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Upper Turonian–Santonian slope limestones of the Islands of Premuda, Ist and Silba (Adriatic Coast, Croatia)

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ABSTRACT

Upper Turonian–Santonian limestones at three island locations (Ist, Silba and Premuda) in the southwestern part of the Adriatic carbonate platform, record slope deposition based on their sedimentological and palaeontological characteristics.

These Upper Cretaceous successions consist of three vertically superimposed lithotypes: (1) pelagic mudstones-packstones, (2) laminated pelagic wackestones-packstones, and (3) bioclastic floatstones-rudstones to packstones-grainstones with fossils of shallow marine organisms.

According to the proximity of the shallow water carbonate platform interior the depositional setting of the slope deposits could be identified as relatively more proximal or distal. The proximal part is characterized by non laminated pelagic limestones with resedimented bioclastic limestones, while the more distal parts have both laminated and non-laminated pelagic limestones with rare resedimented bioclastic limestones. The resedimented bioclastic limestones represent slope apron deposits. Locally, at Premuda Island, the slope apron includes blocks of laminated pelagic limestones. The depositional environments of the Ist and Premuda profiles could be interpreted as of more distal origin, while those of the Silba profile represents a more proximal part of the slope.

Keywords: pelagic, resedimented, limestones, slope apron, slump, rudists, planktonic foraminifera, Upper Turonian-Santonian, Adriatic carbonate platform

1. INTRODUCTION

The Adriatic carbonate platform (AdCP) was one of the largest Mesozoic carbonate platforms of the Perimediterranean region (HERAK, 1986, 1990; TARI 2002; VLAHOVIĆ et al., 2005).

Today the Upper Cretaceous limestones that originated on this platform crop out along the eastern Adriatic coast in a more or less continuous NW-SE trending belt. A shallow water regime persisted throughout the Late Cretaceous, with just two episodes of drowning, first during the Early Turonian and secondly during the Santonian (GUŠIĆ & JELASKA, 1990; MORO et al., 2002; VLAHOVIĆ et al., 2005; KORBAR, 2009). Following both drowning events shallow water sedimentation was re-established. Interestingly, on the southwestern part of the Adriatic carbonate platform deep water sedimentation lasted from the Early Turonian to the end of Cretaceous (KAPOVIĆ & BAUER, 1970; FUČEK et al., 1991).

Generally, deep water carbonates are divided into two major sedimentary facies differing in depositional criteria and diagenetic development: (1) pelagic carbonates composed of fine grained sediments with pelagic organisms and (2) resedimented allochthonous carbonates with constituents exported from the platform and slope settings farther into the basins (FLÜGEL, 2004). This division is used in this paper as the basis for interpretation of the depositional environments of the investigated localities.

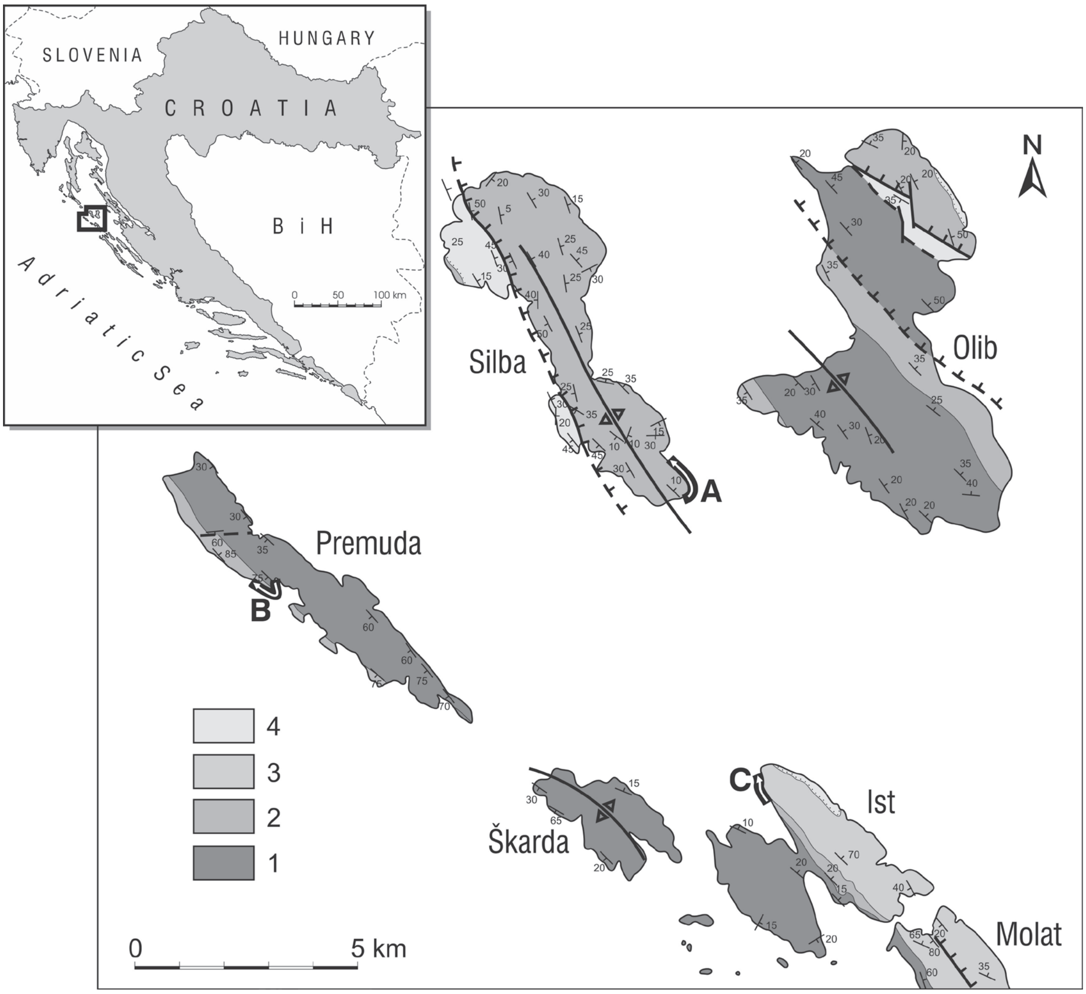


Figure 1: Simplified geological map (after MAMUŽIĆ, 1970 and MAMUŽIĆ et al., 1970) showing the location of the investigated profiles. A– Silba profile, B–Premuda profile, C–Ist profile. Arrows indicate the younging direction of the successions. 1– Cenomanian –Turonian 2– Turonian-Senonian, 3– Senonian, 4– Paleogene.

The aims of this paper are (a) to determine the age attribution based on planktonic foraminifera and (b) to describe the depositional environments of the platform-to-basin transition. Particular emphasis is placed on the description of the lithofacies characteristics and possible palaeoenvironmental conditions involved in their formation.

2. GEOLOGICAL SETTING

The Upper Cretaceous sedimentary rocks from three sections on the islands of Ist, Silba and Premuda were sampled and studied (Fig. 1). The sections belong to the External Dinarides (HERAK, 1986; 1990) or Dinaridic SW Unit or High Karst (KORBAR, 2009) region, comprising the geotectonic unit of folded and faulted Upper Cretaceous and Palaeogene strata (MAMUŽIĆ, 1970; MAMUŽIĆ et al., 1970; MAMUŽIĆ & SOKAČ, 1973; MORO & JELASKA, 1994; ĆOSOVIĆ et al., 1994; MÁRTON & MORO, 2009; MÁRTON et al., 2010). The transition from the Cretaceous to the Palaeogene was marked by emersion, and occasionally with bauxite deposits (KOVAČEVIĆ GALOVIĆ et al., 2012). Bedding dips from 20 to 87 degrees (Fig. 1). The investigated profiles comprise tectonically uninterrupted successions of Upper Cretaceous strata.

3. METHODS

The structural characteristics of the rocks, bed thicknesses, potential cyclicity, and macrofossils were studied in the field. Samples from the massive limestones were collected for thin-section analysis to investigate the microfacies (including textures and skeletal components) and biostratigraphic characteristics. Visual percentage charts were used to estimate the relative abundance of grains (BACCELLE & BOSELLINI, 1965; in FLÜGEL, 2004). The taxonomic study of planktonic foraminifera is based on randomly oriented sections through the test with observable morphological characteristics such as test shape and peripheral thickenings or keels (PREMOLI SILVA & SLITER, 2002; SARI, 2009). The taxonomic framework used to identify species is based on the Practical Manual of Cretaceous Planktonic Foraminifera (PREMOLI SILVA & SLITER, 2002; PREMOLI SILVA

& VERGA, 2004) and publications by SARI (2006, 2009). The biostratigraphic scheme is according to PREMOLI SILVA & SLITER (2002).

4. LITHOFACIES AND BIOSTRATIGRAPHY OF THE INVESTIGATED PROFILES

Lithofacies analysis is based on the study of rock specimens in thin-sections, supplemented by features observed in the field such as bedding, sedimentary structures and macrofossil content.

Three different lithofacies types have been distinguished: (a) laminated pelagic limestones (LF 1), (b) pelagic limestones (LF 2) and (c) bioclastic limestones (LF 3). Texturally, both pelagic limestones are mud-supported mudstones-packstones, and bioclastic limestones are mud- and grain-supported floatstones-rudstones and packstones-grainstones.

4.1. The Silba profile

The maximum total thickness of the studied profile at Silba is 47 m (Fig. 2). Bed thickness ranges from 40–120 cm. The succession consists of LF 2 and LF 3 lithofacies; LF 2 comprises pelagic wackestones-packstones with bed thickness from 40–120 cm and LF 3 consists of bioclastic grainstones-rudstones-floatstones with beds 40–60 cm thick. In vertical succession, LF 2 beds are present throughout the section. LF

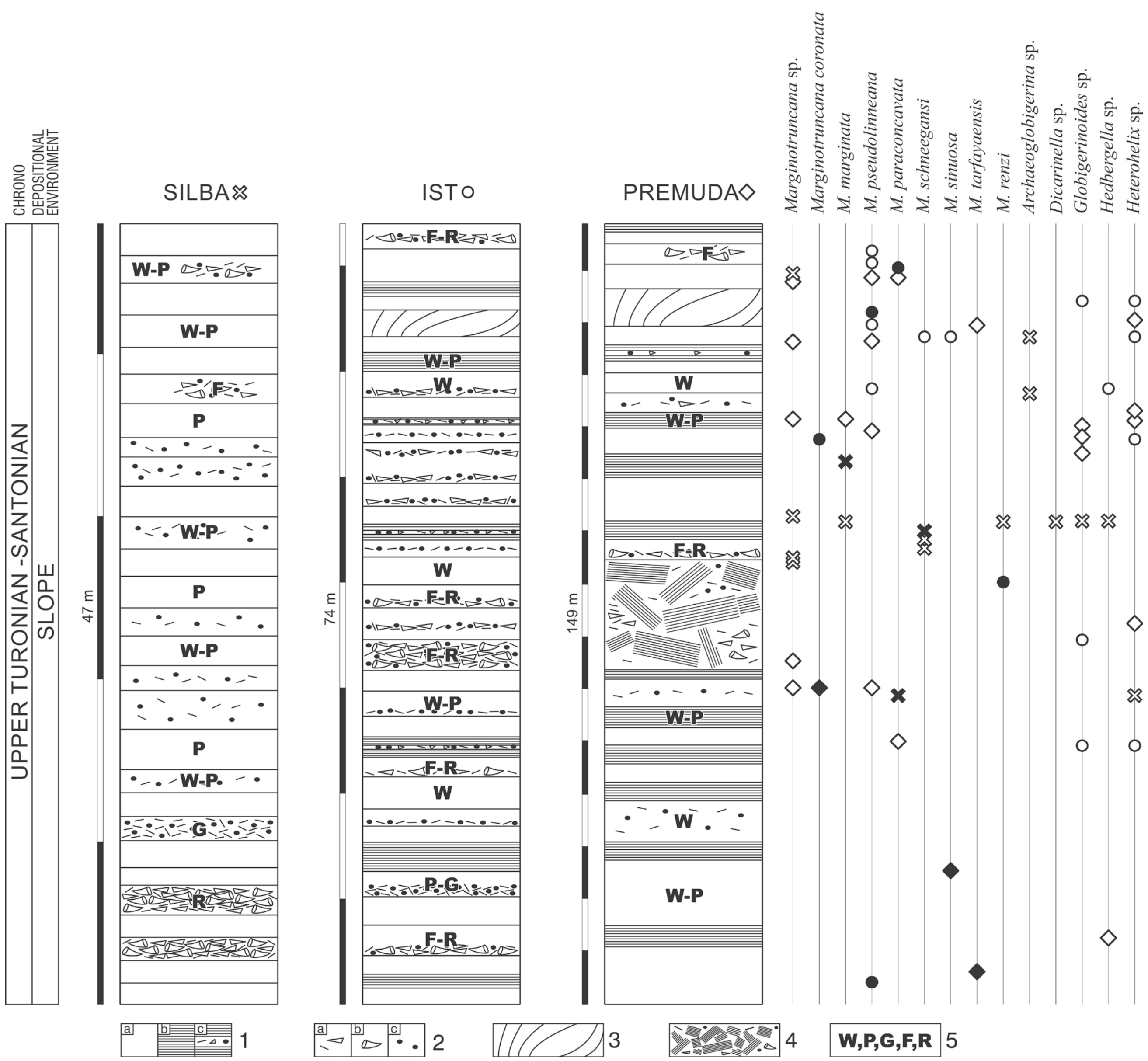


Figure 2: Schematic vertical succession of the investigated profiles. Thickness of the beds is not to scale. 1a– Pelagic limestones (LF 2), b– Laminated pelagic limestones (LF 1), c– Intercalations of bioclastic limestones within laminated pelagic limestones (LF 3), 2– Bioclastic limestones with bioclasts (a– fragments, b– rudist shells) and lithoclasts (c) (LF 3), 3– Slump forms, 4 – Slope apron facies with blocks of laminated pelagic limestones, 5–Structural type: wackestone, packstone, grainstone, floatstone, rudstone. x, o and ◊ in black – cf. probable identification.

3 appears as bioclastic grainstones-rudstones in the lower part, and floatstone intercalations and lenses with pelagic limestones in the upper part of the section. Macrofossils are whole shells and fragments of radiolitid and hippuritid rudist bivalves (Pl. 1, fig. 6).

The LF 2 ranges from pure pelagic packstones with densely packed pelagic particles (Pl. 2, fig. 1) (estimated percentage of pelagic particles is up to 50%), predominantly made of calcispheres with rare planktonic foraminifera (1–2.5%), to wackestones-packstones with pelagic particles (20–25%) and fragments of bioclasts of shallow marine origin (5–10 %) and lithoclasts (3–7.5%). Rarely, these limestones are slightly laminated, where rare shallow water bioclasts are horizontally orientated. Bioclastic rudstones consist of poorly sorted coarse fragments of rudists, which make up to 40–50% of a thin section (Pl. 3, fig. 7). Grainstones are dominated by shallow water macrofossil fragments (40–50%) and lithoclasts (7.5–15%) (Pl. 3, fig. 5). In mud supported packstones-floatstones the estimated percentage range of pelagic particles is 7.5–20%, shallow water bioclasts 20–25% and lithoclasts 7.5–10% (Pl. 3, figs. 4, 6 & 12). Some lithoclasts contain rare small miliolid foraminifera and pelagic particles (Pl. 2, fig. 3).

The microfossil assemblages are composed of planktonic foraminifera: *Marginotruncana marginata* (REUSS), *M. renzi* (GANDOLFI), *M.* cf. *paraconcavata* PORTHAULT, *M. schneegansi* (SIGAL), *Archaeoglobigerina* sp., *Dicarinella* sp., *Globigerinoides* sp., *Hedbergella* sp., *Heterohelix* sp. (Pl. 4, figs. 34–47) and calcispheres. The most common shallow water fossil is the cyanobacterium *Decastronema kotori* (RADOIČIĆ) (GOLUBIĆ et al., 2006) (Pl. 3. fig. 13);less common are the calcareous alga *Thaumatoporella parvovesiculifera* (RAINERI), milolids and shells of hippuritids and radiolitids.

The assemblage of planktonic foraminifera listed above is dominated by species having double-keels and a low trochospiral test, which correspond to the *H. helvetica*, *M. sigali-D. primitiva*, *D. concavata* and *D. asymetrica* planktonic foraminiferal zones, biostratigraphically characteristic of the Late Turonian – Santonian interval (PREMOLI SILVA & SLITER, 2002).

4.2. Ist profile

The Ist profile is a 74 metre-thick succession (Fig. 2). All three (LF 1, LF2 and LF 3) lithofacies types are present. LF 1 occurs in thin to thick beds (5–60 cm) as laminated pelagic wackestones-packstones, LF2 as pelagic wackestones in beds of variable thickness (20–180 cm), and LF 3 as bioclastic grainstones-packstones-rudstones-floatstones with 15 to 60 cm thick intercalations.

In vertical succession LF 1 appears as individual beds associated with one or more beds of LF2, ranging in thickness from 0.7 to 16. 4 m. LF 3 appears in LF 1 and LF 2. LF 3 appears within LF2 randomly as intercalations contains fragments of, and whole radiolitid and hippuritid shells (Pl. 1, fig. 10). The intercalations have sharp bases and tops, or undulating, uneven, rough contacts (Pl. 1, fig 10). Patches of LF 2 pelagic limestone are rarely present within LF 3 floatstones-rudstones, (Pl. 1, fig. 2). Bioclastic limestones appear as 1–2 cm thick intercalations within LF 1 lithofacies.

Thin-sections of LF 1 reveal laminated pelagic particles making up to 3–15% of total sediment, while the frequency of planktonic foraminifera is estimated to be 1–2.5% (Pl. 2, fig. 7). They may also contain intercalated bioclastic packstones–grainstones with shallow water macrofossil fragments and lithoclasts making up 20–50% of a thin–section (Pl. 2, figs. 2 & 11). LF 2 is characterized by pelagic skeletal grains (3–12.5%), with the frequency of planktonic foraminifera varying from 1–3%. Within LF 2 lithofacies, the estimated frequency of shallow-water fossil fragments is 2.5–5%, and lithoclasts 1–3% (Pl. 2, figs. 5 & 13). Intercalations of LF3 consist of pelagic (1–7.5%), and shallow- water derived bioclasts with a frequency of 20–50% (Pl. 3, figs 1 & 2). Lithoclasts (7.5–20%) containing shallow water foraminifera are also present (Pl. 3, figs. 2 & 11). These resedimented bioclastic and lithoclastic grains of LF 3 (Pl. 2, figs 2 & 4; Pl. 3. figs. 1 & 2), with partial to complete grain support, show evidence of slightly normal grading (Pl. 2, figs. 4, 9 & 11) when they appear as intercalations within LF 1. The tops and bottoms of intercalations within LF1 are flat, locally with flute marks at the base (Pl. 2, fig. 9).

The upper part of the profile consists of slump deposits (0.80 m thick and 4.80 m long), deformed limestones belonging to the LF2 lithofacies (Pl. 1, fig. 8). The fossil assemblage comprises the following foraminiferal species and organisms: *Marginotruncana* cf. *coronata* (BOLLI), *M. pseudolinneiana* PESSAGNO, *M.* cf. *renzi* (GANDOLFI), *M. sinuosa* PORTHAULT, *M.* cf. *paraconcavata* PORTHAULT, *M. schneegansi* (SIGAL), *Globigerinoides* sp., *Hedbergella* sp., *Heterohelix* sp. (Pl. 4, figs. 1–15) and calcispheres. *Scandonea samnitica* (DE CASTRO) (Pl. 3, fig. 11), *Decastronema kotori* (RADOIČIĆ), *Thaumatoporella parvovesiculifera* (RAINERI), shell fragments of hippuritids and radiolitids, and rare occurrences of red algae (Pl. 3, fig 10) are observed within resedimented shallow-water particles and lithoclasts.

The planktonic foraminifera determined in the Ist succession indicate the *H. helvetica*, *M. sigali-D. primitiva*, *D. concavata* and *D. asymetrica* planktonic foraminiferal zones, which suggest the Late Turonian – Santonian interval (PREMOLI SILVA & SLITER, 2002).

4.3. Premuda profile

The Premuda succession (Figs. 1 & 2, Pl. 1, fig. 7) is 149 m thick and consists of three lithofacies: LF 1 laminated pelagic wackestone-packstones (2 to 120 cm thick beds), LF 2 pelagic wackestones-packstones (as 20 to 120 cm thick beds), and LF 3 bioclastic packstones-grainstones-floatstones-rudstones.

LF 2 and LF 1lithofacies are cyclically organized, with one or several beds of lithofacies LF 2 separated by an individual bed of LF 1 lithofacies in 0.26 to 4.4 m thick packages (Pl. 1, fig. 7). The LF 3 lithofacies when present (rarely) is intercalated within LF 1 as packstones-grainstones, while within LF2 beds it appears as rare intercalations at the base, or as lenses within the bed, with fragments and whole shells of radiolitids. The thickness of LF 3 intercalations within host LF 2 beds ranges between 10–20 cm. Some beds of LF 2 have a wavy to lenticular or ellipsoidal appearance (Pl. 1, figs. 9 & 11), and occur within both LF1 and LF 2 limestones.

Thin-sections of LF 1 contain planktonic foraminifera and calcispheres with an estimated frequency of 5–25% and 1–2.5% for planktonic foraminifera (Pl. 2, fig. 6). Lithoclasts and shallow water bioclasts are rare. Interbedded within the LF1 type, bioclastic packstones-grainstones consist of shallow water bioclasts (25–50%) and lithoclasts (7.5%). Within the LF 2 lithofacies, the estimated frequency of pelagic skeletal grains ranges from 1 to 2.5% (Pl. 2, fig 12), while shallow-water macrofossil fragments and occasional lithoclasts are rare (Pl. 2, fig 8). Packstone variants of this lithofacies with calcispheres (20–40%) are rare and appear in the lower part of the succession. Floatstones-rudstones-packstones-grainstones of LF 3 contain lithoclasts (10–30%) and shallow water bioclasts with an estimated frequency of 20–25% (Pl. 3, fig. 3). Pelagic bioclasts are present in mud supported floatstones-packstones with an estimated percentage of 2.5–7.5%.

The 20 m thick sequence in the middle part of the profile represents dissected blocks of strata (Pl. 1, fig. 5) of pelagic laminated limestones (Pl. 1, fig. 3). These blocks occur within bioclastic floatstones-rudstones (Pl. 1, figs. 1 & 4; Pl. 2, fig. 10), packstones-grainstones and pelagic mudstones-wackestones, and show no evidence of bedding. Bioclastic floatstones-rudstones and packstones-grainstones contain pellets, peloids, and shallow water bioclasts (12.5–40%), while pelagic bioclasts occur sporadically (Pl. 3, fig. 8 & 9). Pelagic mudstones-wackestones contain pelagic microfossils (3–7.5%). The upper part of the profile is composed of 3.50 m thick slump sediments within pelagic limestones of LF 2 (Fig. 2).

The microfossil assemblage comprises the following planktonic foraminiferal species: *Marginotruncana marginata* (REUSS), *M.* cf. *coronata* (BOLLI), *M. pseudolinneana* PESSAGNO, *M.* cf. *sinuosa* PORTHAULT, *M. paraconcavata* PORTHAULT, *M. tarfayaensis* (LEHMANN), *Globigerinoides* sp., *Hedbergella* sp. and *Heterohelix* sp. (Pl. 4, figs. 16–33). Calcispheres are also present.

Within the Premuda succession, the determined macrofossils include *Vaccinites cornuvaccinum* (BRONN) (Pl. 1, fig. 1) and shells of hippuritids and radiolitids. Remnants of green algae *Thaumatoporella parvovesiculifera* (RAINERI) also occur.

The biostratigraphic age of the Premuda succession is Late Turonian – Santonian based on the range of low-trochospiral marginotruncanids which comprise the *H. helvetica*, *M. sigali-D. primitiva*, *D. concavata* and *D. asymetrica* planktonic foraminiferal zones (PREMOLI SILVA & SLITER, 2002). Also, the chronostratigraphic age interval for *V. cornuvaccinum* is Uppermost Turonian to Middle Coniacian (STEUBER, 1999; STEUBER & SCHLÜTER, 2012), which is consistent with microfossil dating, though implying the older part of the interval for this species.

5. LITHOFACIES ANALYSIS

The limestones described above constitute different lateral parts of slope deposits. The shallowest, proximal, upper part of the slope is represented by the Silba succession, and the more distal, deeper, lower part of the slope is represented by the Ist and Premuda successions. An ideal vertical sequence consists of all the aforementioned limestones, starting from pelagic limestones in the proximal part of the slope to pelagic and laminated pelagic limestones in the more distal parts. The laminated pelagic limestones are developed from the Premuda profile, diminishing towards the Silba profile, where this lithofacies becomes completely absent (Figs. 2 & 3) implying the more proximal position of the latter.

A similar pattern of appearance is shown by the shallow water bioclastic limestones, which are considered to be debris to grain-flow deposits resedimented on a slope apron (TUCKER & WRIGHT, 1990, FLÜGEL, 2004). In the more distal part (Premuda succession) they are present as intercalations and lenses within pelagic limestones, and almost completely absent from the laminated pelagic limestones. Towards the proximal part of the slope (Ist succession) (Pl. 2, figs. 4 & 9; Pl. 3, figs1, 2, 10 & 11) they appear commonly as intercalations within pelagic limestones and locally within laminated pelagic limestones. In the most proximal part (Silba succession) bioclastic limestones form lenses and intercalations in pelagic limestones or individual beds (Pl. 3, figs. 4, 5, 6 & 7). A resedimented sequence, present only in the Premuda succession, consists of shallow-water and pelagic deposits that are part of the slope apron with large blocks of laminated pelagic limestone transported in a disaggregated matrix of shallower slope facies (Fig. 3; Pl. 1, figs. 3 & 5). Such resedimented limestones could be considered as megabreccias, presumably the result of seismic shocks and gravity collapses (SPENCE & TUCKER, 1997; FLÜGEL, 2004). Here they are present in the distal part of the slope (Fig. 3) and most probably resulted from sediment overloading in the upper part of the slope.

Within the shallow water bioclastic limestones, the major constituents are two types of grains: bioclasts of shallow marine origin and lithoclasts. The bioclasts are mainly whole shells and angular fragments of rudists, benthic miliolid foraminifera as well as the green algae *Thaumatoporella* and cyanobacterium *Decastronema*. The lithoclasts are dark fragments of mud-supported limestones originating from the shallow water part of the platform or upper part of the slope. This type of lithoclast indicates the absence of typical platform margin-derived material (e.g. ooids, reef fragments). Most probably, as in the Western Dolomites (BRANDNER et al., 1991), they were eroded from various parts of shallow-water platform environments where the mud-supported limestones originated, from peritidal (with shallowing upward cycles) to relatively deeper subtidal settings (GUŠIĆ & JELASKA, 1990; MORO et al., 2002; VLAHOVIĆ et al., 2005). At the nearby shallow water part of the platform (MORO & JELASKA, 1994) the difference in relative depth of shallow-water subtidal and intertidal sediments could be small. Therefore it seems that the appearance of lithoclasts is the result

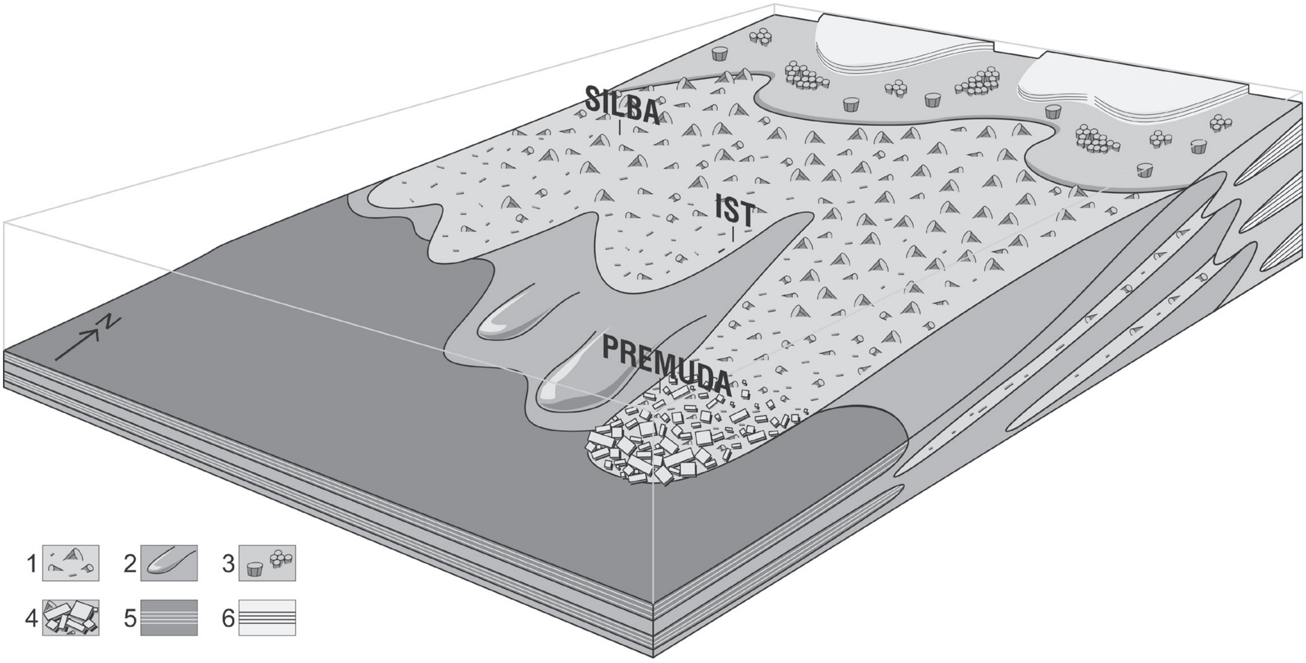


Figure 3: A block diagram showing the reconstructed depositional environments of the study area. 1– Bioclastic limestones of the slope apron, 2– Pelagic limestones with slump features, 3– Shallow-water subtidal deposits, 4– Slope apron with blocks of laminated pelagic limestones, 5– Laminated pelagic limestones, 6– Intertidal laminites. Not to scale.

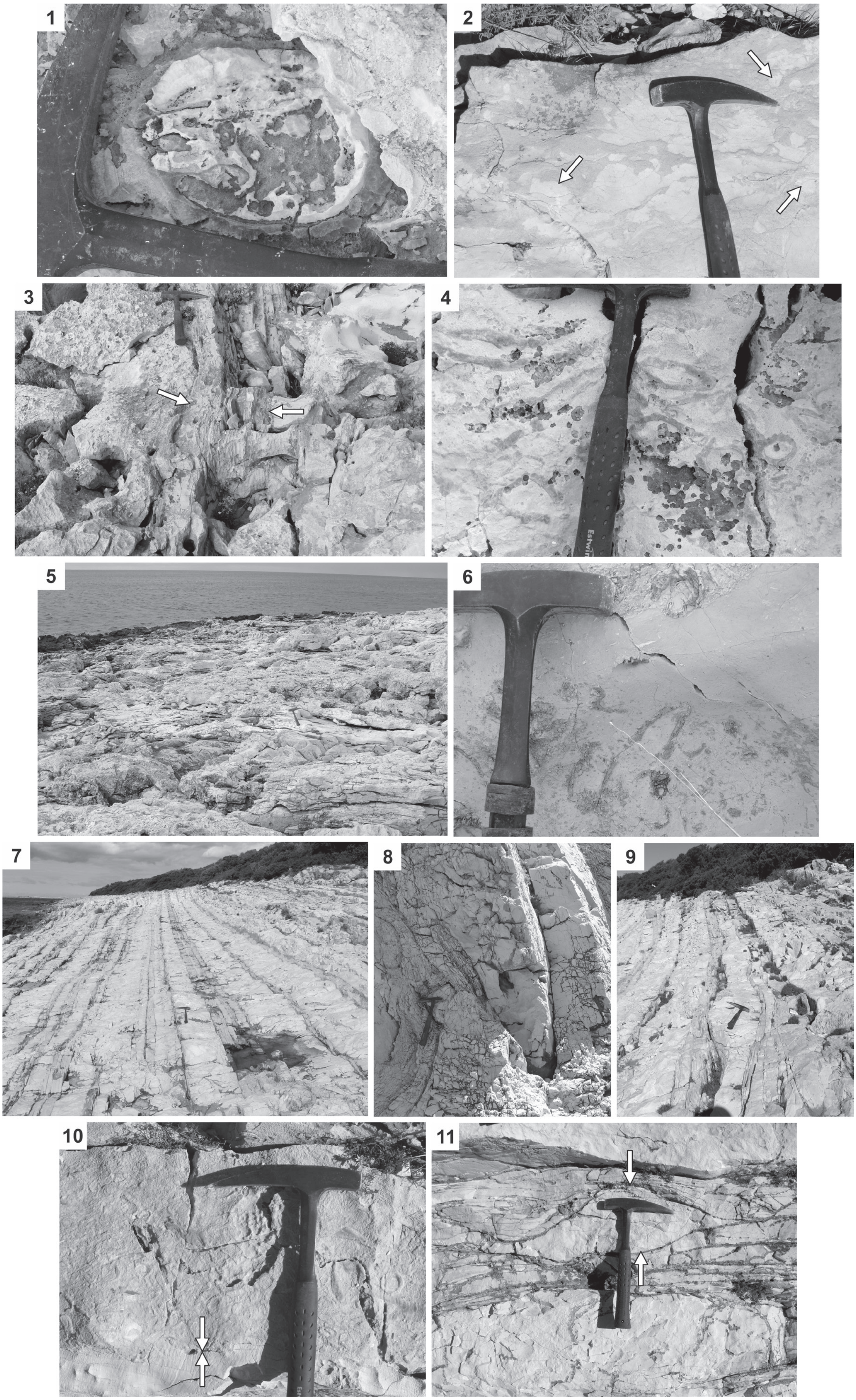
of more or less laterally pronounced shallow water submarine topographic relief, which, as a result of resedimentation processes, produced lithoclasts as well as bioclasts. Another possible explanation is that the appearance of lithoclasts implies higher values of slope angle (KENTER, 1990) together with a relatively prolonged lack of shallow-water subtidal accommodation space.

Lenticular and wavy structures within the pelagic and laminated pelagic limestones of the Premuda succession presumably represent the distal part of the slope apron where the major constituents are mud and pelagic particles. These bed-forms probably resulted from lateral differentiation in the mechanical strength of the apron deposits, leading to distal creep and fringing forms. Another possible explanation is that the bed-forms are slumps originating from the slide and creep of semi-consolidated, internally undeformed sediments, probably due to sediment overloading (FLÜGEL, 2004). Pronounced bedding-planes along these structures make the latter possibility more likely (Pl. 1, Figs. 9 and 11).

Slope strata that include debris to grain-flow deposits and slumps could be formed on a wide range of slope angles (KENTER, 1990; FLÜGEL, 2004). Grain supported fabrics with minor or no matrix, build up on the upper parts of the slopes with higher angles (up to 40 degrees), and those with mud matrix form the lower parts of the slope with low slope angles (up to 15 degrees). Mixtures of grain to mud supported fabrics appear in all three successions, most commonly in the proximal parts of the slope (Silba profile), while towards the distal part (Premuda profile) there is a decrease in their frequency of occurrence. This kind of muddy and granular fabric mixture is typical of slopes with angles between 5–25 degrees (FLÜGEL, 2004), implying that the investigated limestones were deposited on a relatively low angle slope. Also, the majority of ancient slope apron resedimented carbonates are developed along rather gentle (less than 4 degrees), shallow platform to basin slopes (TUCKER & WRIGHT, 1990). Nevertheless, the slope apron sediments with blocks of laminated pelagic limestones in the Premuda

PLATE 1

1 – *Vaccinites cornuvaccinum* in slope apron sediments, Premuda profile; **2** – Shallow water bioclastic floatstone-rudstone with patches of pelagic limestone (arrows), Ist profile; **3** – Block of laminated pelagic wackestone-packstone within slope apron (arrows), Premuda profile; **4** – Shallow water bioclastic floatstone with radiolitid shells within slope apron, Premuda profile; **5** – Slope apron, Premuda profile; **6** – Lenses of shallow water floatstone with rudists shells and shallow water bioclasts within pelagic wackestone-packstone, Silba profile; **7** – Vertical succession of pelagic mudstones-wackestones and laminated pelagic wackestones-packstones, Premuda profile; **8** – Slump within vertically dipping beds, Ist profile; **9** – Frontal part of slump with sliding and creeping pelagic wackestone, Premuda profile; **10** – Intercalation of the shallow water bioclastic floatstone-rudstone with uneven, sharp contact with pelagic wackestones (arrows), Ist profile; **11** – Lens of sliding and creeping pelagic wackestone within frontal part of slump (arrows), Premuda profile.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succession (Fig. 3) are predominantly mud-supported limestones, implying very low-angle, low-relief carbonate slopes with deposits consisting of broad sheets of debris (TUCKER & WRIGHT, 1990).

6. SHALLOW PLATFORM TO BASIN TRANSECT

Although the detailed lateral transition of the shallow platform to basin transect in the investigated area is obscured by the insular restriction of the outcrops (Fig. 1), it is possible to reconstruct a general model for the distribution of the shallow platform-to-basin depositional environments during the Late Cretaceous for this part of the Adriatic carbonate platform. This model includes vertical variation of depositional environments on the Adriatic carbonate platform during flooding of the platform and re-establishment of the shallow-water sedimentation (MORO et al., 2002; VLAHOVIĆ et al., 2005).

There are several possibilities for the origin of the enormous amount of carbonate mud, most probably including disintegration or compaction of soft peloids and faecal pellets, together with bioerosion of the hard parts of shallow water organisms (FÜRSICH et al., 2003). This amount of carbonate mud, together with oscillations of accommodation space provided for their deposition, resulted in the mosaic of slope deposits visible in the vertical appearance of pelagic and resedimented allochthonous carbonates.

The vertical alternation of laminated and non-laminated pelagic limestones within the distal part of the slope is probably a reflection of the shallowing upward cycles within the shallow water part of the platform. The pelagic limestones with a lower frequency of pelagic particles in comparison with the laminated pelagic limestones, were probably deposited while intertidal conditions with low accommodation space prevailed at the shallow-water part of the platform, thus more mud was delivered to the deeper water environments. In contrast, the laminated pelagic limestones would have been deposited when more accommodating subtidal conditions prevailed at the shallow part of the platform, with the lamination reflecting oscillations in the amount of platform mud that settled from suspension.

The Late Cretaceous Adriatic carbonate platform was vast (DERCOURT et al., 1993) and is generally represented by low energy limestones with biostromes of elevator rudists that lived as mud-supported dwellers within different parts of the subtidal environments (SKELTON & GILI, 1991; ROSS & SKELTON, 1993; GILI et al., 1995; MORO & ĆOSOVIĆ, 2000; 2002; SIMONE et al., 2003). During the flooding as well as renewed shallowing following deeper marine deposition, there is no evidence in the vertical succession of the Adriatic carbonate platform deposits of movement of a possible barrier, with or without rudists, towards the proximal or distal part of the platform (MORO et al., 2002, 2008; VLAHOVIĆ et al., 2005).

Presumably the shallow water deposits were protected by the gradual deepening of the carbonate platform (GUŠIĆ & JELASKA, 1990; MORO & ĆOSOVIĆ, 2002; MORO et al., 2008; KORBAR et al., 2010), which ended with foundered platform deposits (MORO et al., 2002; VLAHOVIĆ et al., 2005). The same pattern of absence of a barrier could be presumed for this part of the gently inclined Late Cretaceous Adriatic carbonate platform as has been postulated for the slope sediments of the Catalan Basin (CALVET & TUCKER, 1988).

7. CONCLUSION

According to the sedimentological and palaeontological analyses of the Upper Cretaceous limestones of the Premuda, Silba and Ist islands, it is possible to conclude the following:

1) On the basis of the planktonic foraminifera, as well as rare benthic micro and macrofossils, the studied sediments are assigned to the Upper Turonian-Santonian.

2) A platform to basin depositional transect of slope deposits is reconstructed, which can be divided into proximal and distal parts. Proximal slope sediments comprise non-laminated pelagic limestones with resedimented bioclastic limestones, while more distal slope sediments are characterized by both laminated and non-laminated pelagic limestones with rare resedimented bioclastic limestones.

3) Resedimented bioclastic limestones appear as slope apron deposits. Locally, on Premuda Island, the slope apron includes blocks of distal laminated pelagic limestones. Slumps within the pelagic limestones are present on the Premuda and Ist islands.

4) The platform margin was characterized by a gradually deepening subtidal environment, lacking any kind of barrier.

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PLATE 2

1 – Pelagic packstone, Silba profile; **2** – Laminated pelagic limestone with intercalation of shallow water packstone-grainstone with shallow water bioclasts and lithoclasts, Ist profile; **3** – Pelagic wackestone with lithoclast of pelagic packstone, Silba profile; **4** – Lower (left) and upper (right) part of the intercalation of the shallow water material within laminated pelagic limestone, Ist profile; **5** – Pelagic wackestone-packstone with shallow water bioclasts and lithoclasts, Ist profile; **6** and **7** – Pelagic laminated limestones, Premuda (6) and Ist (7) profile; **8** – Lithoclast with *Thaumatoporella* within pelagic wackestone, Premuda profile, **9** – Resedimented shallow water packstone-grainstone with flute marks (arrows) within laminated pelagic wackestone-packstone, Ist profile; **10** – Floatstone with fragments of rudists (arrows) within slope apron, Premuda profile; **11** – Laminated pelagic wackestone-packstone with intrusion of shallow water packstone, Ist profile; **12** and **13** – Pelagic wackestones, Premuda (12) and Ist (13) profile.

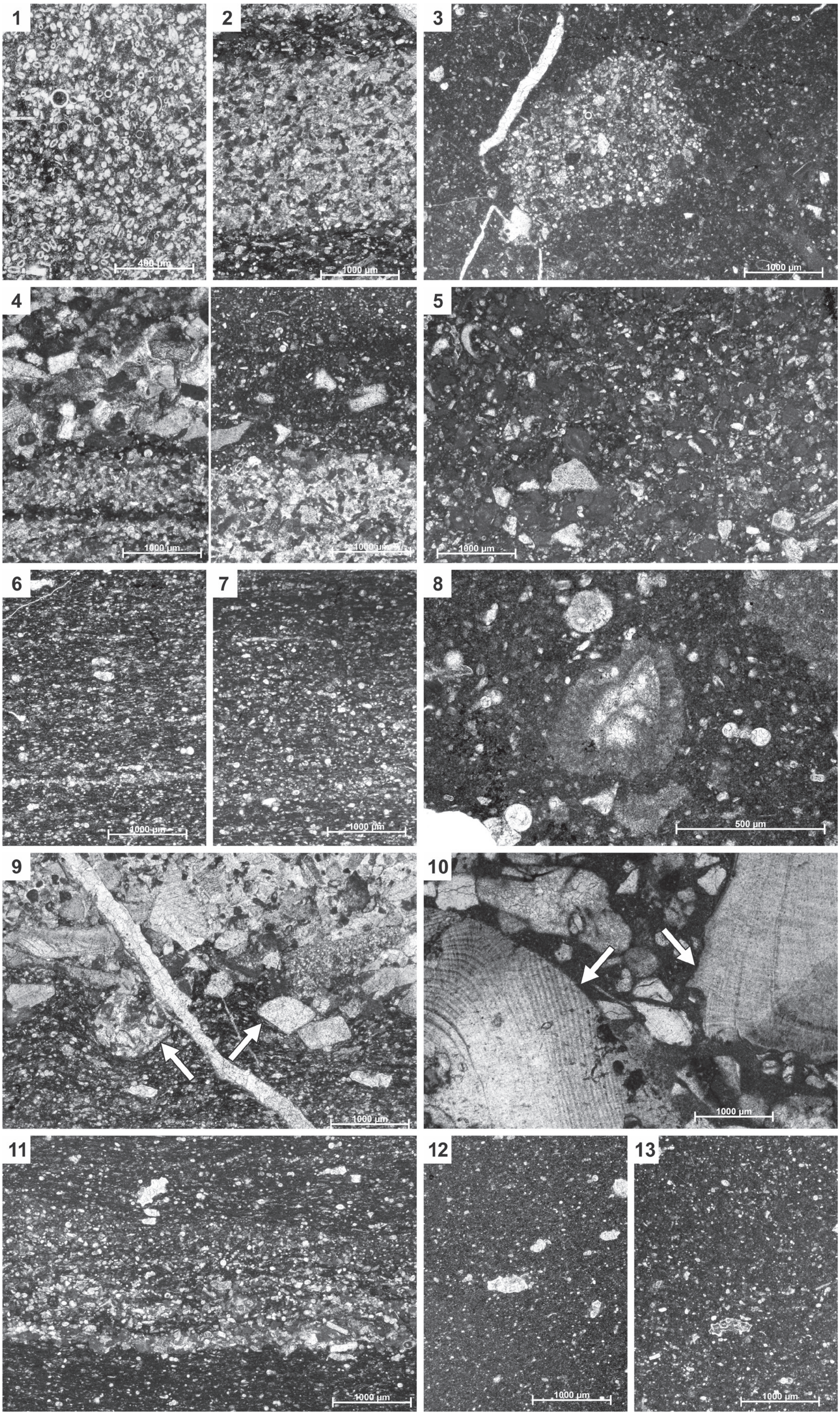
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PLATE 3

1 – Grainstone with shallow water bioclasts and lithoclasts, Ist profile; **2** – Floatstone with shallow water bioclasts and lithoclasts, Ist profile; **3** – Floatstone, Premuda profile; **4** – Packstone with shallow water bioclasts and lithoclasts, Silba profile; **5** – Grainstone, Silba profile; **6** – Rudist floatstone, Silba profile; **7** – Rudist rudstone, Silba profile; **8** and **9** – Slope apron. Wackestone-packstone with miliolids (8) and packstone-grainstone with shallow water bioclasts and lithoclasts (9), Premuda profile; **10** – Fragment of red algae within floatstone-rudstone, Ist profile; **11** – Floatstone matrix with pelagic bioclasts and lithoclast with *Scandonea samnitica*, Ist profile; **12** – Packstone with calcispheres, shallow water bioclasts, Silba profile; **13** – Pelagic packstone with *Decastronema kotori* (arrow), Silba profile.

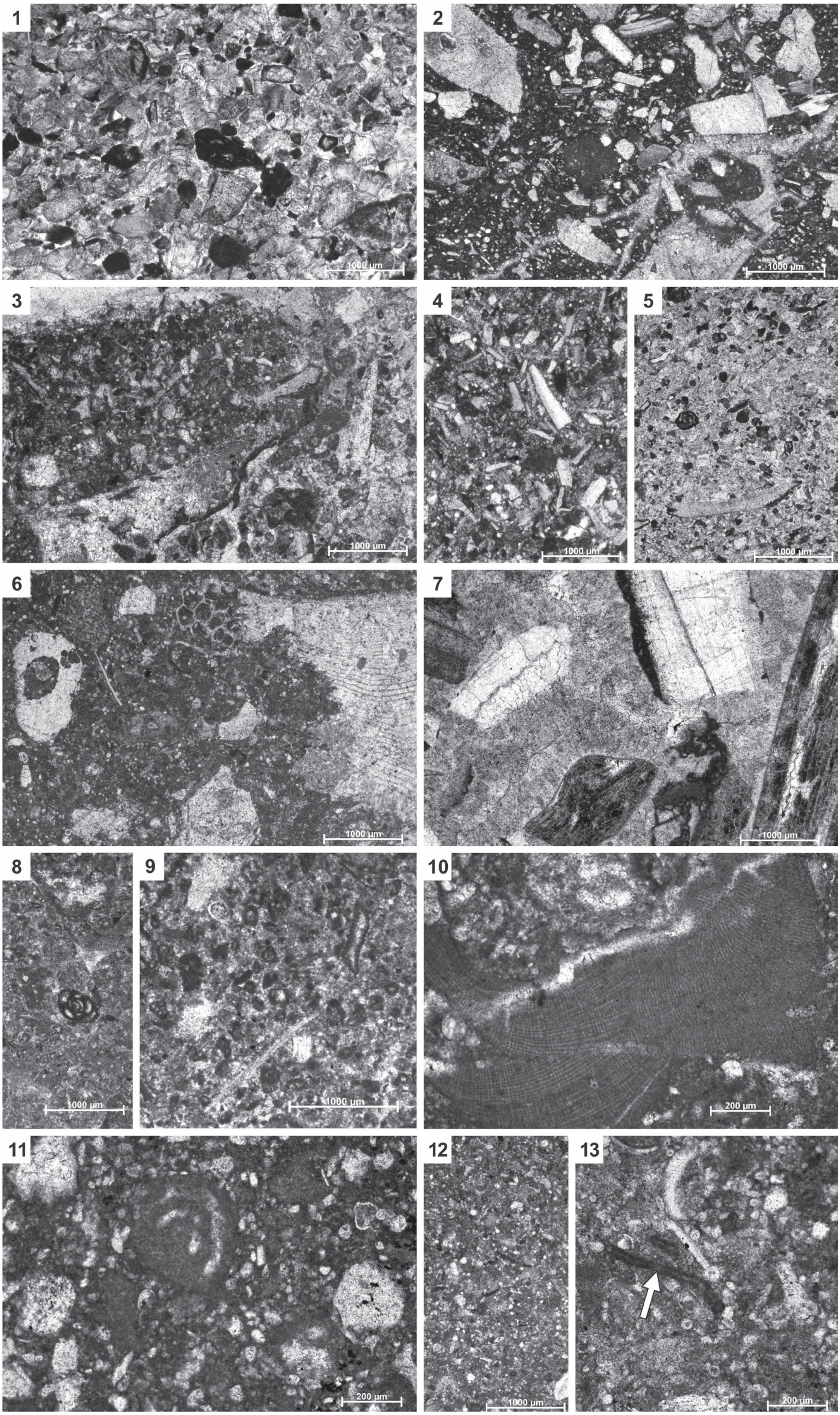
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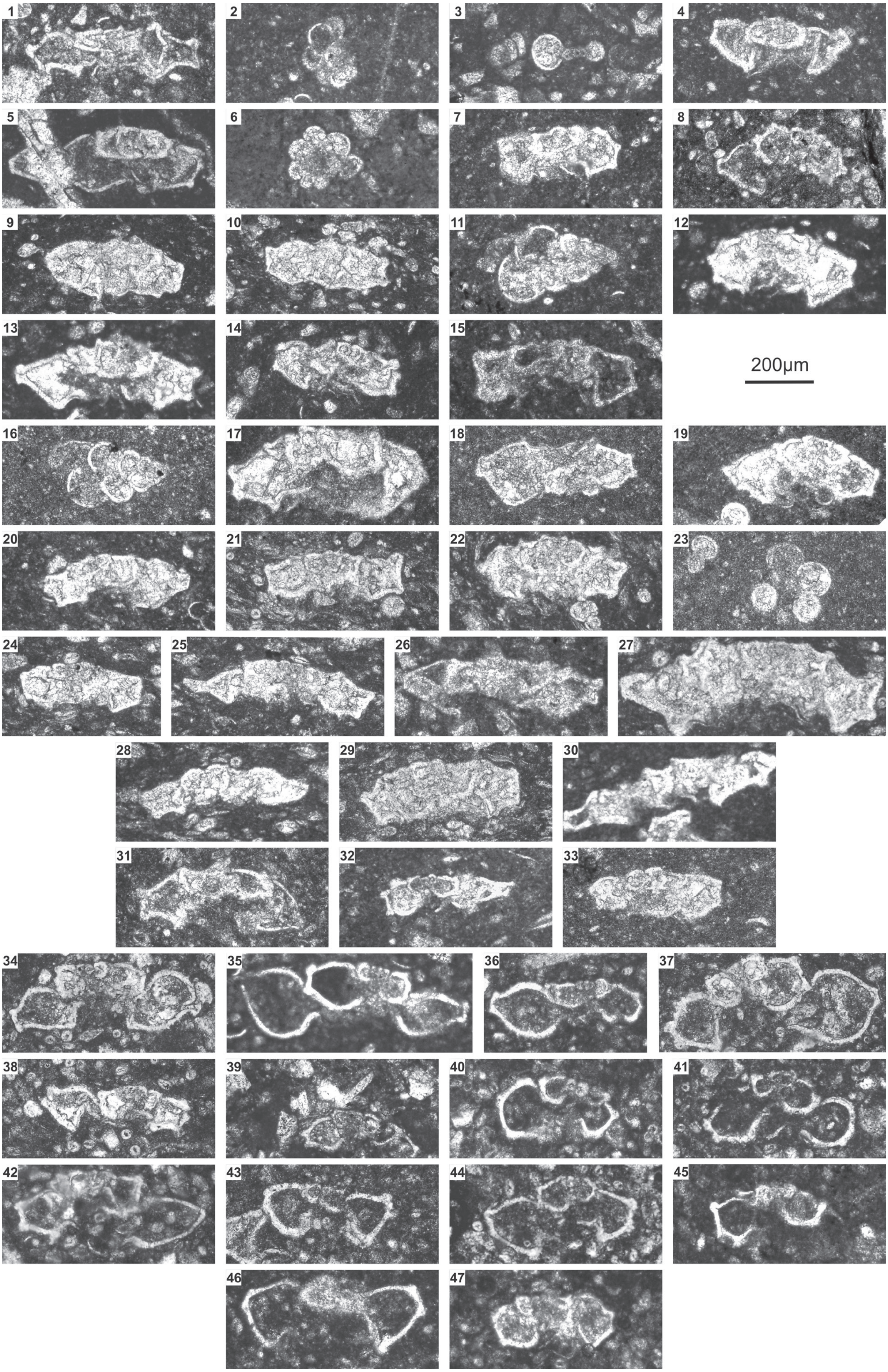
PLATE 4

Planktonic foraminifera

Ist profile: 1. *Marginotruncana* cf. *pseudolinneiana*, **2.** *Hedbergella* sp., **3.** *Globigerinoides* sp., **4.** *Marginotruncana* cf. *renzi*, **5.** *M.* cf. *coronata*, **6.** *Hedbergella* sp., **7.** *Marginotruncana pseudolinneiana*, **8.** *M. schneegansi*, **9.** *M.* cf. *pseudolinneiana*, **10.** *M. pseudolinneiana*, **11.** *Heterohelix* sp., **12.** *Marginotruncana* cf. *paraconcavata*, **13.** *M. sinuosa*, **14.** *M. pseudolinneiana*, **15.** *M. pseudolinneiana*

Premuda profile: 16. *Heterohelix* sp., **17.** *Marginotruncana* cf. *tarfayaensis*, **18.** *M. marginata*, **19.** *Marginotruncana* sp., **20.** *M. paraconcavata*, **21.** *M. pseudolinneiana*, **22.** *M.* cf. *sinuosa*, **23.** *Hedbergella* sp., **24.** *Marginotruncana pseudolinneiana*, **25.** *Marginotruncana* sp., **26.** *M. paraconcavata,* **27.** *M. tarfayaensis*, **28.** *Marginotruncana* sp., **29.** *M. pseudolinneiana*, **30.** *Marginotruncana* sp., **31.** *Marginotruncana* sp., **32.** *M.* cf. *coronata*, **33.** *M. pseudolinneiana*

Silba profile: 34. *Marginotruncana* cf. *schneegansi*, **35.** *M. schneegansi*, **36.** *M. marginata*, **37.** *M. schneegansi*, **38.** *M.* cf. *paraconcavata*, **39.** *Marginotruncana* sp., **40–41.** *Archaeoglobigerina* sp., **42.** *Marginotruncana renzi,* **43.** *Dicarinella* sp., **44–46.** *Marginotruncana* sp., **47.** *M.* cf. *marginata*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