The onset of Maastrichtian basinal sedimentation on Mt. Matajur, NW Slovenia

Začetek maastrichtijske bazenske sedimentacije na Matajurju, SZ Slovenija

Blaž Miklavič[1], Boštjan Rožič[2]

[1]Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia;
E-mail: blaz.miklavic@gmail.com
[2]University of Ljubljana, Faculty of Natural Sciences and Engineering,
Department of Geology, Aškerčeva cesta 12, SI-1000 Ljubljana, Slovenia;
E-mail: bostjan.rozic@ntf.uni-lj.si

Received: October 28, 2007 **Accepted:** May 26, 2008

Abstract: Maastrichtian limestone breccia with varying thickness was deposited with angular discordance on Jurassic and Cretaceous platform limestones on the northern part of Mt. Matajur, Slovenia. The whole area was later overlaid by finer siliciclastic rocks with intra layers of limestone breccia, which changes the frequency of its appearance. We interpreted the resulting situation as a consequence of the sedimentation environment at the margin of the retrograding Dinaric Carbonate Platform in the late Cretaceous.

Izvleček: Na severni strani Matajurja je bila na jurske in kredne platformske apnence s kotno diskordanco odložena maastrichtijska apnenčeva breča različne debeline. Celotno območje je bilo kasneje prekrito s finejšimi siliciklastičnimi kamninami z vmesnimi plastmi apnenčeve breče z različno pogostnostjo pojavljanja. Nastalo situacijo smo interpretirali kot posledico sedimentacijskega okolja na robu retrogradirajoče Dinarske karbonatne platforme v pozni kredi.

Keywords: Maastrichtian, Dinaric Carbonate Platform, Mt. Matajur, flysch, limestone breccia
Ključne besede: maastrichtij, Dinarska karbonatna platforma, Matajur, fliš, apnenčeva breča

Introduction

The area of Mt. Matajur is located in the Julian Prealps, NW Slovenia. In the Late Triassic, Jurassic and early Createaceous it was located in the northern margin of the Dinaric Carbonate Platform. In the late Campanian and Maastrichtian the area experienced accelerated subsidence, related to the tectonically induced southward-retrograding platform. The area was firstly a part of a fault-dissected slope that experienced erosion. Subsequently, due to continuing back-stepping of the platform, the area gradually subsided and the deposition started. Sedimentation was firstly characterized by limestone breccias that originated from the collapse of the platform margin. Later it was reached by the southwards prograding flysch basin (Buser & Pavšič, 1978) that was marked by flysch deposits originating from the rising Alpine orogen in the north, alternating with limestone gravity-flow deposits originating from the south-retreating Dinaric Carbonate Platform. The depositional setting fits well with the collisional fordeep basin model of Bradley and Kidd (1991). The model is additionally supported by the corresponding south-shifting forebulge of the same period that was recognized in the inner parts of the Dinaric Carbonate Platform (Otoničar, 2007).

Although the late Cenomanian/Maasrichtian sedimentary evolution of western Slovenia is generally well resolved, no smaller-scale sedimentological studies were made on the northern margin of the Dinaric Carbonate Platform. The present paper presents such a study from the Mt. Matajur area. It compiles older stratigraphic observations and new data obtained by detailed mapping on a scale of 1:5000, which gave a new insight and interpretation of the sedimentation regime in Maastrichtian for the area concerned. The study focuses on limestone breccia bodies, i.e., their shape, lateral continuity and, the vertical as well as horizontal relationship with the underlying carbonates and the surrounding flysch deposits.

Geological settings

The Mt. Matajur area structurally belongs to the External Dinarides (Buser, 1986), characterized by SW-verging thrust displacements. It lies within the uppermost Trnovo Nappe in its north-western part (Placer, 1981; Buser, 1987). On a smaller scale, the succession forms the Mija–Matajur Anticline, where the Mt. Matajur area is situated in its southern hinge, where the beds generally dip towards the south (Winkler, 1921; Cousin, 1981; Pirini Radrizzani et al., 1986; Buser, 1986). Another important structural feature marks the investigated area; it lies at the boundary with the Southern Alps, a macrotectonic unit that consists of the Tolmin Basin and the Julian Carbonate Platform successions (Buser, 1989, 1996; Placer, 1999; Šmuc, 2005; Rožič, 2005; Rožič and Popit, 2006). The Southern Alps are characterized by younger (Miocene) south-verging thrust displacements (Placer, 1999; Vrabec and Fodor, 2006). Although western Slovenia is dissected by intense NW-SE strike-slip neotectonics, the investigated area is not deformed, which leaves the primary facies relationships undisturbed.

In the Mt. Matajur area one of the northernmost Dinaric Carbonate Platform successions is preserved. It is generally marked by continuous shallow-water sedimentation during the Jurassic, succeeded by a more complex depositional pattern of the tectonically forced, retrograding platform margin. Therefore, the succession that overlies the platform limestones is characteristic for the slope depositional setting, experiencing long periods of non-deposition or erosion, i.e., stratigraphic gaps and occasional condensed carbonate sedimentation. The late Cretaceous is marked by further subsidence in the area and the reoccurrence of continuous sedimentation, this time in the basinal setting. It begins with the base-of-slope deposits, i.e., basal limestone breccias, and is overlain by flysch deposits, occasionally interrupted by abundant carbonate breccias. The composition of the clasts of the breccia indicates that the material must have originated from the collapsing slope of the south-retreating Dinaric Carbonate Platform (Buser & Pavšič, 1978; Buser, 1986). The siliciclastic material of the flysch, on the other hand, must have had a different origin, which may also be concluded from the paleo-current marks observed in the nearby area by Kuščer et al. (1974). The shown SE direction, corrected by the anti-clockwise rotation of the region (30° in the post-Eocene times, Marton & Vejović, 1983), point to north-deriving turbidites.

Stratigraphic units

The territory of our interest on the northern part of Mt. Matajur has been the subject of some previous general geological surveys (Winkler, 1921; Cousin, 1981; Buser, 1986). A more detailed stratigraphic research was made in a nearby area in the Italian territory (Pirini Radrizzani et al., 1986). We present a compilation of these studies and our own work.

Platform limestones – Jurassic

Platform limestones succession forms the northern slopes of the Mt. Matajur range. It begins with Upper Triassic Dachstein Limestone, with typical lofer sequences, and passes upwards into Jurassic limestone. In the investigated area only the topmost Jurassic part of the succession was included in the study. The Jurassic platform limestone typically occurs in layers 0.2 to 1.5 m thick and mostly consists of micrite with stromatolite horizons and frequent desiccation cracks. Bivalves from macrofossils are most abundant (Plate 1, Figure 1). In the western part of the area these beds are overlain by ooidal limestone with interlayers of intraformational limestone breccia.

Close to the mapped area at the Svinja planina, Buser (1986) found Lithiotis bivalves and assigned the overall limestone succession above the Dachstein Limestone to the Lower Jurassic. The Middle Jurassic succession of the Dinaric Carbonate Platform is characterized by abundant ooides (Buser, 1989, 1996), and the ooidal limestone with intraformational breccias that ends the platform limestone succession on the observed territory could be Middle Jurassic in age. Upper Jurassic is probably not preserved in the investigated area. In contrast, a more complete Jurassic succession is reported from the northern hinge of the Mija-Matajur Anticline (Buser, 1987) as well as westward from across the state border (Cousin, 1981; Pirini Radrizzani et al., 1986).

Nodular limestone and calcarenite with chert – Uppermost Jurassic and Lower Cretaceous

On the western part of the mapped area the Jurassic platform limestones are overlain with layers of nodular-bedded micritic limestone intercalated by even-bedded calcarenite (Plate 1, Figure 2). Both facies are replaced with chert nodules and sheets. They have a similar dip to the underlying platform limestone and their total thickness gradually increases towards the west of the mapped area where it reaches 60 m.

The stratigraphic ordering of these limestones varies a great deal from author to author. Winkler (1921) assigned them to the Lower Jurassic, Cousine (1981) classifies the same layers observed in the nearby territory to the Upper Jurassic, whereas Buser (1985, 1987) considers them as Coniacian to Lower Maastrichtian Volče Limestone Formation. Pirini Radrizzani et al. (1986) classify similar layers across the state border to the upper Tithonian to Albian (Soccher limestone). Because they made the most detailed survey of these beds their conclusion is likely to be the most accurate.

Upper Flyschoid Formation – Maastrichtian

The Upper Flyschoid Formation characterizes the Maastrichtian sedimentation of the Slovenian Basin (Cousin 1970, 1981; Caron and Cousin, 1972). It usually begins with a rather thick horizon of basal limestone breccia and is upwards replaced by flyschoid development; i.e., marls and shales alternating with siliciclastic and carbonate turbidites (later in the text the term flysch is used only for the siliciclastic portion of the flyschoid deposits). A very similar facies association is also observed in the Mt. Matajur area, but thick limestone breccias also occur within flyschoid development.

Basal limestone breccia

The basal limestone breccia is thickest on the eastern part of the territory where it reaches 130 m and gradually wedges out toward the west. It consists of several horizons with differing levels of sorting. Clasts are typically 2-5 cm in size with occasional blocks that exceed 1 m in diameter. The roundness varies significantly and these facies would often be better classified as conglomerate. Nevertheless, due to generalization the term breccia is used in the paper. Their composition varies considerably: macroscopically rudist, reef, micritic, and ooidal limestone have been identified. Less common were clasts of Dachstein limestone and chert. The layering is poorly visible with beds above 1 m thick. The matrix is mostly calcarenite, but rarely the marly matrix is also present. Upwards the unit tends to end with calcarenite/limestone sandstone. On the eastern part the limestone breccia is channelized into Jurassic limestones with an angle discordance. Westwards, in the middle part of the mapped area, where it gradually wedges out, it appears only in the form of small pockets on the Jurassic ooidal limestone (Plate 1, Figure 3). On the westernmost part it reappears on the Cretaceous nodular limestone with chert. These layers are most probably younger than the basal limestone

Plate 1. Fig. 1: Jurassic platform limestones with bivalves in the living position, Fig. 2: Lower Cretaceous nodular-bedded limestone and even-bedded calcarenite (above hammer), Fig. 3: Contact between Jurassic ooidal limestone and overlying basal limestone breccia in the central part of the mapped area, Fig. 4: On-lapping of the flyschoid sediments (left) on the paleo-slope composed of Jurassic platform limestones, Fig. 5: Chaotic breccia with limestone and chert clasts outcropping near the 'paleo'-slope

Tabla 1. Sl. 1: Jurski platformni apnenci s školjkami v življenjskem položaju, Sl. 2: Spodnjekredni gomoljastoplastnati apnenec in ravnoplastnati kalkarenit (nad kladivom), Sl. 3: Stik med jurskim ooidnim apnencem in višje ležečo bazalno apnenčevo brečo v centralnem delu raziskanega območja, Sl. 4: Naleganje flišoidnega zaporedja (levo) na »paleopobočje«, ki ga sestavljajo jurski platformski apnenci (desno), Sl. 5: Kaotična breča z apnenčevimi in roženčevimi klasti, ki izdanja v bližini »paleopobočja«

breccias in the eastern part of the mapped area. They thicken westwards, like the underlying limestone with chert (Figure 1).

Flyschoid development with layers of limestone breccia

Flyschoid sediments overlie all the previously described stratigraphic units throughout the Mt. Matajur area. On the extreme eastern and western parts they cover the Maastirchtian limestone breccia, whereas in the middle part they lie over the Jurassic and lower Cretaceous limestones. They mainly consist of reddish, laminated to thin-bedded claystone and marl or brown sandy claystone or marl, rarely exhibiting an incomplete Bauma sequence. Frequently, there are very thin, normally graded siliciclastic sandstone beds. In the central part of the area the several-meters-thick, gray claystone occurs just above the contact with limestone breccia. The X-ray diffraction analysis of this claystone showed a simple mineral composition of the rock containing just filosilicates (chlorite and illite/muscovite), whereas quartz was detected in only a few samples (Miklavič, 2007). Mud-supported (chaotic) breccias occur in the central part of the terrain near the paleotopographic slope (Plate 1, Figures 4,5) (for details see the following section). The clasts in this bed are shallow-water carbonates as well as rare angular cherts (Plate 1, Figure 5). Westward of this paleo-slope, lower Cretaceous nodular limestone is preserved, whereas eastward it was eroded.

Typical for this stratigraphic unit are the 0.1 to 1.5 m thick layers of channelled limestone breccia and calcarenite, which start to occur 10 m above the basal limestone breccias/flyschoid border and stretch laterally over a couple of hundred meters. Normal gradation was observed, especially in the calcarenites. Higher up the stratigraphic sequence the layers of the limestone breccia and calcarenite get thicker and more frequent, thus forming limestone-dominated intervals that are several tens of metres thick. Within the limestone beds interlayers of flysch sediments are still present, being up to 3 m thick. Two such thick intervals are observed on the northern slope of Mt. Matajur. The first characterizes the eastern part of the territory, where it forms the present-day topographic range eastward of Mt. Matajur above the Tršca spring and continues to the peak of Mt. Mrzli vrh. Westward it becomes thinner and finally wedges out above the paleotopographic slope in the western part of the mapped area (Figure 1). The thickness of the flyschoid sediments between the first interval and the basal breccia is generally around 60 meters. It quickly thins above the paleotopographic slope to only 15 meters. In this part of the territory no basal breccia horizons are deposited and the flyschoid sediments directly overlie the lower Cretaceous nodular limestone. A second interval is observed in the western part of the territory, and this forms the top of Mt. Matajur. The thickness of the flyschoid sediments between the second interval and the basal breccia or nodular limestone is relatively uniform and is around 70 meters.

Discussion

In the late Triassic and Jurassic, Mt. Matajur was located on the northern margin of the Dinaric Carbonate Platform. Although

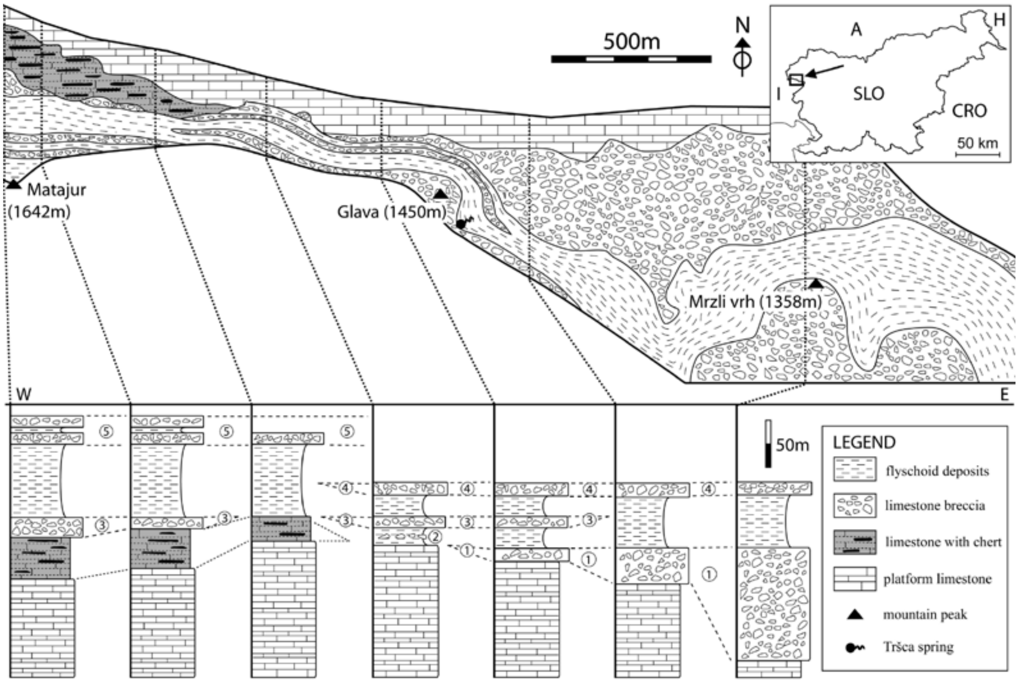

Figure 1. Location (upper-right corner) and geological map of the Mt. Matajur area with simplified stratigraphic sections. Numbering of limestone breccia horizons: 1-basal limestone breccia, 2-mud-supported (chaotic) breccia with limestone and chert clasts, 3-»western« basal limestone breccia, 4-first interval dominated by limestone breccia and calcarenite, 5-second interval dominated by limestone breccia and calcarenite.

Slika 1. Lokacija (zgornji desni kot) in geološka karta območja Matajurja s poenostavljenimi stratigrafskimi stolpci. Oštevilčenje horizontov apnenčevih breč: 1-bazalne apnenčeve breče, 2-kaotične breče s klasti apnencev in rožencev, 3-»zahodne« bazalne apnenčeve breče, 4-prvi interval s prevladujočimi apnenčevimi brečami in kalkareniti, 5-drugi interval s prevladujočimi apnenčevimi brečami in kalkareniti.

Upper Jurassic limestones are probably not preserved in the Mt. Matajur area, the shallow-water sedimentation in the wider area persisted until the late Jurassic, because the Upper Jurassic shallow-water limestones are reported from the northern part of the Mija-Matajur Anticline (Buser, 1989) and also westward in the nearby Italian territory (Pirini Radrizzani et al., 1986).

The Jurassic platform limestones are overlain by upper Tithonian to Albian nodular micritic limestone with chert nodules and calcarenite interbeds. The facies association indicates a deposition in a deeper-water sedimentary environment. Furthermore, nodular bedding of the micritic limestone elucidates a rather condensed carbonate sedimentation (e.g., Martire, 1996), thus the sedimentation of these beds in the slope seams most convenient. The end Jurassic/early Cretaceous subsidence of the Dinaric Carbonate Platform margin coincides with the initial phases of the compressive tectonic regime in the internal domains of the Dinarides (CHANNELL et al., 1979; DIMITRIJEVIĆ, 1982; KARAMATA, 1988) and with the onset of thrusting in the Northern Calcareous Alps (GAWLICK et al., 1999). According to PIRINI RADRIZZANI et al. (1986) the sedimentation of this unit ends in the Albian. The termination coincides with the onset of the sedimentation of the Lower Flyschoid Formation in the Tolmin Basin, characterized in the areas proximal to the Dinaric Carbonate platform by thick basal limestone breccias (CARON and COUSIN, 1972; BUSER, 1987; SAMIEE, 1999; ROŽIČ, 2005). These breccias indicate a new pulse of increased subsidence and the reorganisation of the depositional setting. Namely, the slope became dissected by normal faults, which increased the overall angle and resulted in erosion or at least the non-deposition in the slope, as evidenced by the Albian–Campanian stratigraphic gap in the Mt. Matajur area.

In the Late Campanian/early Maastrichtian a new pulse of accelerated subsidence (the Laramian tectonic phase in BUSER, 1989, 1996) led to the reorganisation of the sedimentary environment in the Mt. Matajur area. Firstly, during subsidence a tectonic block of Mt. Matajur tilted towards the west (Figure 2). This can be deduced from the increasing thickness towards the west of the lower Cretaceous limestones, together with the overlying basal limestone breccia of the Maastrichtian Upper Flyschoid Formation. Further subsidence resulted in the onset of the base-of-slope deposits, i.e., of the basal limestone breccia. The composition records the erosion of older platform limestones, which were exposed in the fault-dissected slope. The deposition of these breccias was at the beginning limited to the eastern part of the examined area (Figure 3). It is either the consequence of (1) erosion of those gravity currents that were directed by the feeder channel, predominantly in the eastern part of the area, or (2) gravity currents filled pre-existing paleotopographic low in the eastern part. Simultaneously, the western part of the area formed paleotopographic high, which was by-passed by gravity currents (Figure 3). In second scenario the paleorelief was moderately increasing towards the west. The exception was the steeper paleo-slope in the western part of the area that was several tens of meters high and extended probably in the N-W direction (Figure 2). At the top of this slope the lower Cretaceous limestone starts to occur. It could indicate that this formation was relatively more erosion-resistant, thus forming the palotopographic high.

The sedimentation of the basal limestone breccias ceased due to the further retrogradation of the Dinaric Carbonate Platform. Subsequent sedimentation is characterized by hemipelagic deposits, as evidenced by the relatively simple mineral composition of the overlying claystones and by the distal flysch deposits marked by incomplete Bouma sequences. This relatively quiet sedimentation period was only occasionally interrupted by carbonate gravity flows originating from the south-retreating platform and the slope. Conspicuous sediments, i.e., debrie flow deposits, occur within the flysch near the previously described paleotopographic slope. These chaotic breccias with a marly matrix contain limestone as well as chert clasts and most probably originated by tectonically

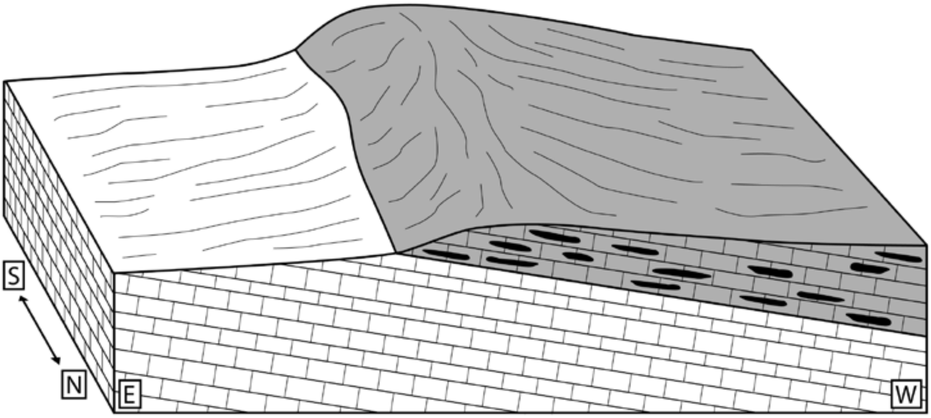

Figure 2. Schematic reconstruction prior to the deposition of the Upper Flyshoid Formation: the succession is tilted toward the west and the paleotopography is gently rising towards the west with a steeper paleo-slope in the central part (for Figures 2 to 7 take into consideration: a) for legend see Figure 1; b) view is from north-east; c) the eastern part of the area is shortened due to more representative reconstruction; d) facts are presented in the front wall, whereas the rest of the reconstruction is an assumption)
Slika 2. Shematska rekonstrucija stanja pred odlaganjem zgornje flišoidne formacije: zaporedje kamnin je nagnjeno proti zahodu in paleotopografija se blago viša proti zahodu s strmejšim »paleopobočjem« v srednjem delu območja (na slikah 2 do 7 naj bralec upošteva: a) litostratigrafske oznake so enake kot na sliki 1, b) pogled je s severovzhoda, c) vzhodni del območja je skrajšan zaradi preglednejše rekonstrucije, d) dejstva so predstavljena na sprednjem delu skice, medtem, ko je ostali del rekonstrukcije domneven)

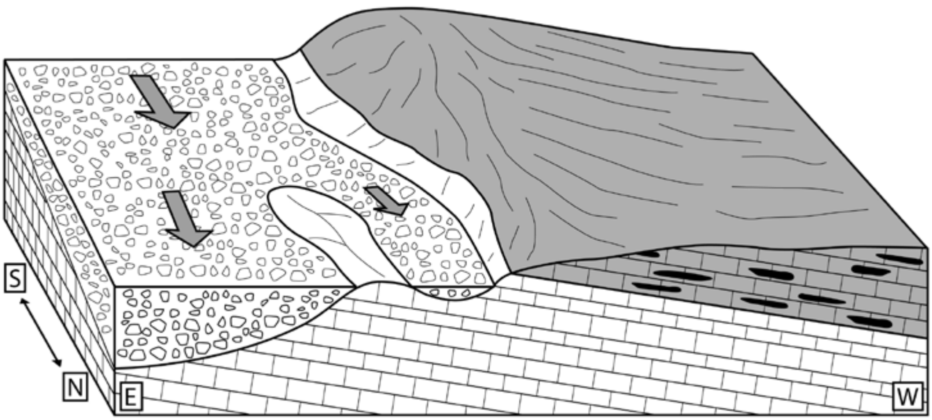

Figure 3. Schematic reconstruction of the basal limestone breccia deposition (for details of the reconstruction see the text for Figure 2)
Slika 3. Shematska rekonstrukcija sedimentacije bazalne apnenčeve breče (podrobnosti rekonstrucije so obrazložene v besedilu pri sliki 2)

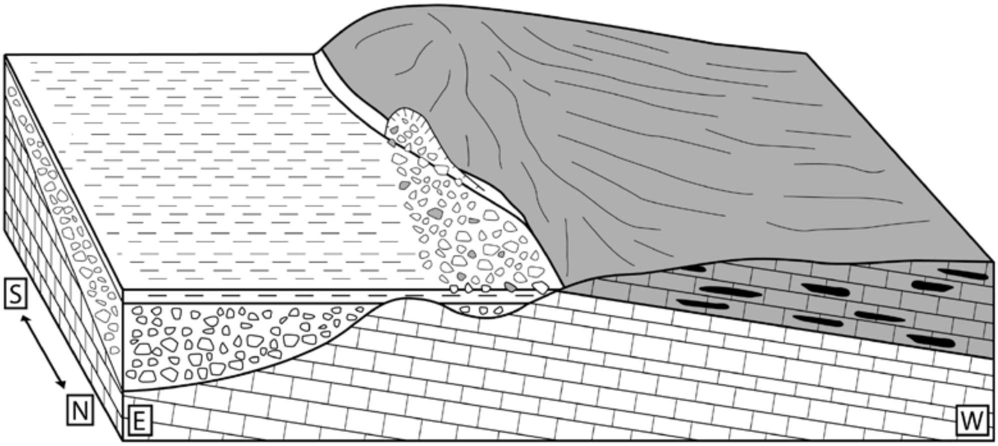

Figure 4. On-lapping of the flyshoid sediments (left) on the paleo-slope composed of Jurassic platform limestones (right)
Slika 4. Shematska rekonstrukcija sedimentacije kaotične breče, ki je nastala s porušitvijo »paleopobočja« v srednjem delu območja (podrobnosti rekonstrucije so obrazložene v besedilu pri sliki 2)

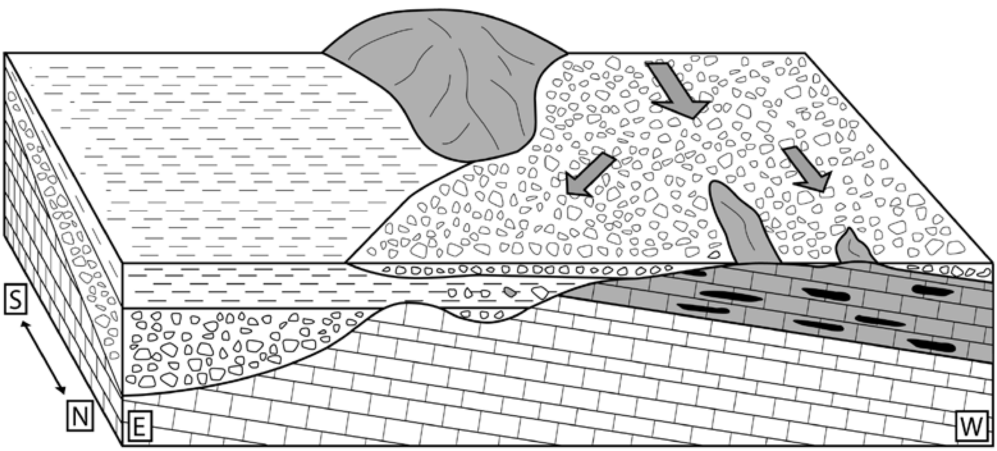

Figure 5. Schematic reconstruction of the »western basal limestone breccia« deposition (for details of reconstruction see the text for Figure 2)
Slika 5. Shematska rekonstrukcija sedimentacije »zahodne« bazalne apnenčeve breče (podrobnosti rekonstrucije so obrazložene v besedilu pri sliki 2)

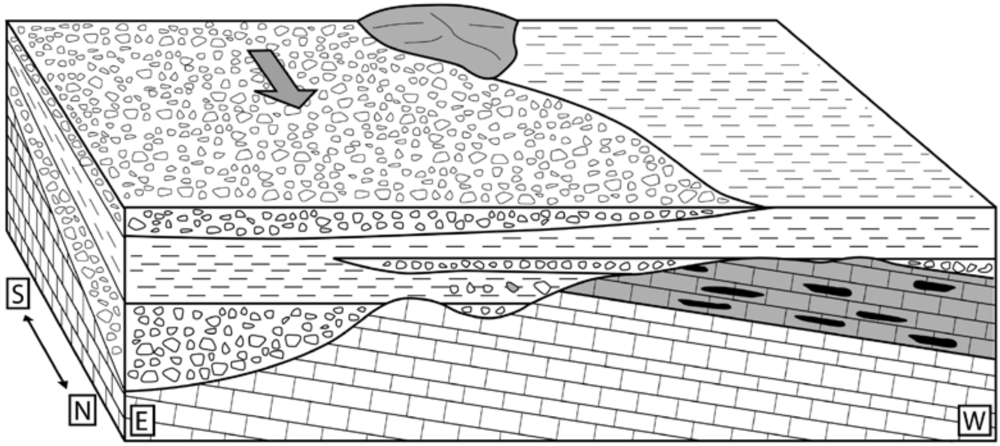

Figure 6. Schematic reconstruction of the deposition during the first interval dominated by limestone breccia and calcarenite (for details of the reconstruction see the text for Figure 2)

Slika 6. Shematska rekonstrukcija sedimentacije prvega intervala s prevladujočimi apnenčevimi brečami in kalkareniti (podrobnosti rekonstrucije so obrazložene v besedilu pri sliki 2)

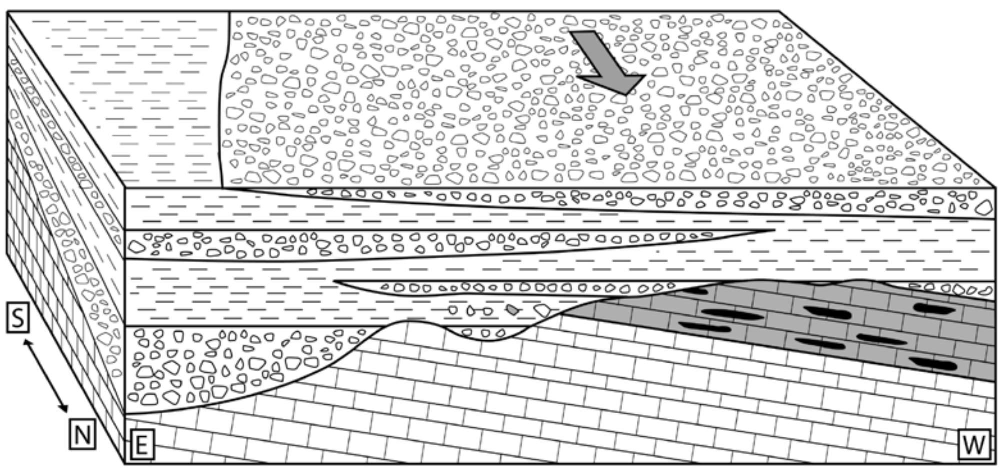

Figure 7. Schematic reconstruction of the deposition during the second interval dominated by limestone breccia and calcarenite (for details of the reconstruction see the text for Figure 2)

Slika 7. Shematska rekonstrukcija sedimentacije drugega intervala s prevladujočimi apnenčevimi brečami in kalkareniti (podrobnosti rekonstrucije so obrazložene v besedilu pri sliki 2) triggered collapses of the previously mentioned slope (Figure 4).

The deposition of limestone breccia that overlies the lower Cretaceous limestone in the western part of the studied area (»western basal limestone breccia«) started when the eastern paleotopographic low was almost filled with distal flysch deposits and minor carbonate resediments (Figure 5). This breccia is thickest on the west; towards the east it thins out and is occasionally discontinued. The widest lateral discontinuity appears above the paleo-slope (Figure 5). Eastward, near the top of this slope, a rather thick limestone breccia bed is situated within the flyschoid deposits and probably represents the eastern continuation of the »western basal limestone breccia«. This bed gradually wedges out further east.

The following distal flysch deposits blanketed the entire paleorelief existing in the examined area. These deposits are interrupted by two thick intervals of limestone breccia and calcarenite, probably originating in periods of increased tectonic activity. The lower interval is deposited predominantly in the eastern part of the mapped area; it still occurs above the paleotopographic slope and finally wedges out towards the west (Figure 6). The upper interval forms the top of Mt. Matajur, which is located in the western part of the area (Figure 7). Although the eastern continuation of the upper interval was not studied, the described distribution of the two horizons probably indicates a westward migration of the limestone breccias supply channel.

Summary

The compilation of the detailed mapping and the older stratigraphic research of the Mt. Matajur area leads to the following conclusions:

A. In the Mt. Matajur area the shallow-water carbonate sedimentation probably persisted almost all through the Jurassic and was only in the latest Jurassic replaced by slope deposits, characterized by nodular micritic limestone with chert nodules and interbedded calcarenites.

B. At the end of Albian the tectonic phase dissected the slope with normal faults, which resulted in an increased slope angle and a subsequent long period of erosion or at least non-deposition.

C. In the late Campanian/early Maastrichtian a new tectonic pulse caused further subsidence of the Mt. Matajur area. Before the deposition reoccurred, the tectonic block was tilted towards the west and an uneven paleorelief existed. The paleorelief was gentle with the exception of a steeper slope in the centre of the mapped area that separated the eastern paleotopographical low and the western paleotopographical high.

D. In the Maastrictian the Upper Flyschoid Formation deposited. It is characterized by alternating south-derived limestone breccias originating from platform collapsing, hemipelagic deposits and north-derived distal flysch deposits. The following depositional stages were recognized: 1. Basal limestone breccias probably additionally eroded and subsequently filled the eastern paleotopographic low. 2. When the deposition of these beds ceased the western paleotopographic high still existed. 3. The remain-

ing depression was filled predominantly by hemipelagic and distal flysch deposits. The collapses of the paleotopographic slope of the area resulted in the formation of debrie flow deposits (chaotic breccias) that occur near the slope within the distal flysch deposits. 4. Just before the paleorelief was levelled the new horizon of limestone breccias deposited predominantly in the western part of the area. 5. The following sedimentation of distal flyschoid deposits finally blanketed the paleorelief. 6. The flyschoid sedimentation was interrupted by two thicker intervals composed predominantly of limestone breccia and calcarenite. The lower interval deposited predominantly in the eastern part, whereas the upper was observed only in the western part of the area. Such a distribution presumably resulted from the westward migration of the supply channel for these deposits.

Povzetek

Začetek maastrichtijske bazenske sedimentacije na Matajurju, SZ Slovenija

Z izsledki detajlnega kartiranja in starejših stratigrafskih raziskav na Matajurju smo prišli do naslednjih zaključkov:

A. Na območju Matajurja je plitvovodna karbonatna sedimentacija najverjetneje trajala večji del jure in je bila šele v pozni juri nadomeščena s pobočno sedimentacijo, pri kateri je bil odložen gomoljasti mikritni apnenec z gomolji roženca in vmesnimi kalkareniti.

B. Na koncu albija je tektonska faza povzročila razkosanje pobočja z normalnimi prelomi, zaradi česar je prišlo do povečanega nagiba pobočja in posledične erozije oz. prekinitve sedimentacije.

C. V poznem campaniju/zgodnjem maastrichtiju je nova tektonska aktivnost povzročila dodatno tonjenje območja Matajurja. Pred ponovno sedimentacijo je prišlo do nagiba tektonskega bloka proti zahodu in obstoja neravnega paleoreliefa. Paleorelief je bil polóžen z izjemo osrednjega dela kartiranega območja, kjer je strmejši del ločeval vzhodni (paleotopografski) nižji predel od zahodnega višjega predela.

D. V maastrichtiju so se odlagali sedimenti zgornje flišoidne formacije. Zanjo so značilne izmenjujoče se plasti apnenčeve breče, hemipelagičnih in flišnih sedimentov. Material apnenčevih breč je izviral iz rušeče se karbonatne platforme na jugu, medtem ko so flišni sedimenti prihajali s severa. Prepoznane so bile sledeče faze odlaganja: 1. Bazalne apnenčeve breče, ki so dodatno erodirale in zatem zapolnile paleotopografski nižji predel. 2. Ko se je odlaganje teh plasti zaključilo, je zahodni paleotopografski višji predel še vedno obstajal. 3. Preostala depresija je bila v glavnem zapolnjena s hemipelagičnimi in distalnim flišnimi sedimenti. Posledica rušenja paleotopografskega pobočja so sedimenti debritnih tokov (kaotična breča), ki se odložili znotraj distalnih flišnih sedimentov. 4. Tik pred izravnavo paleoreliefa se je pretežno na zahodnem delu območja odložil nov horizont apnenčeve breče. 5. Kasneje odloženi distalni flišoidni sedimenti so dokončno prekrili paleorelief. 6. Flišoidna sedimentacija je bila prekinjena z odložitvijo dveh debelejših intervalov sestavljenih pretežno

iz apnenčevih breč in kalkarenita. Spodnji interval je bil odložen v glavnem na vzhodnem delu, medtem ko najdemo zgornjega samo na zahodnem delu območja. Takšna porazdelitev je najbrž posledica migracije dovodnega kanala proti zahodu.

Acknowledgements

We would like to thank the lectors, Dr. Paul McGuiness (English part of the text), and Dr. Matej Šekli (Slovenian part of the text), and the reviser, Dr. Dragomir Skaberne, for their corrections.

References

Bradley, D.C., Kidd, W.S.F. (1991): Flexural extention of the upper continental crust in collisional fordeeps. *Geological Society of America Bulletin*.; Vol. 103, pp. 1416-1438.

Buser, S. (1985): *Rokopisna delovna karta merila 1:25.000 izdelana za Osnovno geološko karto SFRJ 1:100.000, list Tolmin in Videm (Udine)*. Geološki zavod Ljubljana, Ljubljana.

Buser, S. (1986): *Osnovna geološka karta SFRJ, Tolmač listov Tolmin in Videm (Udine)*. Zvezni geološki zavod, Beograd, 103 p.

Buser, S. (1987): *Osnovna geološka karta SFRJ 1:100 000, list Tolmin*. Zvezni geološki zavod, Beograd.

Buser, S. (1989): Development of the Dinaric and Julian carbonate platforms and the intermediate Slovenian basin (NW-Yugoslavia). In: Carulli, GB., Cucchi, F., Radrizzani, CP. (eds.): Evolution of the Karstic carbonate platform: relation with other periadriatic carbonate platforms. *Mem. Soc. Geol. Ital*.; Vol. 40, pp. 313-320.

Buser, S. (1996): Geology of Western Slovenia and its paleographic evolution. In: Drobne, K. et al. (ed.): *The role of impact processes in the geological and biological evolution of planet Earth*. International workshop, September 27 – October 2, 1996, Postojna/Slovenia, pp. 111–123.

Buser, S., Pavšič, J. (1978): Pomikanje zgornjekrednega in paleogenskega flišnega bazena v zahodni Sloveniji. *Zbornik radova 9. kongresa geologa Jugoslavije, Sarajevo 1978*.; pp. 399-419.

Caron, M., Cousin, M. (1972): Le sillon slovène: les formations terrigènes crétacées des unites externes au Nord-Est de Tolmin (Slovénie occidentale). *Bull. Soc. Géol. France*.; Vol. 14, pp. 34-45.

Channell, J.E.T., D`Argenio, B., Horvath, F. (1979): Adria, the African Promontory, in Mesozoic Mediterranean Paleogeography. *Earth-Science Reviews*.; Vol. 15, pp. 213-292.

Cousin, M. (1970): Esquisse géologique des confins italo-yougoslaves: leur place dans les Dinarides et les Alpes méridionales. *Bull. Soc. Géol. France*.; Vol. 7 (XII), pp. 1034-1047.

Cousin, M. (1981): Les repports Alpes – Dinarides. Les confins de l' Italie et dela Yougoslavie. *Sociètè Gèologique du Nord*.; Publi. 5, Vol. 2 – Annexe, 521 p., Villenueve.

Dimitrijević, M.D. (1982): Dinarides: An Outline of the Tectonics. *Earth Evolution Sciences*.; Vol. 2, pp. 4-23.

Gawlick, H.J., Frisch, W., Vescei, A., Steiger, T., Bohm, F. (1999): The change from rifting to thrusting in the Northern Calcareous Alps as recorded in Jurassic sediments. *Geologische Rundschau*.; Vol. 87, pp. 644-657.

Karamata, S. (1988): ``The Diabase-Chert Formation`` some generic aspects. *Bulletin de l`Academis Serbe des Sciences et des Arts, Clase des Sciences naturelled et mathematiques*.; Vol. 95, pp. 1-11.

Kuščer, D., Grad, K., Nosan, A., Ogorelec, B. (1974): Geološke raziskave soške doline med Bovcem in Kobaridom. *Geologija*.; Vol. 17, pp. 426-476.

Martire, L. (1996): Stratigraphy, Facies and Synsedimentary Tectonics in the Jurassic Rosso Ammonitico Veronese (Altopiano di Asiago, NE Italy). *Facies*.; Vol. 35, pp. 209-236.

Marton, E., Veljović, D. (1983): Paleomagnetism of the Istria Peninsula, Yugoslavia. *Tectonophysics*.; Vol. 91, pp 73-87, Amsterdam.

Miklavič, B. (2007): *Pogoji nastanka piritnih in markazitnih konkrecij na Matajurju*. Undergraduate thesis, Univerza v Ljubljani, Naravoslovnotehtniška fakulteta, Oddelek za geologijo. 63 p., Ljubljana.

Pirini Radrizzani, C., Tunis, G., Venturini, S. (1986): Biostratigrafia e paleogeografia dell' area sud-occidentale dell' anticlinale M. Mia – M. Matajur (Prealpi Giulie). *Riv. It. Paleont. Strat.*; Vol. 92/3, pp. 327-382, Milano.

Otoničar, B. (2007): Upper Cretaceous to Paleogene forbulge unconformity associated with foreland basin evolution (Kras, Matarsko podolje and Istria; SW Slovenia and NW Croatia). *Acta Carsologica*.; Vol. 36/1, pp. 101-120, Postojna.

Placer, L. (1981): Geološka zgradba JZ Slovenije. *Geologija*.; Vol. 24/1, pp. 27-60, Ljubljana.

Placer, L. (1999): Contribution to the macrotectonic subdivision of the border region between Southern Alps and External Dinarides, Prispevek k makrotektonski rajonizaciji mejnega ozemlja med Južnimi Alpami in Zunanjimi Dinaridi. *Geologija*.; Vol 41, pp. 223-255.

Rožič, B. (2005): Albian - Cenomanian resedimented limestone in the Lower flyschoid formation of the Mt. Mrzli Vrh Area (Tolmin region, NW Slovenia). *Geologija*.; Vol. 48/2, pp. 193-210, Ljubljana.

Rožič, B., Popit, T. (2006): Resedimented Limestones in Middle and Upper Jurassic Succession of the Slovenian Basin. *Geologija*.; Vol. 49, pp. 219-234.

Samiee, R. (1999): *Fazielle und diagenetische Entwicklung von Plattform-Becken-Übergängen in der Unterkreide Sloweniens - PhD Thesis*. University of Erlangen, 185pp.

Šmuc, A. (2005): *Jurassic and Cretaceous Stratigraphy and Sedimentary Evolution of the Julian Alps, NW Slovenia*. Založba ZRC, 98 pp., Ljubljana.

Vrabec, M., Fodor, L. (2006): Late Cenozoic tectonics of Slovenia: structural styles at the Northeastern corner of the Adriatic microplate. In: Pinter, N., Grenerczy, G., Weber, J., Stein, S. & Medak, D., Eds., The Adria microplate: GPS geodesy, tectonics and hazards. *NATO Science Series*, IV, *Earth and Environmental Sciences*.; Vol. 61, pp. 151-168.

Winkler, A. (1921): *Das mittlere Isonzogebiet*. Jb. Geol. B.A., Wien.