relatively shallow when Halobia-rich waters flooded it. The influx of carbonate was low and couldn’t keep up with the accumulation of the fragile Halobia shells. Frequent storms brought open ocean microfauna of radiolarians that settled in lenses or layers between the Halobia packstones. Halobia packstone is coeval with the lower part of the Drimos Formation (Degnan and Robertson, 1998) exposed in NW Peloponnesus, Greece.

### 3.2. Supratidal — fenestral mudstone

This light grey mudstone (Dunham, 1962) contains abundant fenestrae, mudcracks, intraclasts, and a few fossils (Table 1). Some surfaces of these 0.3–0.5 m thick beds contain oncocoids and calcite lined cavities. The fenestral mudstones are mostly dolomite, and they are intercalated with bluish gray wackstones (limestone) of shallow subtidal facies. These two facies are 140 m thick near the village of Seoca in southeastern Montenegro. The microfacies of the fenestral mudstones are made of peloids, oncocoids, micritic intraclasts, and rare benthic forams and dasycladacean algae. Vadose silt, drusy linings and coarse spar fill the pores, while the oncocoids contain meniscus bridges and stalactitic cement. An abundance of fenestrae,
vadose silt, drusy calcite linings of larger pores, as well as presence of mudcracks and mud intraclasts, indicate subaerial exposure and meteoric diagenesis of the supratidal/upper intertidal facies. Tišlar et al. (2002) report similar rocks as a part of the J-1 megafacies from the western parts of the AdCP.

3.3. Shallow subtidal — wackestone

These bluish gray wackestones (Dunham, 1962) are 0.1–0.3 m thick and contain thin laminations and/or bioturbated beds. The wackestone microfacies contains peloids, benthic foraminifers, gastropods, dasycladacean algae and rare ostracods scattered in a mud matrix (Table 1). Deposition of this facies occurred in the shallow subtidal zone that was partially exposed during extremely low tides.

3.4. Shoal — ooid grainstone

The Lower Jurassic bluish gray ooid grainstone (Bešić, 1975; Mirković et al., 1976) attains a maximum thickness of 80 m near the village of Livari on the northern slopes of Mt. Rumija. Its basal contact with cherty oolitic packstone (Facies 5) is transitional, while its upper contact with the brachiopod packstone (Facies 14) is sharp and disconformable. Thin to medium bedded grainstones are intercalated with thin marl layers and thin chert lenses in the basal 10 m of this facies. The rest of this unit is either medium bedded or made of up to 2 m thick massive banks. Planar lamination (Fig. 4B) or cross lamination is present within some beds. Radial concentric ooids are the most common allochems (85%), while crinoids, peloids, dasycladacean algae and intraclasts make up the remainder of grains, which are well to moderately sorted (Table 1). Throughout most of this facies the allochems are in point contacts. Drusy spar surrounds the grains while the rest of the pore spaces are filled with a mosaic of blocky spar that increases in size toward the centers of the pores. In the upper 10 m of this facies the ooids are more closely packed, with common concavo/convex (Fig. 5A) contacts, and spalling-off the outer cortices. There is no cement between the interpenetrating grains, suggesting early compaction before the lithification of the sediment.
Ooid grainstone represents the shallowing upward upper ramp shoals (Read, 1985). Laminated beds most likely represent tidal channels, with a stronger flood tide depositing larger ooids and skeletal grains, and a weaker ebb tide depositing small ooids and peloids. Most of the ooid grainstone is cemented early, which was evidenced by the weak compaction and the remaining large, intergranular spaces filled with drusy and blocky spar. Only the top 10 m of the ooid grainstone compacted significantly.

Table 1
Livari Supersequence (Sinemurian–Toarcian) facies composition

<table>
<thead>
<tr>
<th>Facies</th>
<th>Lithology</th>
<th>Sedimentary structures</th>
<th>Fabric</th>
<th>Grains</th>
<th>Biota</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Early Basin</td>
<td>Packstone</td>
<td>Thin beds, banks, chert lenses</td>
<td>Poorly sorted, mud to</td>
<td>Skeletal allochems,</td>
<td>Bivalves, conodonts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>granule size</td>
<td>peloids</td>
<td></td>
</tr>
<tr>
<td>2. Supratidal</td>
<td>Fenestral mudstone</td>
<td>Massive beds, mudcracks, bird’s-eye</td>
<td>Poorly sorted, mud to</td>
<td>Intraclasts</td>
<td>Benthic foraminifers</td>
</tr>
<tr>
<td>3. Shallow subtidal</td>
<td>Wackestone</td>
<td>Thin beds, lamination, rare mudcracks</td>
<td>Well to moderate sorting,</td>
<td>Peloids, skeletal allochems</td>
<td>Benthic foraminifers, gasropods,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>mud to granule size</td>
<td></td>
<td>dasyycladacean algae, ostracods</td>
</tr>
<tr>
<td>4. Shoal</td>
<td>Ooid grainstone</td>
<td>Banks, medium beds, rare crossbedding and</td>
<td>Poor to moderate sorting,</td>
<td>Ooids, peloids, intraclasts,</td>
<td>Benthic foraminifers, bivalves,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lamination</td>
<td>mud to granule size</td>
<td>skeletal allochems</td>
<td>crinoids, dasyycladacean algae,</td>
</tr>
<tr>
<td>5. Mid-ramp</td>
<td>Cherty ooid</td>
<td>Thin beds, chert crusts</td>
<td>Poor to moderate sorting,</td>
<td>Ooids, peloids, skeletal</td>
<td>Benthic foraminifers, crinoids,</td>
</tr>
<tr>
<td></td>
<td>packstone</td>
<td></td>
<td>mud to medium sand</td>
<td>allochems</td>
<td>radiolarians</td>
</tr>
<tr>
<td>6. Mid-ramp</td>
<td>Wackestone</td>
<td>Thin beds</td>
<td>Poor sorting, mud to</td>
<td>Peloids, skeletal allochems</td>
<td>Benthic foraminifers, crinoids,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>medium sand</td>
<td></td>
<td>radiolarians</td>
</tr>
<tr>
<td>7. Mid-ramp</td>
<td>Mudstone</td>
<td>Thin plates</td>
<td>Poor sorting, mud to</td>
<td>Rare peloids and skeletal</td>
<td>Radiolarians, crinoids,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>very-fine sand size</td>
<td>allochems</td>
<td>calcispheres</td>
</tr>
<tr>
<td>8. Outer ramp</td>
<td>Cherty wackestone</td>
<td>Thin beds, chert lenses</td>
<td>Poor sorting, mud to</td>
<td>Skeletal allochems</td>
<td>Radiolarians, calcispheres,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>very-fine sand size</td>
<td></td>
<td>sponges, crinoids</td>
</tr>
<tr>
<td>9. Outer ramp</td>
<td>Nodular</td>
<td>Styloites, chert concretions</td>
<td>Poor sorting, mud to</td>
<td>Skeletal allochems</td>
<td>Radiolarians, calcispheres,</td>
</tr>
<tr>
<td></td>
<td>wackestone</td>
<td></td>
<td>very-fine sand size</td>
<td></td>
<td>sponges, crinoids</td>
</tr>
<tr>
<td>10. Basin floor</td>
<td>Chert</td>
<td>Bands, laminations, thin plates</td>
<td>Poor sorting, mud to</td>
<td>Skeletal allochems</td>
<td>Radiolarians, calcispheres,</td>
</tr>
<tr>
<td></td>
<td>(Passeé Jaspeuse)</td>
<td></td>
<td>very-fine sand size</td>
<td></td>
<td>sponges, crinoids, conodonts</td>
</tr>
</tbody>
</table>

Fig. 5. Livari Supersequence facies: (A) photomicrograph (crossed nicols) of the ooid grainstone (Facies 4). Patches of an early meteoric vadose spar (arrow) could not prevent compaction and spalling-off ooid cortices during the burial. Large poikilotopic spar (PS) occludes most of the pore space; (B) photomicrograph (plain light) of cherty ooid packstone (Facies 5) showing radial concentric ooid replaced by fibrous chalcedony (center). Note (arrow) late diagenetic euhedral dolomite replacing chalcedony; (C) photomicrograph (crossed nicols) of delicate Halobia shells (Facies 1) in early Budva Basin. Note mud trapped on the concave underside of the shells and spar filling intergranular space; (D) photomicrograph (plain light) of the Passe Jaspeuse formation from Budva Basin (Facies 10). Light cherty part contains partially dissolved radiolarians (R), conodonts (C), sponge spicule (S), and chert replaced echinoderms (E). Similar assemblage of the microfossils is present in darker carbonate.
before cementation took place. This indicates subaerial exposure, partial lithification and a meteoric source of early cement. Subsequent burial caused grain compaction and later growth of poikilotopic spar (Fig. 5A), which occluded the remaining pore space. In the Croatian part of the AdCP, J-5 megafacies (Tišijar et al., 2002) of the Upper Lias are of similar oolite character, while the Trento Carbonate Platform equivalent is San Vigilio Oolite (Winterer and Bosellini, 1981).

3.5. Mid-ramp — cherty ooid packstone

Brownish gray cherty ooid packstone appears in thin (0.2 m) beds with cherty crusts (F5 in Fig. 4C). About a 55 m thick section near the village of Livari (Crne et al., 2006) contains this facies stacked on top of 0.5–1 m thick shallowing upward cycles. Throughout the exposure the cherty ooid packstones have sharp upper contact with thinly laminated mudstone (Facies 7). At the top of its exposure cherty ooid packstone has a transitional contact with the ooid grainstone (Facies 4). The basal contacts of the cherty ooid packstones are transitional with mid-ramp greenish wackestones (Facies 6). Small (0.2 mm) micritic and radial ooids, pealoids, as well as crinoids and bivalves with thick micrite envelopes make up this facies (Table 1). Chert replaces the original matrix and cement as well as some of the small radial ooids, while late diagenetic euhedral dolomite (Fig. 5B) grows in the cherty areas of this facies. The cherty ooid packstones represent shallow mid-ramp deposition that received sediment from nearby shoals.

3.6. Mid-ramp — wackestone

These massive greenish grey wackstones (F6 in Fig. 4C) have transitional contacts and are the thickest units (0.2 m–0.5 m) in the middle ramp cycles. Benthic foraminifers — *Involutina jurassica*, *Miliolidae* sp., *Glomospira* sp., and *Spirillilina* sp. — (Čadjenović et al., 2005), crinoids and radiolarians are found scattered throughout this unit (Table 1). This facies represents deposition in the calmer water of the mid-ramp with more influence from the shallow ramp than from the open ocean.

3.7. Mid-ramp — mudstone

Thin (0.1–0.2 m) dark grey mudstones (marl) are at the bases of the outer ramp cycles (F7 in Fig. 4C). Rare radiolarian, calcispheres, and crinoid fossils are found along the surfaces that weather into thin papery plates (Table 1). This facies indicates deposition below the photic zone with greater influence of the open ocean than the shallow ramp environment.

3.8. Outer ramp — cherty wackestone

Thinly bedded (0.1 m) olive grey wackstones are intercalated with thin chert lenses in a 50 m thick facies. Disarticulated crinoids, sponge spicules, radiolarians, and calcispheres, are sparsely scattered in a mud matrix (Table 1). The presence of chert lenses and fossil assemblage indicate deposition in a distal outer ramp.

3.9. Outer ramp — nodular wackstone

The deepest part of the outer ramp is made of 45 m thick grey nodular wackstones with prominent stylolites and chert concretions along bedding planes. The abundant deep water biota contains radiolarians, sponges, and calcispheres (Table 1) that create intermittent packstone partings (Čadjenović et al., 2005).

3.10. Budva Basin — Passeé Jaspeuse chert

The Passeé Jaspeuse formation (Fleury, 1980) is exposed at the Stari Bar section, conformably overlying Halobia Limestone and disconformably covered by Bar Limestone (Goričan, 1994). The approximately 40 m thick unit (Crne et al., 2006) is made of red or green thinly (2–6 cm) banded chert intercalated with thin (1–3 cm) dark brown or green siliceous mudstones (Fig. 4D). The siliceous mudstones weather into thin plates along surfaces that contain microfossils. The banded chert is internally thinly laminated (Fig. 5D) with a dark carbonate rich laminae and a light siliceous laminae. Radiolarians, pelagic echinoderms, conodonts, calcispheres, and sponge spicules make up the allochems (Table 1). While most of the radiolarians were partially to almost completely dissolved, echinoderms and calcispheres retained their original shapes but were replaced by chert.

The uniform thickness of cherty bands, regularity of their intercalation with siliceous mudstones, and lack of structures indicating transport or truncation of layers, suggest that sediments of the Passeé Jaspeuse formation were deposited at a great depth without turbidity influence. Cherty bands represent the accumulation of radiolarians during times of their abundance in quiet, surface ocean waters, and minimal input of periplatform muds. Siliceous mudstones most likely accumulated during the seasons of low radiolarian populations in surface waters, when suspended periplatform muds slowly settled on the deep basin floor. Goričan (1994) determined a radiolarian association (*Katroma* with *Gigi*) from the Passeé Jaspeuse formation and considered it to be of Sinemurian to Upper Pliensbachian age.

4. Stacking patterns in the Livari Supersequence

The Middle Triassic riffling and separation of Adria from Africa (Channell et al., 1979) created the Adriatic Carbonate Detached Ramp (AdCDR) (Read, 1985; Schlager, 2005). Even though global sea level remained low through the Late Triassic and the earliest Early Jurassic, the subsiding Budva Basin was inundated by Tethys Ocean water, and Halobia Limestone (Facies 1) was deposited. The Sinemurian transgression (Vail et al., 1984; Hallam, 2001; Ruiz-Ortiz et al., 2004) flooded the AdCDR interior. The facies arrangement (Fig. 9) along the mid-ramp indicates shallowing-up parasequences (Van Wagener, 1995) which are stacked in the progradational parasequence sets. The Sinemurian—Early Toarcian sedimentation is best preserved at Livari (Figs. 1, 3, and 9) and represents a Supersequence (Sarg et al., 1996) with a basal S boundary (Schlager, 2002; 2005) and a flooding surface (P boundary) on top. Parasequences of the Livari
Supersequence generally consist of two lithologies, except the mid-ramp which consists of three distinct components. Cherty crust on top of the cherty oolitic packstone (Facies 5) represents a rapid transgression, starvation of carbonate sedimentation, and the settling of the open ocean radiolarians. Marl (Facies 7) at the base of the parasequence is dominated by radiolarians, but the wackestone (Facies 6) in the middle of the parasequence contains mixed biota of benthic foraminifers and radiolarians. The gradual increase in ooid content through the top part of the parasequence indicates a filling of the sedimentation space by prograding shoals. Five to eight parasequences make up a 3–5 m thick parasequence set.

Fig. 6. (A) The Briska Breccia with angular clasts derived from the loferite facies and the supratidal fenestral mudstone (Facies 2). (B) Supratidal black pebble conglomerate (Facies 11) on the top of the Tejani Supersequence. The tip of the hammer is 5 cm long. (C) Banks of lagoon packstones (Facies 12) full of lithiotis bivalves. (D) The hardground surface (arrow) at the top of the middle ramp wackestones (Facies 15), overlain by the ooid grainstone of hypersaline shoal (Facies 13). (E) Intercalated wackestones and marl from the lower ramp (Facies 16). The wackestone nodules (arrows) are separated by massive marl. (F) Thin to medium bedded Bar Limestone from the Budva Basin slope (Facies 17). Note lateral change in bed thickness, irregular bedding surfaces, chert intercalations (arrow) and convolute bedding (CB). (G) Stari Bar Oolite Conglomerate (OC) makes the base of the Stari Bar Supersequence in the Budva Basin (Facies 18). Deep water chert of Lastva Radiolarite (LR) represents a TST of the Stari Bar Supersequence. (H) Close up view of the Stari Bar Oolite Conglomerate facies.
The lack of evidence of Lower Jurassic glaciations leads us to suggest that the thermal expansion of deeper ocean water (Schulz and Schafer-Neth, 1997) or changes in lake and groundwater storage (Jacobs and Sahagian, 1993) caused cyclic deposition of parasequences in the Livari Supersequence. Both of the proposed models rely on Milankovitch’s 20 kyr precession of the equinoxes climate change cycles.

5. Renewed tectonism and Early Toarcian transgression

5.1. Briska Breccia

The Lower Jurassic breccia (Bešić, 1975; Mirković et al., 1976) appears as discontinuous lenses that reach up to a 45 m thickness in the vicinity of the Upper Briska and Lower Briska villages (Fig. 1, near Locality 2). The basal parts of the breccia are made of light gray to tan clasts (0.1 to 0.5 m) of the loferite facies (Fig. 6A). In its upper part the Briska Breccia contains smaller clasts of fenestral mudstone (Facies 2) and wackestone (Facies 3). Reddish calcareous silt and calcite cement bind the carbonate clasts.

Renewed Lower Jurassic extensional tectonism (Channell et al., 1979) broke up parts of the exposed ramp facies of the Livari Supersequence and created a lagoon in the inner ramp. The subsidence in the mid-ramp coincided with Toarcian transgression (Haq et al., 1987; Hallam, 1988; Jenkyns, 1988) which induced carbonate sedimentation in the Tejani Supersequence.

6. Tejani Supersequence facies

6.1. Supratidal — black pebble conglomerate

This is about 10 m thick light gray to dark blue fenestral mudstone, which contains intraformational black pebble conglomerates (Fig. 6B) in the upper 2 m of its exposure. The basal contact with the ooid grainstone (Facies 13) is transitional. The floors of bird’s-eye and other cavities in the fenestral mudstone contain peloids and vadose silt (Fig. 7A). Microstalactitic spar grows from the cavity ceilings, while the blocky spar fills the remaining pore space. The black pebble conglomerate consists of light gray and dark brown micritic clasts and oolitic intraclasts, cemented by blocky spar or binded by vadose silt (Table 2). This facies represents progradation of supratidal flats over the shoals.

6.2. Lagoon — Lithiotis wackestone/packstone

This Lower Jurassic Lithiotis Limestone (Mirković et al., 1976) is made of bluish, medium bedded (0.3 m) wackestones, which are intercalated with banks (1 m) of brownish wackstones and packstones (Fig. 6C). Near the village Seoca (Fig. 1, Fig. 7. Microfacies of the Tejani Supersequence: (A) photomicrograph (crossed nicols) of fenestral pores in the black pebble conglomerate (Facies 11). Small peloids and vadose silt fill the bottom of the pore, while stalactite druses (arrow) grow from the cavity roof. Blocky spar fills the rest of the pore; (B) photomicrograph (crossed nicols) of cerebroid ooids in the shoal/pond ooid grainstone (Facies 13). Note circumgranular spar (1) as the earliest cement, followed by the vadose geopetal fill (2), large bladed cement (3), and blocky spar (4) in the center of the pores; (C) photomicrograph (crossed nicols) of the vertical boring (outlined by arrows) at the hardground surface in the lower ramp wackstone (Facies 15); (D) photomicrograph (crossed nicols) of the Stari Bar Oolite Conglomerate of the Budva Basin (Facies 18). The clast is composed of partially lithified ooid grainstone (left, Facies 4) and cherty ooid packstone (right, Facies 5) derived from the upper ramp facies of the Livari Supersequence.
Locality 1) this facies attains about a 300 m thickness. The banks have a sharp base made of broken bioclast packstones that gradually pass into wackestones with scattered whole fossils. The tops of the banks consist of thin bioclastic or oncoidal packstones. There is an abundance of shallow water fauna which includes a variety of benthic foraminifera (Miliolidae sp., Textulariidae sp., Orbitoparella praecursor, Vidalinae martana, Pseudocyclammina sp.), several species of algae (Thaumatoporella parvovesiculifera, Palaedasycladus mediterraneus, Cyanophytae sp.), bivalve Lithiotis problematica, some gastropods and echinoderms (Table 2). A thin (0.2 m) veneer of nodular packstone that contains reddish ooids caps this facies.

The abundant and diverse fauna in this facies indicates a normal marine, lagoon environment of deposition. The presence of the lithiotis packstones suggests shallowing and stormy conditions during the facies deposition. In the western part of the AdCP Tišljar et al. (2002) classify similar rocks as J-4 megafacies, found within the Middle Liassic strata. The lagoon wackstone/packstone facies is coeval and lithologically very similar to the Calcare Grigi Formation (Bosellini and Broglio Loriga, 1971; Zempolich, 1993) of northern Italy, and the middle member of the Gavilan Formation (Ruiz-Ortiz et al., 2004) of Spain. This association of lithiotis bivalves, foraminifera, and algae was widespread in the southern Tethys carbonate platforms while it was almost totally absent in the northern Tethys (Channell et al., 1979). Near the end of this facies deposition, a brief episode of starvation in sediment production occurred during the establishment of shoals.

6.3. Shoal — ooid grainstone

The ooid grainstone facies has sharp basal contact with lagoon wackstones/packstones (Facies 12) and mid-ramp crinoid (Facies 14) wackestones (Fig. 6D). Its upper contact with the supratidal black pebble conglomerate (Facies 11) is transitional. In previous works (Mirković et al., 1976) this facies was described as part of the Middle Jurassic oolitic and pseudo-oolitic limestones. The bluish gray ooid grainstone is about 20 m thick and made of thin to medium beds (0.1–0.3 m) intercalated with massive banks (1–1.5 m). An almost total lack of sedimentary structures, except for sporadic storm layers within the banks, typifies this facies. The thin to medium beds contain small (0.3–0.5 mm) ooids with tangential and micrite cortices, peloids, intraclasts, and rare bioclasts (Table 2). The banks contain larger (0.5–2 mm) micritic, and tangential ooids, common cerebroid (Carozzi, 1962) ooids, peloids, intraclasts, as well as rare gastropods and ostracods. The cerebroid ooids (Kilibarda et al., 2006) are best developed near the top of the facies exposure at the Tejani village. Small, radial concentric or micritic ooids are the most common nuclei, around which 0.1–0.5 mm thick cerebroid cortices developed. While most cerebroid ooids are spherical (Fig. 7B) there are also elliptical, irregular, elongated, and dumbbell shapes, determined by the nucleus type. Other cerebroid ooid nuclei are made of gastropod, echinoderm, and ostracod grains enveloped in carbonate mud, and then coated by a cerebroid cortex. These well sorted cerebroid ooids have open fabric with several generations of cement (Fig. 7B).

The ooid grainstones are deposited along the ramp shoals that were spreading landward and prograding basinward. Shoaling along the upper ramp created some protected pools, where cerebroid ooids were forming. The scarcity of fossils in this facies suggests elevated salinities during dry seasons (Kilibarda et al., 2006). The best modern analog of this facies depositional environment is the hyper saline shallow water of the Great Salt Lake (Carozzi, 1962; Sandberg, 1975). We suggest that increased evaporation during the dry seasons elevated calcium-carbonate concentrations and induced cerebroid ooid growth, while more diluted and agitated waters during monsoon seasons (Jacobs and Sahagian, 1993) caused abrasion of the outer cerebroid cortices. The prograding shoals changed the geometry of a depositional environment into a distally steepened ramp (Read, 1985). The ooid grainstone facies are coeval and similar to the San Vigilio Oolite (Winterer and Bosellini, 1981) of the Trento plateau (Italy), and Ternowaner Oolite (Bosellini et al., 1981) of the Friuli platform (Italy).
6.4. Inner ramp — brachiopod packstone

About a 60 m thick bluish gray packstone is made of medium to thin beds (0.1–0.4 m) intercalated, in its upper part, with thin lenses (<0.1 m) of dark gray to tan mudstone (marl). Basal contact of this facies with ooid grainstone (Facies 4) is sharp and unconformable, while its upper contact is transitional with the outer ramp mudstone (Facies 16). The sedimentary structures within the mostly bioturbarited beds are rare and include planar lamination and graded beds. Some beds are coquinas made almost entirely of Terebratulid and Rhyncho-

6.5. Mid-ramp — crinoid wackestone/packstone

This thin to medium bedded (0.1–0.3 m) brownish gray crinoid wackestone (Fig. 6D) is about 35 m thick. Within the beds, thin (5 cm) packstone layers erratically occur. Crinoids, peloids, brachiopods and benthic foraminifers are scattered throughout the carbonate mud (Table 2). The top of this facies is capped by a thin (0.1 m) hardground surface (Fig. 6D). This brecciated hardground surface contains reddish limonite nodules and crusts, and greenish films of glauconite. A mixed fauna of brachiopods, echinoderms, juvenile ammonites, and foraminifers is found along the bored (Fig. 7C) hardground surface.

Crinoid wackestone represents the beginning of the prograding regressive sedimentation in the mid-ramp setting. Brachiopods and benthic forams in the lower part of the facies suggest sedimentation within the photic zone. Near the end of this facies deposition crinoids became the dominant fauna while ammonite presence suggests open ocean influence. The bored surface with juvenile ammonites indicates submarine hard-

6.6. Outer ramp — wackestone/mudstone (marl)

The very thinly bedded (0.1 m) and nodular tan wackestones are intercalated with gray, massive or papery, marls (Fig. 6E) and comprise about a 10 m thick outer ramp facies. This facies conformably overlies brachiopod packstones (Facies 14) and is

conformably overlain by crinoidal wackestones (Facies 15). Tan wackstone nodules were separated by massive grey marls (Fig. 6E), while the thinly bedded wackestones frequently have wavy or scoured surfaces. The wackestones contain pelagic microfossils of radiolarians, echinoderms, and sponges that float in a mud matrix (Table 2). The massive marls are devoid of fossils, and the laminated marls weather in thin plates along the surfaces that contain radiolarian fossils. This facies represents the peak of Toarcian transgression along the ramp, when waters became too deep for brachiopod or crinoid growth.

6.7. Budva Basin lower slope — Bar Limestone

Bar Limestone as originally described by Goričan (1994) consists of a lower and upper member. We will introduce a new formation, Stari Bar Oolite Conglomerate, for Goričan’s previous designation of the upper member, and retain the name Bar Limestone for Goričan’s lower member. Bar Limestone is 180 m thick (Fig. 6F) and consists of very thin (<0.1 m) to medium bedded (0.3) light gray to purplish gray limestones. In the lower part of the formation medium thick beds predominate, while in the upper part thin beds are more common. The surfaces separating the beds are frequently irregular. A lateral change in bed thickness is also common, with pinch-outs or partings on the other end. Convolution of the thinner beds (Fig. 6F) is common throughout the unit. Intercalations of thin chert layers or lenses and conglomerate beds occur intermittently at intervals of 2–5 m throughout the Bar Limestone. The medium beds are predominantly rudstones (Embry and Klován, 1971) made of a variety of clasts including echinoderms, ooids, peloids, micritic lithoclasts with shallow water fauna, and micritic intraclasts with radiolarians and calcispheres. The thin beds are floatstones (Embry and Klován, 1971) predominantly composed of micritic intraclasts, with radiolarians and calcispheres mixed with shallow water ooids, peloids and calcareous algae (Table 2). Partial to complete chertification of skeletal allochems commonly occurs below cherty intercalations.

The sharp and irregular surfaces of the bedding planes, rapid changes in beds geometry and thickness, convolute beds, and cherty lenses indicate deposition of Bar Limestone along the Budva Basin slope. Quiet deposition of fine muds with pelagic fauna was frequently interrupted by debris flows (Obradović et al., 1988) from the ramp. The mixture of lithoclasts with shallow water allochems (ooids, peloids, echinoderms) and intraclasts with deep water allochems (radiolarians, calcispheres) is a good indication of a transitional environment between the shallow ramp and the deep basin. The lenticular nature of these deposits, which laterally pinch-out and reappear as much thinner and narrower lenses, suggests apron like deposits forming at the bases of submarine canyons. Cherty layers or lenses may represent breaks between debris flow events.

7. Stacking patterns in the Tejani Supersequence

The Tejani Supersequence stacking pattern (Fig. 9) resembles sedimentation sequences in the Livari Supersequence,
having the most diverse lithologies in the mid-ramp. Lagoon and inner to mid-ramp parasequences consist of shallowing-up 0.5–2 m thick packstones to wackestones, and ooid grainstones to ooid packstones. The outer ramp cycles (Facies 16) are thinnest (<0.2 m) and consist of marl to wackstone parasequences. Lower slope sedimentation of flowstones and rudstones (Facies 17) is too chaotic to be considered cyclic. Even though thin marl and chert layers in these facies may reflect cyclic sea-level rises, much thicker flowstone and rudstone components were induced not only by cyclic sea-level falls, but also by frequent storms and tectonic activity.

8. Stari Bar Supersequence facies

8.1. Budva Basin upper slope — Stari Bar Oolite Conglomerate

The Stari Bar Oolite Conglomerate is about 200 m thick (Fig. 6G) and conformably overlies Bar Limestone (Facies 17), while its upper contact with Lastva Radiolarite (Facies 21) is sharp and disconformable. Four cycles (Goričan, 1994) of massive bluish gray rudstones are separated by 5–10 m thick resedimented cherty floatstones. The massive rudstones are made of well rounded clasts (1–15 cm diameter) of ooid grainstone (Fig. 6H), wackestone, and packstone. Comparisons of clasts’ composition with the lithology of ramp facies suggest identical grain assemblages with ooid grainstone (Facies 4) and cherty ooid packstone (Facies 5) of the Livari Supersequence (Fig. 7D). The conglomerate clasts are mixed with loose ooids derived from the prograding shoals (Facies 13). The dark grey cherty floatstones contain pelagic radiolarians and calcispheres mixed with shallow water ooids, algae, and echinoderms.

The Stari Bar Oolite Conglomerate represents an upper slope deposition of carbonate material generated at the ramp. The lack of planar or cross-stratification within the beds, their conglomeratic character, and the chaotic mixture of the clasts from different formations indicate transport of partially consolidated Tejani Supersequence material along the slope and its mixing with older, partially lithified Livari Supersequence sediments. Debris flow episodes, which brought shallow water coarser carbonates, were separated by fine grained deeper water sediments. The upper 20 m of the Stari Bar Oolite Conglomerate, which lacks fine grained layers, represents the end of the regressive sequence in the Budva Basin. The very similar facies of Vajont Oolite (Zempolich and Hardie, 1997) in Beluno Basin are coeval with the Stari Bar Oolite Conglomerate.

8.2. Shoal — ooid grainstone

Banks (1–2 m) of bluish gray ooid grainstone reach a thickness of about 30 m near Livari (Fig. 1, Locality 2), but this unit is much thicker (over 80 m) in western Montenegro. The basal part of this unit contains closely packed medium sized ooids mixed with large lithoclasts derived from the underlying black pebble conglomerate (Facies 11). The rest of the unit is almost pure oolite, which frequently contains storm layers (Fig. 8A). Storm layers contain large ooids, pisoids, intraclasts (Fig. 8B), grapestones, and a few skeletal allochems (Table 3). The ooids have a micritic and/or tangential cortex, which is thinner than the nuclei. Throughout most of this unit grains are floating or in point contacts. The circumgranular cement is succeeded by a large, radiaxial bladed spar followed by mosaic blocky spar in the centers of the larger pores. Larger clasts of corals (Fig. 8A) and calcareous sponges are common near the top of this facies.

The ooid grainstones indicate transgression and a return of the shoals, in which agitated waters incorporated some of the reworked black pebble clasts and larger chunks of dasycladacean algae. Brief exposure surfaces and temporary interruptions of slow transgression were revealed by closely packed oolitic lithoclasts with meniscus cement. A gradual increase in the abundance of corals and calcareous sponges near the top of the ooid grainstone indicates deepening and an eventual fixing of mobile shoal sand by the establishment of platform margin reefs.

8.3. Platform margin — framestone

A bluish gray massive framestone (Embry and Klovan, 1971) conformably overlies the ooid grainstone (Facies 19) and appears as broad discontinuous convex-up bodies (Fig. 8C) that in places reach a relative thickness of over 50 m. Colonial corals (Columnocoenia jurassica, Pseudocoenia sp.) and calcareous sponges are largest components of the boundstones, between which foraminifers (Kurnubia palastinensis, Pfenderina salenitana, Trocholina elongata), algae (Bacinella irregularis), and carbonate debris are scattered (Table 3). The boundstone represents establishment of reef communities that created an elevated AdCP margin, which restricted export of the shallow water carbonate sediments into the Budva Basin.

8.4. Budva Basin — Lastva Radiolarite

Lastva Radiolarite Goričan (1994) is about 40 m thick and consists of green and red cherts near Stari Bar (Fig. 1, Locality 3). The lower 15 m of the formation consists of thinly bedded (5–15 cm), dark green (Fig. 8D) cherts with very rare, dark brown thin (1 cm or less) shales. Bedding planes are sharp but frequently show wavy, undulating surfaces. A variety of partially dissolved radiolarian fossils are scattered in an almost pure silica matrix (Table 3). The upper 25 m of the Lastva Radiolarite is made of red ribbon chert (Goričan, 1994). Red argillaceous limestone intercalations are common between the chert layers. The red cherts contain better preserved radiolarians than the green cherts, but also contain sponge spicules and chertified calcispheres.

We agree with Goričan’s (1994) interpretation of Lastva Radiolarite as a product of cratonic deep-sea sedimentation. The green chert lacks carbonates and most likely represents sedimentation below the CCD (Bosellini and Winterer, 1975). Its green color indicates higher sedimentation rates of organic matter which caused a reducing environment during early diagenesis. Winterer and Bosellini (1981) described green chert with thin shale intercalations of the lower Selcifero Lombardo from the western part of Lombard Basin, which they consider to
be of Callovian–Oxfordian age. The lower part of the Aroania Chert Member of the Lesteena Formation (Degnan and Robertson, 1998) in Greece is coeval and lithologically very similar to the green chert of the Lastva Radiolarite. The red chert and reddish argillaceous limestone from the upper Lastva Radiolarite suggest depth above CCD (Bosellini and Winterer, 1975), which might have been a result of more intense bottom water circulation rather than shallowing of the Budva Basin (Goričan, 1994). The red chert of the Aroania Chert Member of the Lesteena Formation (Degnan and Robertson, 1998) in Greece is coeval and very similar to the red chert of the Lastva Radiolarite. The uppermost part of the Selcifero Lombardo from the western part of the Lombard Basin has been assigned the Oxfordian–Kimmeridgian age (Winterer and Bosellini, 1981) and is coeval with the upper part of the Lastva Radiolarite.

9. Discussion

The Middle Triassic separation of Adria from Africa (Bortolotti and Principi, 2005) generated numerous secondary rifts that defined boundaries between the smaller platforms, which were originally part of a single South Tethyan Megaplatform (Vlahović et al., 2005). Renewed tectonic activity during the Late Triassic (Bosellini and Hsu, 1973; Dercourt et al., 1986; Ziegler, 1988) caused separation of AdCP from the other South Tethyan platforms. The Rhaetian regression (Hallam, 1988, 2001) exposed platform sediments (loferite facies) to surface weathering, karstification, and bauxite development (Pajović, 2000) while the young Budva Basin was inundated by Tethys water. The Rhaetian regression created the type 1 sequence boundary (Posamentier and Vail, 1988; S boundary of Schlager, 2002;

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of the Livari Supersequence. The Halobia Limestone was deposited in relatively shallow – within the photic zone – water but well below the wave base, because the fragile shells do not show any signs of abrasion or major reworking. The Halobia Limestone represents the Lowstand System Tract (Posamentier and Vail, 1988) of the Livari Supersequence.

The Sinemurian transgression (Hallam, 2001) coincided with tectonic rifting and the opening of the Dinaric–Hellenic basin (Dercourt et al., 1986; Zeigler, 1988). The rifting also caused differential settling of platform blocks along several secondary normal faults and the southeastern part of the Adriatic Platform achieved geometry of a detached ramp (AdCDR) (Read, 1982; Schlager, 2005) that would persist through the Lower Jurassic. The Transgressive System Tract (Posamentier and Vail, 1988) of the Livari Supersequence consists of cherty wackestone (Facies 8) and nodular wackestone (Facies 9). The predominance of marls and cherty lenses in these facies indicates a depth of several hundred meters, most likely below the photic zone. The basal part of the wackstone (Facies 3) represents TST in the AdCDR interior. We did not recognize a maximum flooding surface (Van Wagoner, 1995) in the subtidal wackstones (Facies 3). Most of the Livari Supersequence was deposited during the Highstand System Tract (HST) (Posamentier and Vail, 1988). Mid- to outer ramp parasequences (Facies 4, 5 and 6) were prograding basinward and shedding some carbonate mud that settled between the siliceous ooze buildups in the Budva Basin (Facies 10). The ramp interior was filling with subtidal wackestones (Facies 3) and prograding supratidal mudstone (Facies 2), while ooid grainstone (Facies 4) shoals were prograding over the mid-ramp.

The Pliensbachian regression (Hallam, 1988) was depositional (Schlager, 2005) in the AdCDR, and exposed parts of some shoals and ramp interior, but did not change the sedimentation pattern in the Budva Basin.

The Early Toarcian transgression (Haq et al., 1987, 1988; Hallam, 1988, 2001; Jenkyns, 1988) coincided with tectonic activity in the AdCDR, which created a protected lagoon behind the higher ramp rim. A sequence P boundary (Schlager, 2002, 2005) separates the Livari Supersequence from the Tejani Supersequence. Brachiopod packstone (Facies 14) represents initial stages of Toarcian transgression (TST) that culminated by deposition of wackestone/marl (Facies 16). Highstand productivity

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Fig. 9. Detached ramp–distally steepened ramp–Adriatic Carbonate Platform evolution from Rhaetian to Oxfordian in the southern Montenegro. Numbers next to lithologies correspond to the facies descriptions in text. SB — type S sequence boundary and PB— type P boundary (Schlager, 2005). Location of three measured sections is shown.
and filling of the sedimentation space (HST) in the mid-ramp was revealed by deposition of crinoidal wackestone/packstone (Facies 15). Relatively high sedimentation rates in the inner ramp kept up with the pace of rising sea level and maintained same lithologies with cyclic character. About 1–2 m thick lagoon parasequences are shallowing up, from lithiotis rich subtidal packstone to shallower lithiotis wackestone (Fig. 9; Facies 12). Highstand sedimentation led to formation of shoals and deposition of ooid grainstone (Facies 13). Shoals restricted exchange of water and nutrients between lagoon and open ocean, causing starvation in lagoon sedimentation and deposition of thin nodular limestone on top of the lithiotis packstones/wackestones. The shoals, in addition to intensified bottom currents (Rais et al., 2007), also diminished sedimentation in the mid-ramp and caused ground development on top of the crinoid wackestone/packstone (Facies 15). Prograding shoals induced gravity flows that carried middle and outer ramp sediments into Budva Basin. Gravity flows removed not only unconsolidated ramp sediments but also scoured older, partially lithified, sediments of the Livari Supersquence, mixing them in flowstones and rudstones (Facies 17) of the Budva Basin. Buildup of shoals flattened the mid-ramp, and gravity flows increased the slope of the outer ramp, changing the AdCDR geometry to a distally steepened ramp (AdCDSR) (Read, 1982).

The Bathonian regression (Haq et al., 1987, 1988; Hallam, 1988, 2001) caused inner ramp exposure and development of black pebble conglomerate (Facies 11), which represents a type 1 (Posamentier and Vail, 1988) or S (Schlager, 2002; 2005) sequence boundary, which separates the Tejani and Stari Bar Supersequences.

The Stari Bar Oolite Conglomerate (Facies 18) is a Lowstand Wedge (Schlager, 2005) in the Budva Basin, at the base of the Stari Bar Supersquence. Similar coarsening of the sediment in the basin-slope settings during the sea-level lowstands was reported from the Early Jurassic of northern Italy (Bosellini et al., 1981; Zempolich, 1993), the Early Jurassic of Morocco (Blomeier and Reijmer, 2002), Cretaceous of France (Everts et al., 1999), and Quaternary of Bahamas (Grammer and Ginsburg, 1992).

The Middle Callovian transgression (Hallam, 2001) was one of the most important deepening events in the whole Jurassic. The ooid shoals (Facies 19) advanced over a weathered black pebble conglomerate (Facies 11) representing TST of the Stari Bar Supersquence. Even though most of ooid grainstones facies in other platforms and ramps were attributed to shoaling processes during the HST and LST, there is another example (Husinec and Read, 2006) of TST ooid facies in the AdCP. Rising waters over the platform provided stable, normal marine conditions in which corals and calcareous sponges began to grow and fix oolitic sand. Gradual transition between the ooid grainstone (Facies 19) and the overlying reef framestone (Facies 20) indicates that sedimentation kept pace with the rising sea level. Development of reefs (Radioč, 1988) near the end of the Middle Jurassic created an accretionary rimmed margin (Ginsburg and James, 1974; Read, 1982) and established a true carbonate platform environment. In the Budva Basin, TST sedimentation is revealed in the Lastva Radiolarite (Facies 21). The lack of carbonates, the ribbon-like nature, and green color of the Lastva Radiolarite lower cherts indicate a deeper water (Bosellini and Winterer, 1975) and larger amplitude of transgression than the Early Jurassic transgressions, which deposited Passeé Jaspeuse cherts.

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