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Upper Jurassic Platform succession with characteristics of a deeper water intraplatform trough (Mt. Svilaja, Croatia)

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From the middle part of the Late Jurassic (Kimmeridgian), the hitherto uniform depositional environment of the Adriatic carbonate platform began to show differentiation. In the central part of the platform two intraplatform troughs were formed, one of which stretched from the Karlovac area southward and is known as the Lemeš Trough. The depositional processes that took place within this trough can be observed in the sedimentary succession of Mt. Svilaja. Based on investigated facies characteristics five lithofacies units were distinguished, representing three paleoenvironmental units: (1) shallow subtidal zone below the fair-weather wave-base; (2) intraplatform trough; (3) shallow subtidal zone above the fair-weather wave-base. The environmental changes are related to the tectonically-controlled retrogradation of the shallow subtidal platform, when the deeper-water intraplatform trough area, connected with the open Tethys realm, spread over the sunken part of the platform. Progressive infilling of the trough with bioclastic material led to the re-establishment of the shallow subtidal environment, and the area of the previously existing intraplatform trough was occupied by coral-hydrozoan reefal buildups.

Key words: Upper Jurassic, intraplatform trough, Adriatic carbonate platform, Mt. Svilaja, Croatia

Introduction

The Jurassic carbonates of the Karst Dinarides were deposited in shallow-water platform environments, within the realm of the Adriatic carbonate platform (ACP). Until the Middle Triassic this area represented a part of the northern Gondwana shelf, characterized by deposition of siliciclastics and carbonates. During the Middle Triassic the shelf disintegrated and the huge shallow-water

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shelf fragment of the Adria Microplate came into being within the Tethyan realm (Bernoulli and Jenkyns 1974). During late Early Jurassic the disintegration of the Adria Microplate resulted in the formation of three isolated platforms, the Adriatic–Dinaric, Apenninic, and Apulian, respectively. These were separated by deep-water basins, the Adriatic and Molise–Lagonero Basins, respectively (Velić et al. 2003). From the late Early Jurassic until the end of the Cretaceous, shallow-water carbonate deposition prevailed in the ACP area. Today, the ACP platform carbonates crop out in an area extending from the Slovenian Kras, along the eastern Adriatic coast to the Krasta-Cukali Trough in Montenegro and Albania, covering an area of about 700 by 150 km (Velić et al. 2002a).

This paper summarizes the result of my studies of the sedimentary features of the formations of Mt. Svilaja. Numerous facies studies have been carried out on the Upper Jurassic of the Karst Dinarides (e.g. Furlani 1910; Ziegler 1963; Chorowicz and Geyssant 1972; Radoičić 1966; Gušić 1969; Milan 1969; Gušić and Babić 1970; Babić 1973; Savić 1973; Nikler 1978; Ćosović 1987; Velić and Tišljar 1988; Tišljar et al. 1989; Tišljar and Velić 1991, 1993; Tišljar et al. 1994; Velić et al. 1994, 1995, 2002a, b; Bucković 1995, 2006a, b; Bucković et al. 2004). The intention of this paper therefore is to contribute to the knowledge of the sedimentary characteristics of the Upper Jurassic formations based on studies of a lesser-known Upper Jurassic section on Mt. Svilaja.

General characteristics of the Karst Dinaridic Upper Jurassic carbonates

Unlike the underlying Lower and Middle Jurassic carbonates, those of the Upper Jurassic comprise a greater variety of facies types, reflecting a more differentiated platform. Thus, in the area of the ACP three significantly different lithofacies types of the Upper Jurassic formations can be distinguished that were formed in different platform subenvironments: (1) typical shallow-water platform carbonates; (2) shallow-water platform carbonates, but partly with pelagic, deeper-water characteristics; (3) shallow-water platform carbonates, punctuated by an emersion.

(1) Shallow-water platform carbonates are the most common and typically exposed in the western Gorski Kotar area (e.g. Tišljar and Velić 1993; Bucković et al. 2004; Bucković 2006a). The boundary between the lower and upper portion of the Upper Jurassic succession is marked by the first appearance of *Clypeina jurassica* Favre. The lower portion of the Upper Jurassic carbonates is predominantly mud-rich, whereas its higher portion is built up of more grainy facies types. Thus, the Upper Jurassic levels consist of successive series of shallowing/coarsening-upward cycles with ooidal/pisoidal lower/upper cycle members and common emersion features.

(2) The eastern and southeastern Gorski Kotar, Lika and Dalmacija are regions where shallow-water lower parts of Upper Jurassic carbonates are overlain by deeper-water intraplatform trough carbonates, ending the Upper Jurassic

succession with overlying shallow-water carbonates again. These deeper-water intraplatform trough carbonates are well known by the name "Lemeš Beds", after their type locality the Lemeš Pass on Mt. Svilaja (Furlani 1910; Ziegler 1963; Chorowicz and Geyssant 1972).

(3) The third Upper Jurassic development occurs in Istria and in the southern Dalmatian area (Velić and Tišljar 1988; Tišljar et al. 1989). It begins similarly as the Upper Jurassic succession in the western part of Gorski Kotar: mud-rich carbonates are overlain by successive series of coarsening-upward cycles. However, contrary to the Upper Jurassic shallowing/coarsening-upward cycles in the western Gorski Kotar area, these cycles consist of thicker upper-cycle members, with ooidal-bioclastic texture and distinct sedimentary features. Additionally, in Istria, the upper cycle members contain a considerably richer macrofossil assemblage, abundant in fragments of Cladocoropsis, various mollusk debris, large hydrozoans and coral "heads". Beginning with the Early Kimmeridgian a regressive tendency can be recognized. Breccia, and locally bauxite deposits (Istria), indicate terrestrial conditions. In the Late Tithonian transgressive events led to re-establishment of shallow-water conditions and accordingly successive series of peritidal shallowing-upward sequences were formed (Velić and Tišljar 1988; Tišljar et al. 1989).

Description of facies and depositional environments

The investigated succession from Mt. Svilaja (Fig. 1) consists of carbonate beds ranging from the lower to the upper part of the Upper Jurassic, with a total thickness of approximately 520 m. Field data suggest a subdivision of this succession into five lithofacies units (Fig. 2), as follows: (1) Svi-1 unit – shallow-water pelletal-bioclastic wackestone and mudstone; (2) Svi-2 unit – deeper-water pelletal-bioclastic wackestone-packstone with sporadic intercalations of pelletal-bioclastic wackestone-packstone/floatstone ("Lemeš Beds"); (3) Svi-3 unit – deeper-water pelletal-bioclastic wackestone-packstone with frequent intercalations of chert ("Lemeš Beds"); (4) Svi-4 unit – deeper-water pelletal-bioclastic wackestone-packstone with frequent intercalations of peloidal-bioclastic wackestone-packstone/floatstone ("Lemeš Beds"); (5) Svi-5 unit – shallow-water pelletal-bioclastic wackestone/floatstone and grainstone/rudstone.

Svi-1 unit

Description: Unit 1 is characterized by a 110 m-thick succession of pelletal-bioclastic wackestone and mudstone. The pelletal-bioclastic wackestone contains pellets, fragments of foraminifera, tiny bivalves, gastropods, ostracodes and echinoderms as well as, sporadically, coarser peloids (micritized bioclasts and/or rounded intraclasts?). Algal oncoids and angular to rounded micritic intraclasts, together with coarser mollusk fragments in micrite, occur only sporadically. The

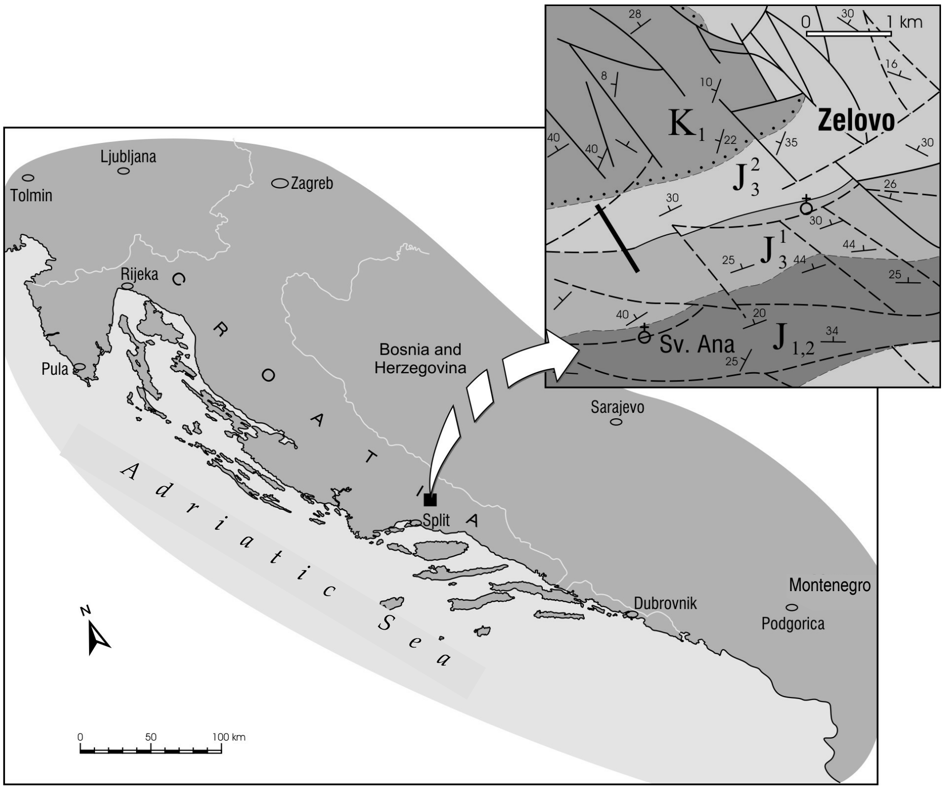


Fig. 1
Geographic position of the investigated succession (studied section is exposed along the thick line). Dashed line marks the recent position of Kimmeridgian troughs and northeastern ACP–Tethys margin – Dragičević and Velić 2002; Vlahović et al. 2005, modified). Geologic sketch according to Basic Geologic Map 1:100000, sheet Sinj (Papeš et al. 1982). $J_{1,2}$ – Lower and Middle Jurassic, J_3^1 – lower Upper Jurassic, J_3^2 – upper Upper Jurassic, K_1 – Lower Cretaceous

mudstone contains small amounts of pellets, foraminiferal skeletons (indeterminable lituolids and valvulinids) and tiny mollusk bioclasts. In places both texture types contain variable amounts of late diagenetic euhedral dolomite crystals dispersed in the pelletal/micritic matrix (Fig. 3a). The upper part of this unit comprises several, 2–7 m thick, late diagenetically dolomitized intervals. Almost every wackestone sample contains foraminiferal/algal skeletons. Among these *Redmondoides lugeoni* (Septfontaine) (Fig. 3a), *Kurnubia palastiniensis* Henson (Fig. 3a), *Salpingoporella sellii* (Crescenti), *Praekurnubia crusei* Redmond and *Pseudocyclammina lituus* (Yokoyama) are the most common. Toward the middle part of this unit, fragments of *Cladocoropsis mirabilis* Felix (Fig. 3b) were locally found on bedding planes, together with crinoids and small brachiopod shells. These macrofossils are much rarer in the rest of this unit.

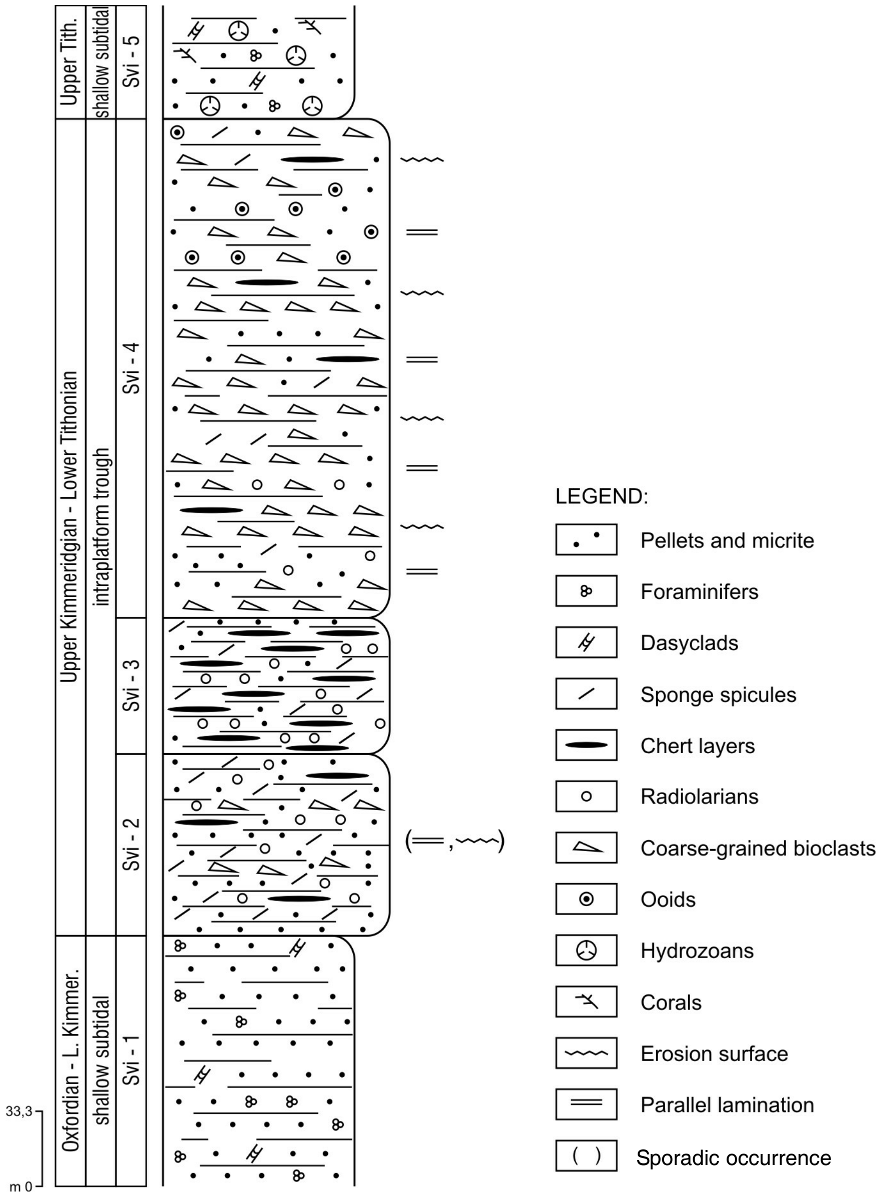
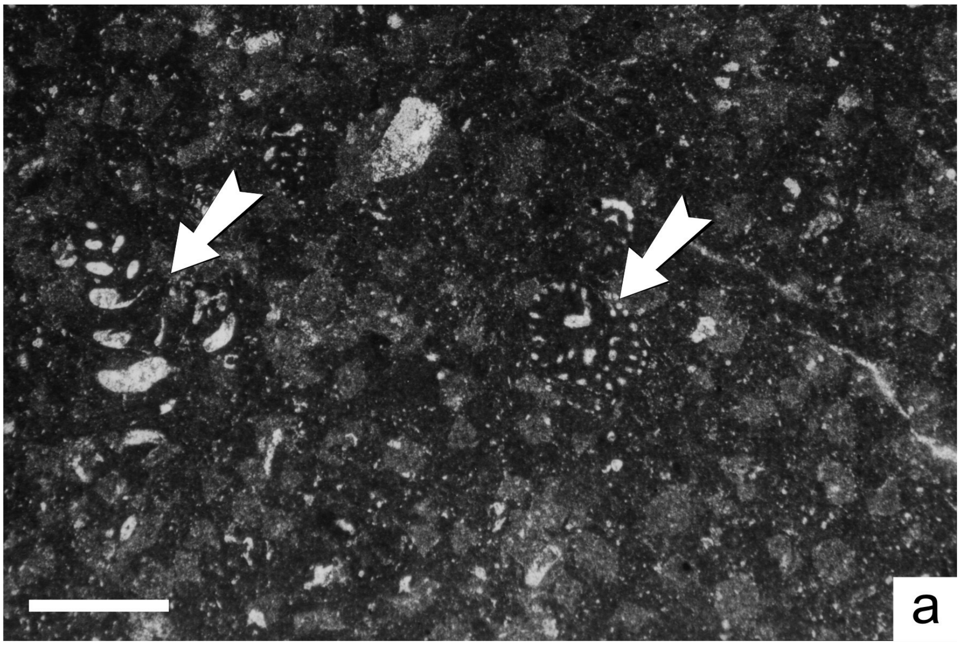


Fig. 2

Fig. 2
Stratigraphic column of the investigated succession. Svi-1 ... –Svi-5 – distinguished lithofacies units



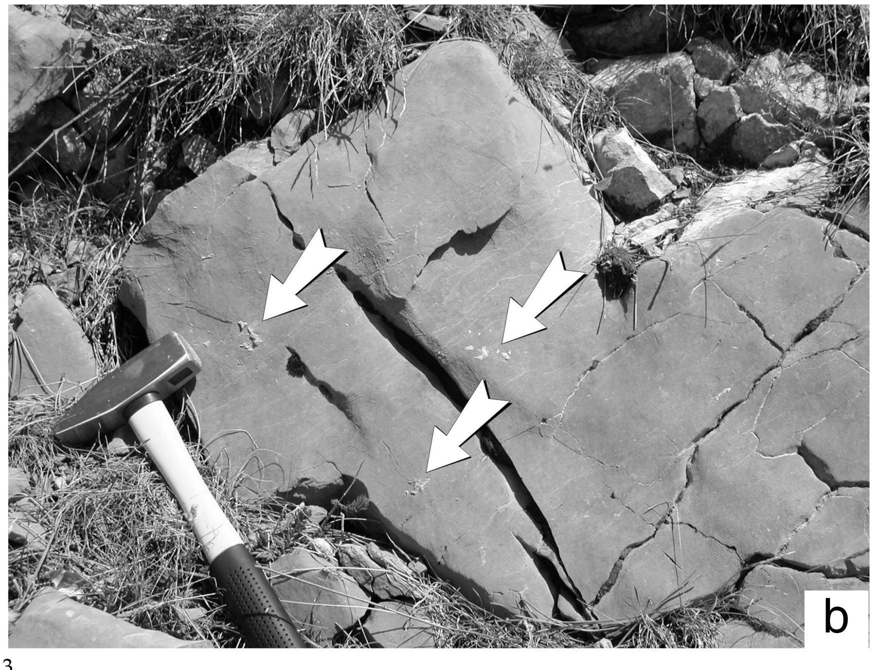


Fig. 3
Shallow subtidal microfacies: a) pelletal-bioclastic wackestone. Left arrow – *Redmondoides lugeoni* (Septfontaine), right arrow – *Kurnubia palastiniensis* Henson. Unit Svi-1. Scale bar 0.8 mm. b) arrows point at fragments of *Cladocoropsis mirabilis* Felix. Unit Svi-1

In the shallow-water Jurassic formation of the Dinarides and other peri-Mediterranean carbonate platforms such a fossil association indicates latest Oxfordian to earliest Kimmeridgian age (Velić et al. 2002b), i.e. this unit can be assigned to the Oxfordian–Kimmeridgian boundary interval. Biostratigraphically it belongs to the *Salpingoporella sellii* Assemblage Zone defined by Velić and Sokač (1974, 1978) and Velić (1977).

Interpretation: The presence of the mentioned allochems clearly implies that this unit was formed under low-energy subtidal conditions below the fair-weather wave-base in a well-oxygenated, lagoonal environment of normal salinity, where constant and steady sediment accumulation took place (e.g. Wilson 1975; Flügel 1982; D' Argenio et al. 1993; Buonocunto et al. 1994).

Svi-2 unit

Description: The next unit, 80 m thick, consists predominantly of pelletal-bioclastic wackestone-packstone with variable amounts of pellets and siliceous skeletons of biota such as siliceous sponge spicules and radiolarian test, but calcitic bioclasts such as pelagic crinoids (saccocoma) and tiny benthic echinoderm and ostracode fragments also occur in the micrite matrix (Fig. 4a). A few cm/dm-thick coarse-grained intercalations of pelletal-bioclastic wackestone-packstone/floatstone are also encountered. These are composed of poorly sorted, abraded echinoderm and mollusk fragments inserted in a fine-grained pelletal-bioclastic groundmass (Fig. 4b). Some of these bioclasts, elongated in form, may be oriented parallel to bedding. Foraminifera, micritic intraclasts, peloids and algal oncoids are much rarer in these bioclastic layers. Chert interbeds and large chert nodules can be observed locally. Due to weathering, the chert nodules are commonly porous and impregnated with iron hydroxides on the surface.

Interpretation: The predominance of sponge spicules, radiolarians and pelagic crinoids indicate a deeper-water basin as the site of deposition of the bulk of this unit. The sedimentary textures and presence of platform-derived bioclasts in coarse-grained intercalations indicate periodical sediment transport from a shallow-water platform margin and foreslope into the adjacent deeper-water basin environment, i.e. deposition in a deeper-water toe-of-slope environment (e.g. Reijmer and Everaars 1991; Reijmer et al. 1991; Herbig and Bender 1992; Harris 1994; Herbig and Mamet 1994).

Svi-3 unit

Description: The third unit, 60 m thick, is represented by platy and thin-bedded limestone containing lenses and numerous thin layers of grey chert. As to allochems, this intensely fragmented limestone differs from the pelletal-bioclastic wackestone-packstone of the underlying unit by more frequent occurrence of radiolarians (Fig. 5a). This wackestone-packstone is frequently

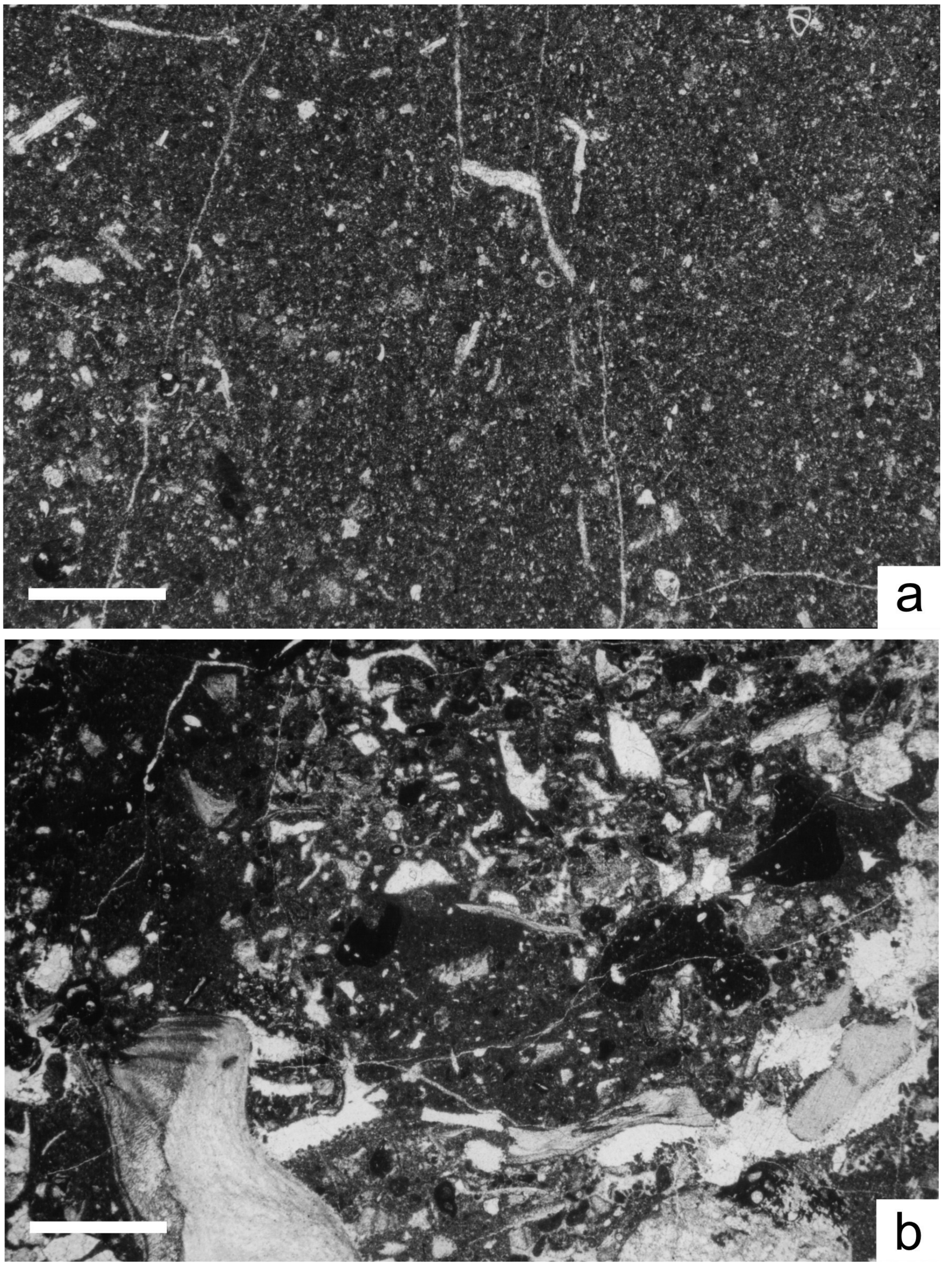


Fig. 4
Toe-of-slope microfacies: a) pelletal-bioclastic wackestone with sporadic spicules of siliceous sponges. Unit Svi-2. Scale bar 0.8 m. b) pelletal-bioclastic wackestone/floatstone with coarse-grained echinoderm and mollusk fragments. Unit Svi-2. Scale bar 1.6 mm

silicified, although relics of calcitic bioclasts commonly occur. These 4–10 mm-thick cherty layers give this unit a ribbon-like appearance (Fig. 5b). This is the most typical appearance of the Lemeš Beds. The stratigraphic range of the Lemeš Beds in the type section of this unit at Lemeš Pass is determined as Upper Kimmeridgian–Lower Tithonian on the basis of ammonites (e.g. *Perisphinctes, Ochetoceras, Haploceras, Glochiceras*) (Furlani 1910; Ziegler 1963; Chorowicz and Geyssant 1972).

Interpretation: The lack of bioclastic gravitational flows and predominance of radiolarians indicates a pelagic basin depositional setting far from the shallow-water platform margin, i.e. in a

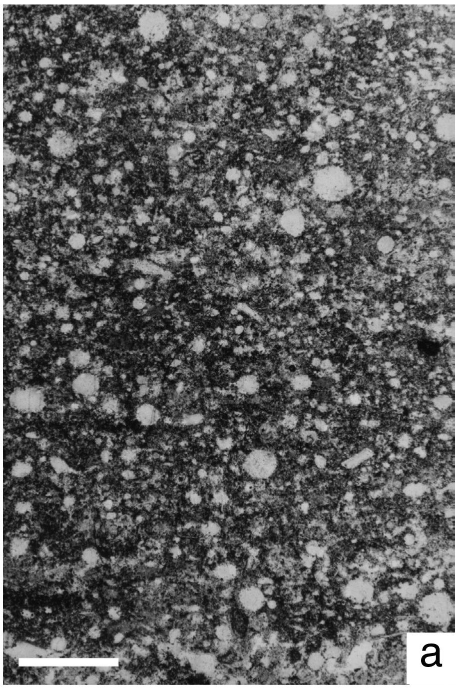


Fig. 5
Intraplatform trough microfacies: a) pelletal-bioclastic wackestone rich in radiolarians. Unit Svi-3. Scale bar 0.8 mm. b) ribbon-like appearance of fragmented beds. Unit Svi-3

deeper-water intraplatform trough well below the fair-weather and even storm-weather wave-base. The frequent occurrence of radiolarians clearly indicates that the silica in these beds is of biogenic origin. The partial or pervasive silicification and formation of chert nodules is a product of burial diagenesis (Hesse 1989).

Svi-4 unit

Description: The fourth unit, 220 m thick, consists predominantly of coarse-grained peloidal-bioclastic wackestone-packstone/floatstone and subordinately fine-grained pelletal-bioclastic wackestone-packstone, in interlayers only a few cm-dm thick. The composition of the coarse-grained wackestone-packstone/floatstone differs from the similar texture type in unit Svi-2. Just as in unit Svi-2, poorly sorted, abraded echinoderm and mollusk fragments, partly recrystallised and/or micritized, are the predominant components (Fig. 6a), but additionally oval peloids also occur. The coarse-grained layers are usually separated from each other or from the fine-grained wackestone-packstone by a sharp and slightly uneven erosional contact (Fig. 6b). Furthermore, the elongated coarse-grained bioclasts are as a rule oriented parallel to bedding (Fig. 6c). In addition almost every sample taken from the upper part of this unit contains a few or more ooids with radial microstructure. Ooids of crushed and multiphase regenerated types are the most common (Fig. 6d). In a few places ooids are even more frequent, as a result of which bioclastic-ooidal wackestone intercalations appear. In this unit chert layers occur only sporadically (Fig. 6c and e). Foraminiferal tests, micritic intraclasts, algal oncoids, and peloids are only sporadically present.

Interpretation: Successive coarse-grained bioclastic layers indicate deeper-water toe-of-slope depositional environment where redeposited bioclasts and/or ooids derived from the shallow-water platform margin were accumulated.

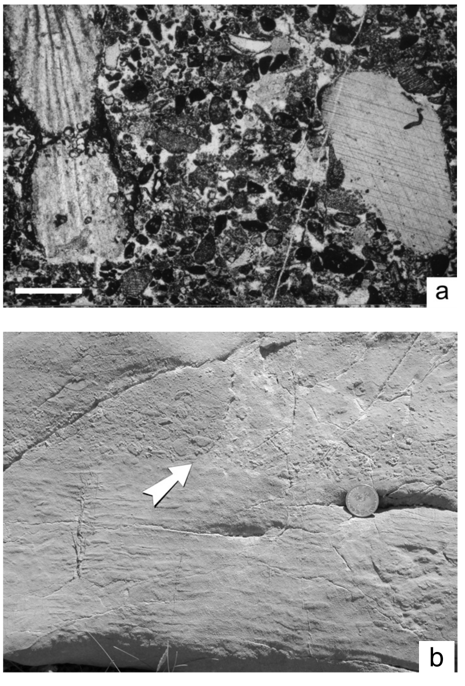
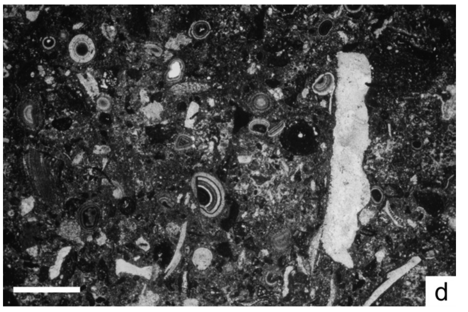


Fig. 6a, b
Toe-of-slope microfacies: a) peloidal-bioclastic packestone/floatstone with coarse-grained echinoderm and mollusk fragments. Unit Svi-4. Scale bar 1.6 mm. b) sharp contact between two coarse-grained intercalations. Unit Svi-4



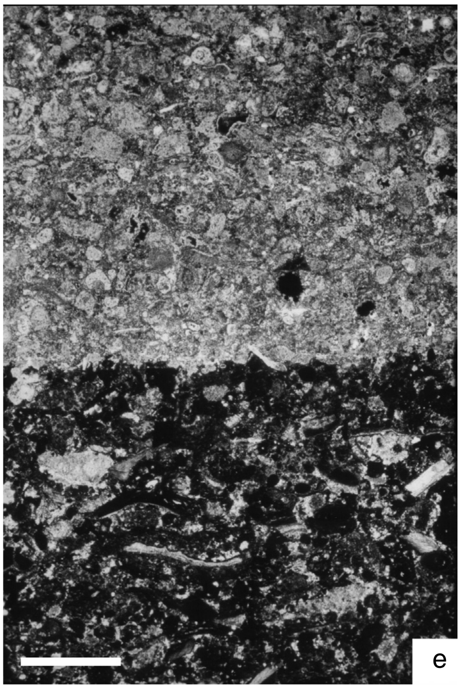


Fig. 6c, d, e
Toe-of-slope microfacies: c) parallel orientation of elongated coarse-grained bioclasts. Unit Svi-4. d) peloidal-bioclastic wackestone/floatstone with multiphase regenerated ooids. Unit Svi-4. Scale bar 1.6 mm. e) sharp contact between chert layer (silicified limestone) and peloidal-bioclastic packstone/floatstone (note the preservation of coarse-grained allochems within the chert layer). Unit Svi-4. Scale bar 1.6 mm

Svi-5 unit

Description: The uppermost unit of the investigated succession is 50 m thick. Irregular alternations of thick beds of pelletal-bioclastic wackestone/floatstone and grainstone/rudstone are the main characteristic of this unit. Both texture types occur in 20–60 cm-thick beds and are made up of poorly sorted and various coarse-grained bioclasts in a micritic/pelletal matrix (Fig. 7a), with sporadic occurrence of the stratigraphically valuable alga *Campbelliella striata* (Carozzi) (Fig. 7b). Unbroken skeletons of reef-building organisms such as a variety of coral types, hydrozoans (Fig. 7c), stromatoporoids, bryozoans, gastropods, bivalves, echinoderms and brachiopods also occur "*in situ*". Numerous taxa were described from the topmost parts of similar Upper Jurassic successions throughout the Karst Dinarides (e.g. Poljak 1936a, b, 1944; Milan 1969; Nikler 1969; Turnšek 1975; Velić 1977; Turnšek et al. 1981). Most frequently mentioned are those from the Sphaeractinidae family, e.g. *Ellipsactinia ellipsoidea* Steinmann, *E. caprense* Canavari, *E. polypora* Canavari, *E. ramosa* Canavari, *E. tyrhenica* Canavari, *Sphaeractinia steinmanni* Canavari, *S. diceratina* Steinmann, gastropods of genus *Nerinea,* e.g. *N. defrancei posthuma* Zittel, *N.*

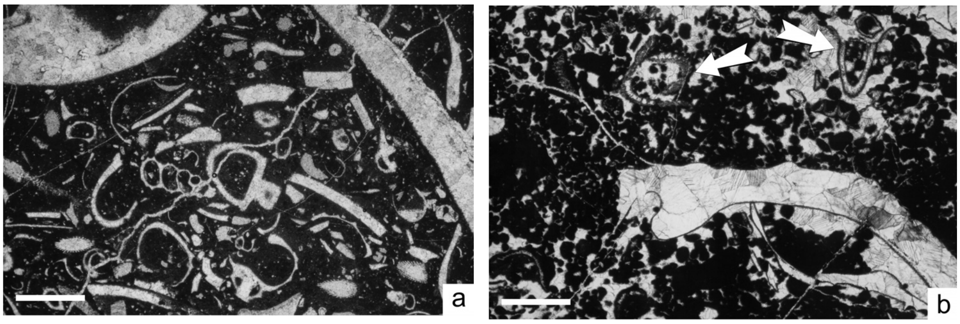


Fig. 7
Shallow subtidal microfacies: a) bioclastic wackestone/floatstone with coarse-grained mollusk fragments. Unit Svi-5. Scale bar 1.6 mm. b) pelletal-bioclastic grainstone/rudstone. Arrows point at alga *Campbelliella striata* (Carozzi). Unit Svi-5. Scale bar 1.6 mm. c) "*In situ*" skeletons of corals and hydrozoans. Unit Svi-5

zeuschneri Peters, then *Ptygmatis bruntrutana* (Thurmann), *Cryptoplocus consobrinus* Zittel, etc. Irregular fenestrae and/or dissolution vugs filled with drusy calcite sporadically occur within these coarse-grained beds. On the basis of sporadic occurrences of the alga *Campbelliella striata* (Carozzi) and the stratigraphic assignment of the underlying Lemeš Beds (Furlani 1910; Ziegler 1963; Chorowicz and Geyssant 1972), it may be concluded that this unit was deposited during the latest Early Tithonian to Late Tithonian.

Interpretation: The coarse-grained bioclasts indicate a high rate of carbonate accumulation in a higher-energy shallow-water environment above the fair-weather wave-base. This was very favorable for the local formation of some organic structures (reef mounds and/or reefs?). As a result of their destruction by currents and waves during major storms, coarse-grained skeletal fragments were distributed throughout the adjacent shallow-water area, producing grainstone/rudstone beds. On the other hand, during periods of more tranquil weather conditions, wackestone/floatstone was deposited. The presence of occasional irregular fenestrae and/or dissolution vugs indicates variable, intertidal to shallow subtidal environmental conditions, when the deposited sediments were subject to vadose diagenetic processes.

Discussion and Conclusion

Synsedimentary tectonics during the Kimmeridgian were most likely responsible for the deepening of the depositional environment that enabled the sedimentation of the deeper-water facies units Svi-2 through Svi-4. It is well known that during the Late Jurassic synsedimentary tectonic activity of varying intensity was very pronounced in the area of the Karst Dinarides. According to Velić et al. (2002a) and Vlahović et al. (2005) the beginning of the Late Jurassic was characterized by the gradual differentiation of environments, reaching its climax with the maximum in the Late Kimmeridgian. The southwestern part of the Adriatic carbonate platform (ACP) emerged during the Late Kimmeridgian, resulting in significant paleokarstification (e.g. Mt. Biokovo – Tišljar et al. 1989) and the establishment of conditions suitable for the formation of bauxite deposits (in W Istria – Polšak 1965; Tišljar and Velić 1987; Velić and Tišljar 1988; Tišljar et al. 2002) (Fig. 1). A similar situation was described in the northern and northeastern parts, and along the platform margin in central and SE Slovenia (Dozet and Mišić 1997), NW Bosnia (Vrhovčić et al. 1983), E Herzegovina (Natević and Petrović 1967) and W and N Montenegro (Vujisić 1972; Mirković and Mirković 1987). At the same time, in the northeastern part of the ACP in the Karlovac area in Croatia, totally opposite tendencies can be interpreted – after a long-term emergence a large part of this area was submerged. The formerly emergent areas, which existed from the middle part of the Early Jurassic to the Kimmeridgian (Bukovac et al. 1974, 1984; Šparica 1981; Dragičević and Velić 1994, 2002), became a platform margin characterized by barrier coral-hydrozoan reefs. These Kimmeridgian– Tithonian biolithites along the northern and northeastern ACP margin are mostly preserved in a more or less continuous belt from W Slovenia to SE Montenegro (Dragičević and Velić 2002) (Fig. 1). In Croatia they are documented in the vicinity of Ozalj and Karlovac (Bukovac et al. 1974, 1984; Dragičević and Velić 1994). Reefal and peri-reefal environments gradually prograded toward the open Tethyan realm, enabling the gradual migration of the platform margin towards the N and NE. A different ACP platform margin architecture is reported in Lower Jurassic of Mt. Žumberak (Babić 1976; Dragičević and Velić 2002; Bucković 2006b). In the central part of the ACP deeper areas were formed penecontemporaneously, in the form of two intraplatform troughs (probable pull-apart basins): one of them occurs in the eastern part of Gorski Kotar, the other one, known as the Lemeš Trough, stretches southward from the Karlovac area (Vlahović et al. 2005) (Fig. 1). The latter was deeper, and due to its connection with the open Tethys its pelagic influence was more pronounced.

The investigated Upper Jurassic Mt. Svilaja succession described above belongs to the ACP area where the Lemeš Trough existed. Thus, during the Late Jurassic, the environmental dynamics in this area can be envisaged as follows. After the Oxfordian to earliest Kimmeridgian, deposition of the Svi-1 unit took place in a quiet, subtidal environment below the fair-weather wave-base (Figs 2 and 8a).

Synsedimentary tectonics caused the formation of a large intraplatform trough within the ACP, connected with the open Tethys realm. In the toe-of-slope environment of this trough the Svi-2 unit was accumulated, whereas the more distal, inner part of this trough was the sedimentation site of the Svi-3 unit (Figs 2 and 8b). This process can be envisaged as a tectonically-controlled retrogradation of shallow subtidal facies, whereby the part of the succession ranging from shallow-water platform to deeper-water pelagic-influenced intraplatform trough carbonates were formed.

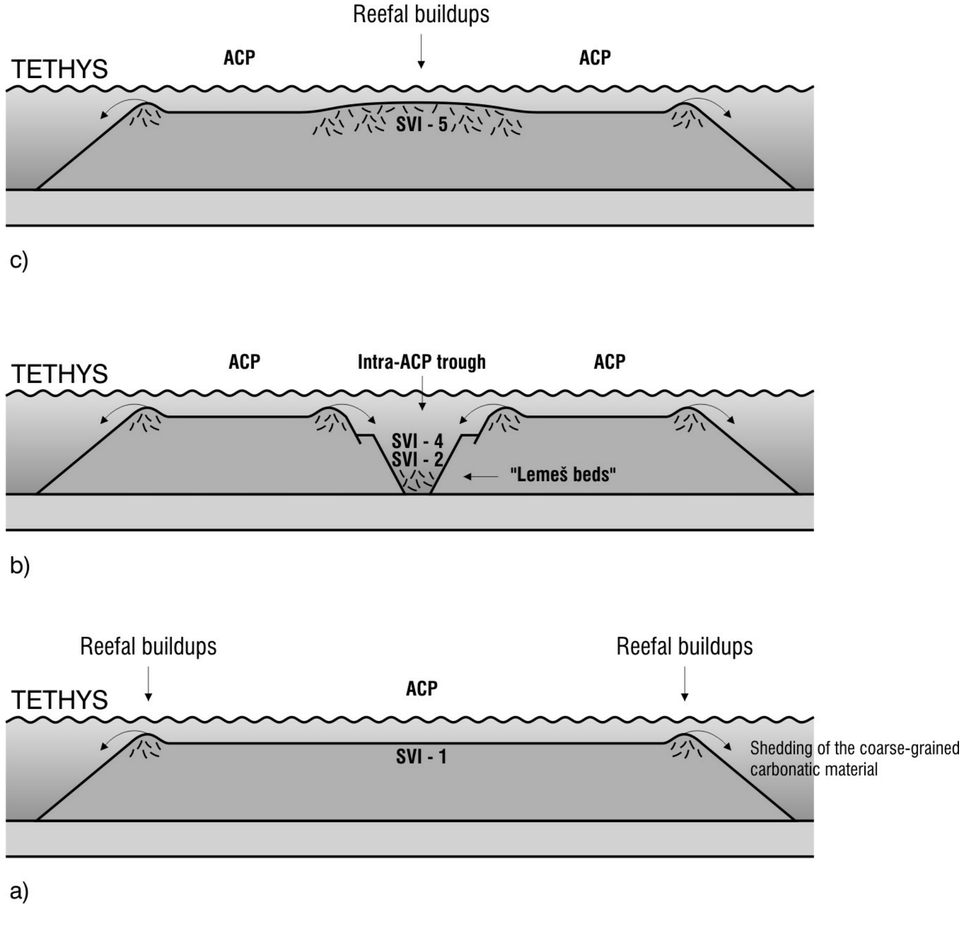


Fig. 8
Simplified schematic geodynamic interpretation in the Lemeš Trough vicinity: a) during Oxfordian to earliest Kimmeridgian deposition took place within the ACP subtidal zone below the fair-weather wave-base; b) during middle to late Kimmeridgian an intraplatform trough was formed and up to the end of Early Tithonian deposition took place within this deeper-water environment; c) during Late Tithonian the shallow subtidal environment was re-established and occupied by coral-hydrozoan reefal buildups

Pronounced and frequent shedding of the coarse-grained carbonate material from trough margin to toe-of-slope environment via gravity flows, triggered by periodical storms and/or frequent earthquakes induced by intense tectonic activity (e.g. Bucković 2006a), led to the progressive infilling of the trough when the Svi-4 unit was deposited (Figs 2 and 8b). As the observed thicknesses of pelagic Svi-2 through Svi-4 units at Mt. Svilaja is about 150–200 m greater than that of the lithologically similar units at the eastern part of Gorski Kotar (Bucković 1995; Velić et al. 2002b), this confirms the assumption of Velić et al. (2002b) and Vlahović et al. (2005) that the Lemeš Trough was deeper and longer than the other one extending through the eastern part of Gorski Kotar.

Progressive infilling of the trough with bioclastic material (and subordinately oolitic material) led to the re-establishment of the shallow subtidal environment, and the area of previously existing intraplatform trough was occupied by coral-hydrozoan reefal buildups of the Svi-5 unit (Figs 2 and 8c), whereby the part of the succession ranging from the deeper-water pelagic-influenced intraplatform trough carbonates to shallow-water platform carbonates, was formed.

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References

Babić, LJ. 1973: Upper Tithonian to Valanginian Basinal sediments west of Bregana. – Geol. vjesnik, 26, pp. 11–27.

Babić, LJ. 1976: Migration of the boundary between "inner" and "outer" Dinaridic zones. – 8. jugosl. geol. kongres, 2, pp. 45–52.

Bernoulli, D., H.C. Jenkyns 1974: Alpine, Mediterranean and central Atlantic Mesozoic facies in relation to the early evolution of Tethys. – In: Dott, R.H., R.H. Shaver (Eds): Modern and Ancient Geosynclinal Sedimentation, Soc. Econ. Paleont. Mineral. Spec. Publ., 18, pp. 129–160.

Bucković, D. 1995: Upper Jurassic carbonate facies succession at Breze (Velika Kapela, Croatia). – Geol. Croatica, 48/1, pp. 9–16.

Bucković, D. 2006a: Jurassic section of Gorski Kotar (Western Karst Dinarides, Croatia); facies characteristics, depositional setting and paleogeographic implications. – Acta Geologica Hungarica, 49/4, pp. 331–354.

Bucković, D. 2006b: Jurassic limestone units of Sošice, Mt. Žumberak, Croatia; sedimentary signature of the platform to basin transition. – Acta Geologica Hungarica, 49/4, pp. 355–371.

Bucković, D., B. Cvetko Tešović, I. Gušić 2004: Late Jurassic paleoenvironmental evolution of the western Dinarides (Croatia). – Geol. Carpathica, 55/1, pp. 3–18.

Bukovac, J., I. Velić, B. Sokač 1974: Stratigraphy, tectonics and paleogeography of the region between Dugaresa, Barilović and Skradska gora (Croatia). – Geol. vjesnik, 27, pp. 59–77.

Bukovac, J., M. Šušnjar, M. Poljak, M. Čakalo 1984: Basic geological map of SFRY 1:100.000, the Crnomelj sheet. – Geološki zavod Zagreb, Geološki zavod Ljubljana, Savezni geološki zavod, Beograd.

Buonocunto, F.P. 1993: Microstratigrafia e stratigrafia sequenziale. Studi sui depositi di piattaforma carbonatica, Cretacico del Monte Maggiore (Appennino Meridionale). – Boll. Soc. Geol. Ital., 112, pp. 739–749.
Buonocunto, F.P., B. D' Argenio, V. Ferreri, A. Raspini 1994: Microstratigraphy of highly organized carbonate platform deposits of Cretaceous age. The case of Serra Sbregavitelli Matese (Central Apennines). – Giornale Geol., 56, pp. 179–192.
Chorowicz, J., J.R. Geyssant 1972: Presence des couches de Lemeš (Calcaiers a Ammonites submediterraneennes du Malm) dans la Lika (Croatie, Yougoslavie). – C.R. Seances Acad. Sci., 275, pp. 731–734.
Cosović, V. 1987: Biostratigraphic features of Jurassic sediments in Gorski Kotar. – Mem. Soc. Geol. Ital., 40, pp. 85–89.
D' Argenio, B., V. Ferreri, F. Ardillo, F.P. Buonocunto. 1993: Microstratigrafia e stratigrafia sequenziale. Studi sui depositi di piattaforma carbonatica, Cretacico del Monte Maggiore (Appennino Meridionale). – Boll. Soc. Geol. Ital., 112, pp. 739–749.
Dozet, S., M Mišić 1997: On Malm bauxites and adjacent carbonate rocks in Suha Krajina (central Slovenia). – Rudarsko–metalurški zbornik, 44/3–4, pp. 201–222.
Dragičević, I., I. Velić 1994: Stratigraphical position and significance of reef facies at the northern margin of the Dinaric carbonate platform during the Late Jurassic and Cretaceous in Croatia and Bosnia. – Géologie Méditerranéenne, 3–4, pp. 59–63.
Dragičević, I., I. Velić 2002: The northeastern margin of the Adriatic carbonate platform. – Geol. Croatica, 55/2, pp. 185–232.
Flügel, E. 1982: Microfacies analysis of limestones. – Springer-Verlag, Berlin, Heidelberg, New York, I, 636 p.
Furlani, M. 1910: Die Lemeš-Schichten. Ein Beitrag zur Kenntnis der Juraformation in Mitteldalmatien. – Jahrb. Geol. Reichsanstalt, 60/1, pp. 67–98.
Gušić, I. 1969: Biostratigraphic and micropaleontologic characteristics of some Jurassic cross-sections in central Croatia. – Geol. vjesnik, 22, pp. 89–97.
Gušić, I., Lj. Babić 1970: Some biostratigraphic and lithogenetic characteristics of the Jurassic in Žumberak (Northwest Croatia). – Geol. vjesnik 23, pp. 39–56.
Hariss, M.T. 1994: The foreslope and toe-of-slope facies of the Middle Triassic Latemar buildup (Dolomites, northern Italy). – J. Sedim. Res., 64, pp. 132–145.
Herbig, H.G., P. Bender 1992: A eustatically driven calciturbidites sequence from the Dinantian of the eastern Rheinische Schiefergebirge. – Facies, 27, pp. 245–262.
Herbig, H.G., B. Mamet 1994: Hydraulic sorting of microbiota in calciturbidites. A Dinantian case study from the Rheinische Schiefergebirge, Germany. – Facies, 31, pp. 93–104.
Hesse, R. 1989: Silica diagenesis: origin of inorganic and replacement cherts. – Earth-Sci. Rev., 26, pp. 253–284.
Milan, A. 1969: Faziesverhältnisse und Hydrozoenfauna des Malms im Küstenland der nördlichen Velebit and Velika Kapela. – Geol. vjesnik, 22, pp. 136–149.
Mirković, M., B. Mirković 1987: New data about distribution of Jurassic sediments in the area of Sinjavina, Durmitor and Ljubišnja. – Geološki glasnik, 12, pp. 61–87.
Natević, LJ., V. Petrović 1967: Basic geological map of SFRY 1:100.000, the Trebinje sheet. – Geološki zavod Sarajevo, Savezni geološki zavod, Beograd.
Nikler, L. 1969: Die Nerineen des Tithons von Velika Kapela. – Geol. vjesnik, 22, pp. 219–227.
Nikler, L. 1978: Stratigraphic position of the Malmian reef facies in northwestern Dinarides. – Geol. vjesnik, 30/1, pp. 137–150.
Papeš, J., R. Marinković, V. Raič, N. Magaš, V. Sikirica 1982: Base Geological Map of Yugoslavia 1:100 000, Sinj sheet. – Geoinženjering-Institut za geologiju, Sarajevo, Geološki zavod OOUR za geologiju i paleontologiju, Zagreb, Savezni geološki zavod, Beograd.
Poljak, J. 1936a: Ein Beitrag zur Kenntnis der Chaetetiden aus dem Tithon der Velika Kapela. – Glasnik Hrv. prir. društva, 41–48, pp. 105–117.

Poljak, J. 1936b: Ein Beitrag zur Kenntnis der Hydrozoenfamilie Ellipsactinidae aus dem Tithon der Velika Kapela Gebirge. – Glasnik Hrv. prir. društva, 41–48, pp. 255–271.
Poljak, J. 1944: Über die Tithonbildungen und ihre Fauna aus dem Gebiete des Velika Kapela-Gebirges in Kroatien. – Vjestnik Hrv. drž. geol. zav. i Hrv. drž. geol. muz., 2–3, pp. 281–340.
Polšak, A. 1965: Stratigraphie des couches jurassiques et crétacées de l'Istrie centrale. – Geol. vjesnik, 18/1, pp. 167–184.
Radoičić, R. 1966: Microfacies du Jurassique des Dinarides externes de la Yougoslavie. – Geologija, 9, pp. 5–378.
Reijmer, J.J.G., J.S.L. Everaars 1991: Carbonate platform facies reflected in Carbonate basin facies (Triassic, Northern Calcareous Alps, Austria). – Facies, 25, pp. 253–278.
Reijmer, J.J.G., W.G.H.Z. Ten Kate, A. Sprenger, W. Schlager 1991: Calciturbidite composition related to exposure and flooding of a carbonate platform (Triassic, Eastern Alps). – Sedimentology, 38, pp. 1059–1074.
Savić, D. 1973: Jurassic and Cretaceous beds between Gornje Jelenje and Grobničko polje. – Geol. vjesnik, 25, pp. 127–148.
Šparica, M. 1981: Geology of the Mesozoic areas of Kordun, Banija and NW Bosnia, Yugoslavia. – Nafta, Spec. Publ., XII+245 p.
Tišljar, J., I. Velić 1987: The Kimmeridgian tidal-bar calcarenite facies of western Istria (western Croatia, Yugoslavia). – Facies, 17, pp. 277–284.
Tišljar, J., I. Velić, B. Sokač 1989: Einflüsse von Emersionen auf die Flachwasserkarbonate sedimenten im Malm (Oberer Jura) des Biokovo-gebirges (Südkroatien, Jugoslawien). – Geol. Paläont. Mitt. Insbruck, 16/1, pp. 199–201.
Tišljar, J., I. Velić 1991: Carbonate facies and depositional environments of the Jurassic and Lower Cretaceous of the coastal Dinarides (Croatia). – Geol. vjesnik, 44, pp. 215–234.
Tišljar, J., I. Velić 1993: Upper Jurassic (Malm) shallow-water carbonates in the Western Gorski Kotar area: facies and depositional environments (Western Croatia). – Geol. Croat., 46/2, pp. 263–279.
Tišljar, J., I. Velić, I. Vlahović 1994: Facies diversity of the Malmian platform carbonates in Western Croatia as a consequence of synsedimentary tectonics. – Géologie Méditerranéenne, 21/3–4, pp. 173–176.
Tišljar, J., I. Vlahović, I. Velić, B. Sokač 2002: Carbonate platform megafacies of the Jurassic and Cretaceous deposits of the Karst Dinarides. – Geol. Croatica, 55/2, pp. 139–170.
Turnšek, D. 1975: Malmian corals from Zlobin, south-west Croatia. – Palaeont. Jugosl., 16, pp. 7–23.
Turnšek, D., S. Buser, B. Ogorelec 1981: An Upper Jurassic reef complex from Slovenia, Yugoslavia. – SEPM Spec. Publ., 30, pp. 361–369.
Velić, I. 1977: Jurassic and Lower Cretaceous assemblage zones in Mt. Velika Kapela, central Croatia. – Acta geol., 9/2, pp. 15–37.
Velić, I., B. Sokač 1974: On the tripartite subdivision of the Malm in Mt. Velika Kapela (Croatia). – Geol. vjesnik, 27, 143–150.
Velić, I., B. Sokač 1978: Biostratigraphic analysis of the Jurassic and Lower Cretaceous in the wider region of Ogulin, central Croatia. – Geol. vjesnik, 30/1, pp. 309–337.
Velić, I., J. Tišljar 1988: Lithostratigraphic units in the Doger and Malm of western Istria. – Geol. vjesnik, 41, pp. 25–49.
Velić, I., I. Vlahović, J. Tišljar 1994: Late Jurassic lateral and vertical facies distribution: from peritidal and inner carbonate ramps to perireefal and peritidal deposits in SE Gorski Kotar (Croatia). – Géologie Méditerranéenne, 21/3–4, pp. 177–180.
Velić, I., D. Matičec, I. Vlahović, J. Tišljar 1995: Stratigraphic succession of Jurassic and Lower Cretaceous carbonates (Bathonian – Upper Albian) in Western Istria. – In: Vlahović, I., I. Velić (Eds): First Croatian Geological Congress, Excursion Guide-Book, pp. 31–66.
Velić, I., I. Vlahović, D. Matičec 2002a: Depositional sequences and palaeogeography of the Adriatic carbonate platform. – Mem. Soc. geol. It., 57, pp. 141–151.

Velić, I., J. Tišljar, I. Vlahović, J. Velić, G. Koch, D. Matičec 2002b: Palaeogeographic variability and depositional environments of the Upper Jurassic carbonate rocks of Velika Kapela Mt. (Gorski Kotar area, Adriatic carbonate platform, Croatia). – Geol. Croatica, 55/2, pp. 121–138.
Velić, I., J. Tišljar, I. Vlahović, D. Matičec, S. Bergant 2003: Evolution of the Istrian part of the Adriatic carbonate platform from the Middle Jurassic to the Santonian and formation of the flysch basin during the Eocene: Main events and Regional comparison. – In: Vlahović, I., J. Tišljar (Eds): Evolution of Depositional environments from the Palaeozoic to the Quaternary in the Karst Dinarides and the Panonian Basin. – 22nd IAS Meeting of Sedimentology. Field Trip Guidebook, pp. 3–17.
Vlahović, I., J. Tišljar, I. Velić, D. Matičec 2005: Evolution of the Adriatic carbonate platform: palaeogeography, main events and depositional dynamics. – Palaeogeography, palaeoclimatology, palaeoecology, 220, 3–4, pp. 333–360.
Vrhovčić, J., L. Vujnović, M. Mojičević 1983: Basic geological map of SFRY 1:100.000, the Ključ sheet. – Geoinženjering Sarajevo, Savezni geološki zavod, Beograd.
Vujisić, T. 1972: Basic geological map of SFRY 1:100.000, the Nikšić sheet. – Zavod za geol. i geofiz. istraž. Beograd, Savezni geološki zavod, Beograd.
Wilson, J.L. 1975: Carbonate facies in geologic history. – Springer–Verlag, Berlin, Heidelberg, New York, 471 p.
Ziegler, B. 1963: Die Fauna der Lemeš-Schichten (Dalmatien) und ihre Bedentung für den mediterranen Oberjura. – N. Jb. Geol. Palaont., Mh 8, pp. 405–421.