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Tectono-sedimentary evolution of the NE Dinarides margin during the Cretaceous Adria-Europe convergence

Uroš Stojadinović[1] & Nemanja Krstekanić[1]

Abstract. The Cretaceous sedimentation along the NE Dinarides margin occurred in basins above the Europe-dipping Neotethyan Sava subduction zone positioned between Adria- and Europe-derived continental units. The Cretaceous sedimentation on the upper plate of the Sava subduction system took place in a fore-arc basin, developed in frontal parts of the active European continental margin. The Cretaceous sedimentation in the lower Adria plate domain of the Sava subduction system includes sediments deposited in the basin developed over the passive continental margin of the Internal Dinarides and the sediments deposited in the Sava subduction trench. While the Cretaceous sedimentation on the entire Adriatic continental margin was associated with an overall contraction, which led to the progressive subsidence towards the end of the Cretaceous, the fore-arc basin on the European continental margin displays three depositional cycles during the Early Cretaceous–Cenomanian, Turonian–Santonian, and Campanian–early Paleogene, reflecting three stages of deformation, contraction, extension, and ultimately contraction again during the Adria-Europe collision.

Key words:
Adria-Europe convergence, Sava subduction system, Cretaceous syntectonic sedimentation.

Апстракт. Кредна седиментација дуж североисточног обода Динарида одвијала се у басенима лоцираним изнад Сава субдукционе зоне, која се налазила између континенталних јединица адријског и европског афинитета. Кредна седиментација на горњој плочи Сава субдукционог система одвијала се у испредлучном басену, које је формиран у фронталним деловима активне европске континенталне маргине. Кредна седиментација у домену доње, адријске, плоче Сава субдукционог система укључује како депонате басена развијеног на пасивној маргини Динарида, тако и депонате Сава субдукционог тренча. Док је кредна седиментација у домену читаве адријске континенталне маргине контролисана контракцијом и континуираном супсиденцијом, испредлучни басен на европској континенталној маргини прошао је кроз три депозициона циклуса током доње креде до ценомана, турон–сантона и кампана до старијег палеогена, који су били контролисани контракцијом, екстензијом и финалном контракцијом током колизије Европе и Адрије.

Кључне речи:
конвергенција Адрије и Европе, Сава субдукциони систем, кредна синтектонска седиментација.

[1] University of Belgrade, Faculty of Mining and Geology, Djušina 7, 11000 Belgrade, Serbia. E-mail: uros.stojadinovic@rgf.bg.ac.rs

Introduction

The Cretaceous sedimentation in basins situated along the northeastern margin of the Dinarides Orogen (Fig. 1) was controlled by the subduction of the Europe-dipping (i.e., dipping towards Europe) Neotethyan slab located between Adria- and Europe-derived continental units (i.e., the Sava subduction system, Schmid et al., 2020). The Cretaceous sedimentation on the upper plate of the Sava subduction system took place in a fore-arc basin, which was developed in frontal parts of the active European continental margin (Toljić et al., 2018). The Cretaceous sedimentation in the lower Adria plate domain of the Sava subduction system includes sediments deposited in the basin developed over the passive continental margin of the Internal Dinarides and the sediments deposited in the Sava subduction trench (Stojadinovic et al., 2022). The early stages of the latest Cretaceous–Paleogene Adria-Europe continental collision along the Sava Zone (Ustaszewski et al., 2010) resulted in large-scale WSW-wards (in present-day coordinates) thrusting that inverted and juxtaposed the former upper plate fore-arc and lower plate basins along NE Dinarides margin. The subsequent Middle to Late Eocene out-of-sequence thrusting during the final moments of collision, followed by the Oligocene–Miocene Pannonian Basin extension caused the fragmentation of Cretaceous basins along the NE Dinarides margin, which resulted in a complex present-day architecture of the former subduction/collision zone.

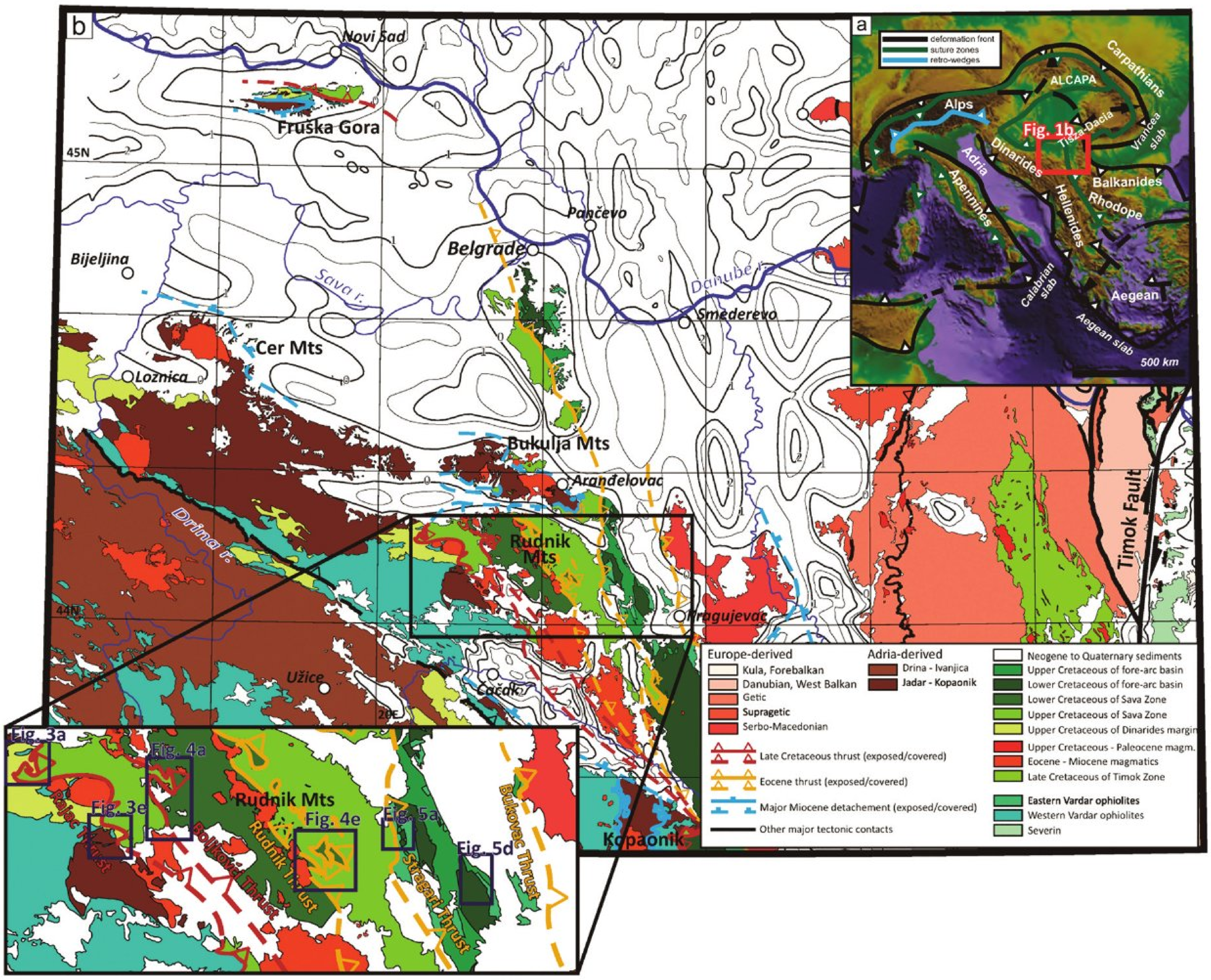

*Fig. 1. **a)** Topographic map of Central Mediterranean orogens, displaying suture zones, orogenic fronts, and retro-wedges (modified after Krstekanić et al., 2020). The red rectangle marks the position of Figure 1b; **b)** Geological map of the connection between the Dinarides, South Carpathians, and Pannonian Basin, with the zoom-in view of the broader study area delimited by the black rectangle (modified after Stojadinovic et al., 2022). Blue rectangles in the zoom-in indicate the location of local geological maps in Figures 3, 4, and 5.*

This paper aims to define the criteria that can be used to differentiate Cretaceous sedimentary sequences along the NE Dinarides margin, which were initially deposited in different basins but were juxtaposed by the subsequent contractional deformations. Along the entire northeastern margin of the Internal Dinarides, the broader area of the Rudnik Mts. in central Serbia (Fig. 1b) represents one of the very few regions where Cretaceous sediments are largely exposed and are less affected by the post-collisional deformations. Therefore, to correlate the Cretaceous sedimentary sequences across the Adria-Europe convergence zone in central Serbia, we used the available data from several existing regional publications in the broader area of the Rudnik Mts. (Filipović et al., 1976; Brković et al., 1979; Obradović, 1987; Dimitrijević & Dimitrijević, 2009; Djerić & Gerzina, 2014; Toljić et al., 2018; Bragina et al., 2020; Stojadinovic et al., 2022; Bradić-Milinović et al., 2022).

Geodynamic evolution of the Sava subduction-collision system in central Serbia

The convergence zone between Adria- and Europe-derived continental units were structured during the Late Jurassic to Eocene closure of the northern segment of the Neotethys Ocean (i.e., the Vardar Ocean sensu Dimitrijević, 1997). Following the latest Jurassic bi-vergent obduction of ophiolites over both continental margins and associated thrusting (the Western and Eastern Vardar Ophiolitic units of Schmid et al., 2008; Fig. 1b), the ongoing Cretaceous convergence led to the E-ward subduction of the remaining oceanic part of the Adria lower plate beneath the overriding Europe-derived units. This subduction was associated with the accumulation of Lower Cretaceous turbidites in the Sava subduction trench (Fig. 2a). During the Late Cretaceous, the retreating and steepening of the subducting lower plate lithosphere triggered syn-subductional extension in the fore-arc basin on the European upper plate (see Toljić et al., 2018, 2020) and accelerated subsidence in the Adriatic lower plate domain of the Sava subduction system. This led to the W-ward migration of the Sava subduction trench and continuous deposition of the Upper Cretaceous deep-water trench turbidites, while the Lower Cretaceous turbidites were gradually accreted to the upper plate as an accretionary wedge (Fig. 2b). The latest Cretaceous–Paleocene onset of the Adria-Europe continental collision along the Sava Zone led to the large-scale WSW-wards thrusting of the European fore-arc basin and Lower Cretaceous Sava trench turbidites over the Upper Cretaceous Sava trench turbidites and the Upper Cretaceous deposits on the

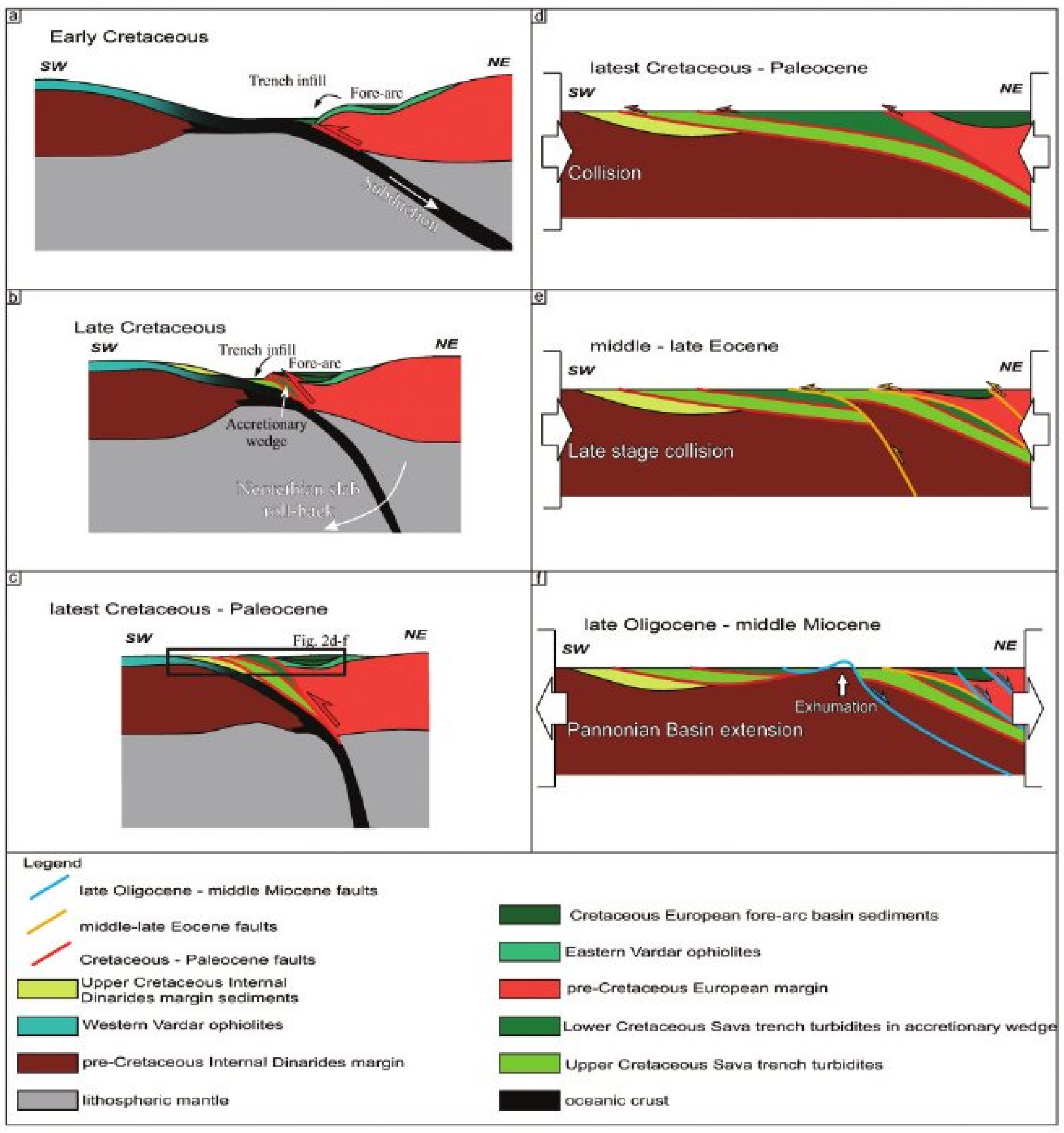

Fig. 2. *Conceptual sketch (not to scale) of the Adria-Europe convergence zone evolution in central Serbia during Cretaceous–Miocene times (modified after Stojadinovic et al., 2022):* ***a)*** *The Early Cretaceous E-ward subduction of the Adria lower plate beneath the overriding Europe-derived units, within the Sava subduction system;* ***b)*** *The Late Cretaceous accelerated subsidence in the Sava subduction system due to the Neotethyan slab roll-back;* ***c, d)*** *Latest Cretaceous to Paleocene continental collision and WSW-ward thrusting of the European fore-arc basin and Lower Cretaceous Sava trench sediments over the Upper Cretaceous Sava trench turbidites and Internal Dinarides margin deposits;* ***e)*** *Middle to late Eocene out-of-sequence thrusting and exhumation of the Upper Cretaceous Sava trench turbidites underneath the overlying Lower Cretaceous Sava trench sediments;* ***f)*** *Oligocene–Miocene extensional reactivation of segments of the inherited thrusts and exhumation of the Adria lower plate.*

Internal Dinarides margin (Figs. 2c, d). During the final stages of collision in the middle to late Eocene, out-of-sequence thrusting in the innermost orogenic segments exhumed the Upper Cretaceous Sava trench turbidites underneath the overlying Lower Cretaceous deposits (Fig. 2e, see also Stojadinovic et al., 2022). The subsequent Oligocene–Miocene extension reactivated segments of the inherited thrusts and exhumed the lower Adria plate along a series of extensional detachments (Fig. 2f, see also Matenco & Radivojević. 2012).

Correlation of Cretaceous sedimentary sequences across the Adria-Europe convergence zone in central Serbia

Cretaceous sedimentation in the Internal Dinarides margin basin

Cretaceous sedimentation across the entire distal continental margin of the Internal Dinarides was associated with the overall Late Cretaceous transgression, driven by the continuous shortening due to the subduction of the Adriatic plate beneath the overriding European plate (Fig. 2b). Following the latest Jurassic obduction of ophiolites over the Internal Dinarides margin (the Western Vardar Ophiolites Unit, Fig. 1b), the onset of Cretaceous overstep sequence is marked by the Albian–Cenomanian trangressive coarse-clastics that are gradually deepening into the clastic-carbonatic shelf deposits (Figs. 3e, 6). The base of this sedimentation is made up of conglomerates, sandstones, and sandy limestones with fragments of serpentinized peridotites (Fig. 3f). The ongoing Late Cretaceous subsidence is indicated by deposition of the distal shelf to proximal slope carbonates and clastics during the Turonian–Santonian (see Djerić & Gerzina, 2014), followed by the distal slope deposition during the Santonian–Campanian (i.e., the Struganik facies, Figs 3a-d, 6; Bragina et al., 2020; Bradić-Milinović et al., 2022). The Struganik facies (Fig. 3a) are made up of thin-bedded marly limestones, calc-rudites, and calcarenites that display fine lamination and upward fining (Fig. 3b) and convolution (Fig. 3c), as well as limestones with chert nodules (Fig. 3d).

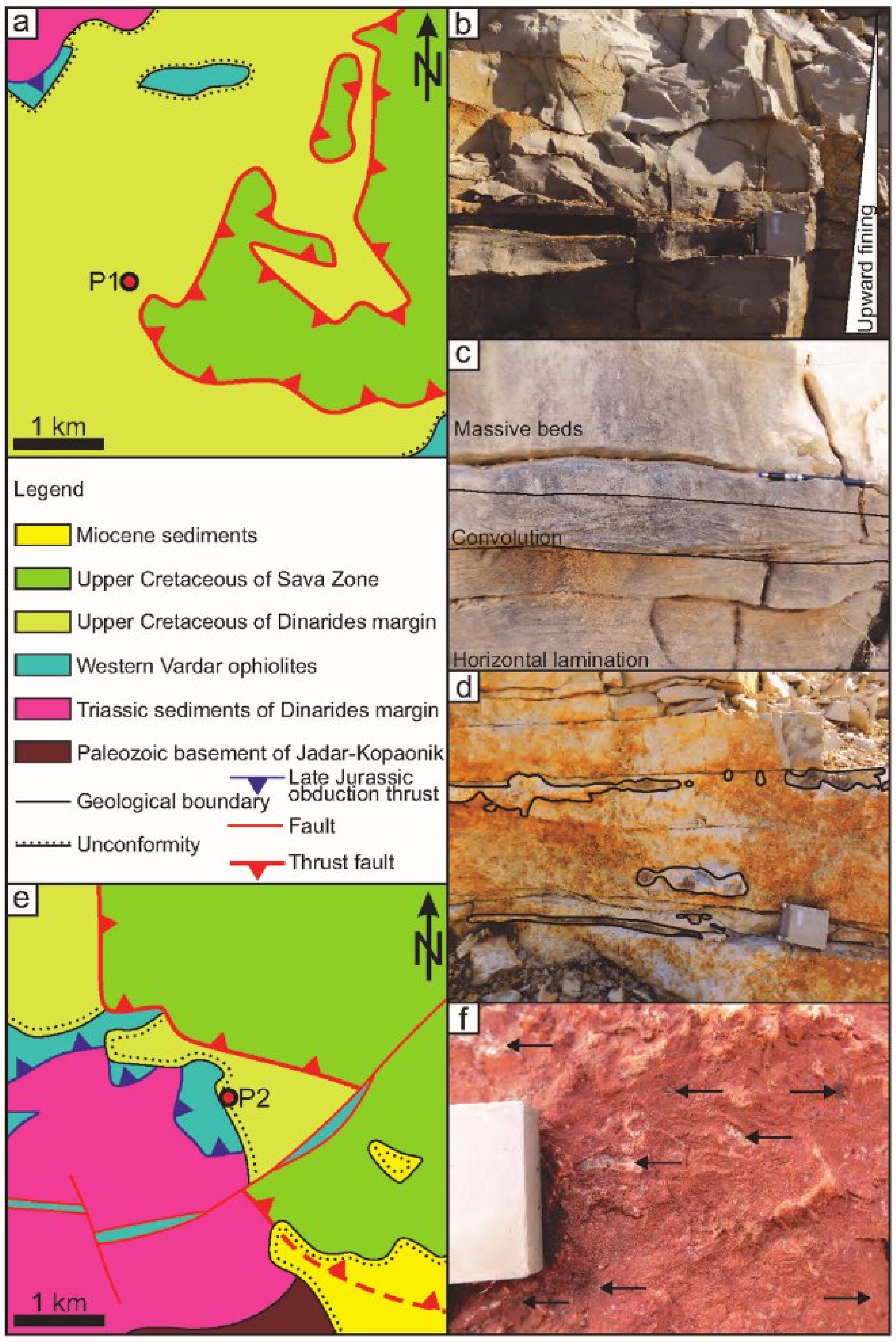

Fig. 3. a) *Local geological map of the Struganik area where the Campanian–Maastrichtian Sava trench turbidites of the Ljig Formation are thrust on top of the Santonian–Campanian distal slope of the Dinarides margin along the Rajac Thrust (modified after Bradić-Milinović et al., 2022);* ***b)*** *Upward fining in the Santonian–Campanian calc-arenites and pelagic limestones at the observation point P1 (coordinates 20°10'84''E, 44°18'78''N);* ***c)*** *Turbiditic sedimentary textures in the Santonian–Campanian calc-arenites. Observation point P1;* ***d)*** *Santonian–Campanian limestones with chert nodules (outlined in black) at the observation point P1;* ***e)*** *Local geological map of the Rajac area where the Campanian–Maastrichtian Sava trench turbidites of the Ljig Formation are thrust on top of the Albian–Cenomanian Western Vardar ophiolites overstep sequence along the Rajac Thrust (modified after Bradić-Milinović et al., 2022);* ***f)*** *Basal deposits of the Cretaceous sedimentation over the Dinarides margin represented by the Albian-Cenomanian sandy limestones with centimeter-scale fragments of serpentinized peridotites, indicated by arrows. Observation point P2 (coordinates 20°26'12''E, 44°12'41''N).*

Cretaceous sedimentation in the Sava subduction trench

The sedimentation in the Sava subduction zone is represented by the Lower to Upper Cretaceous turbidites deposited in the trench–accretionary wedge system (Figs. 2a, b, 4, 5a, e, and 6). The Lower Cretaceous trench sedimentation is represented by Barremian–Aptian distal clastic turbidites, followed by the Albian–Cenomanian laminated fine-grained clastics and carbonates (i.e., the Boljkovci Formation, Figs. 4a, d-j, and 6; Stojadinovic et al., 2022). These sediments were gradually accreted to the upper plate as an accretionary wedge (Fig. 2b). The Sava subduction trench sedimentation continues with the Turonian distal mudstones that possibly derive from the older, reworked material of the accretionary wedge. These are overlain by the distal Coniacian–Maastrichtian clastic-carbonatic turbidites of the Upper Cretaceous Rudnik Formation (Figs. 4f, k, 5a, e, and 6). The accelerated subsidence during the Late Cretaceous resulted in the westward migration of trench sedimentation towards the Dinarides margin and the deposition of the middle Campanian–late Maastrichtian siliciclastic trench turbidites of the Ljig Formation (Figs. 4a-c, and 6; Stojadinovic et al., 2022). The process culminated during the late Maastrichtian when the foredeep sediments of the Ljig Formation, which indicate the final phases of the Sava subduction trench evolution, were deposited adjacent to the passive continental margin of the Dinarides (i.e., the Ljig flysch, Obradović, 1987).

Cretaceous sedimentation in the European margin basin

The sedimentary facies in the fore-arc basin developed along the active continental margin of the upper European plate of the Sava subduction system indicate three deposition cycles during Early Cretaceous–Cenomanian, Turoni-an–Santonian, and Campanian–Maastrichtian (see Toljić et al., 2018). An important distinguishing feature of Early Cretaceous sedimentation along the European continental margin is the presence of the “para-flysch” deposits

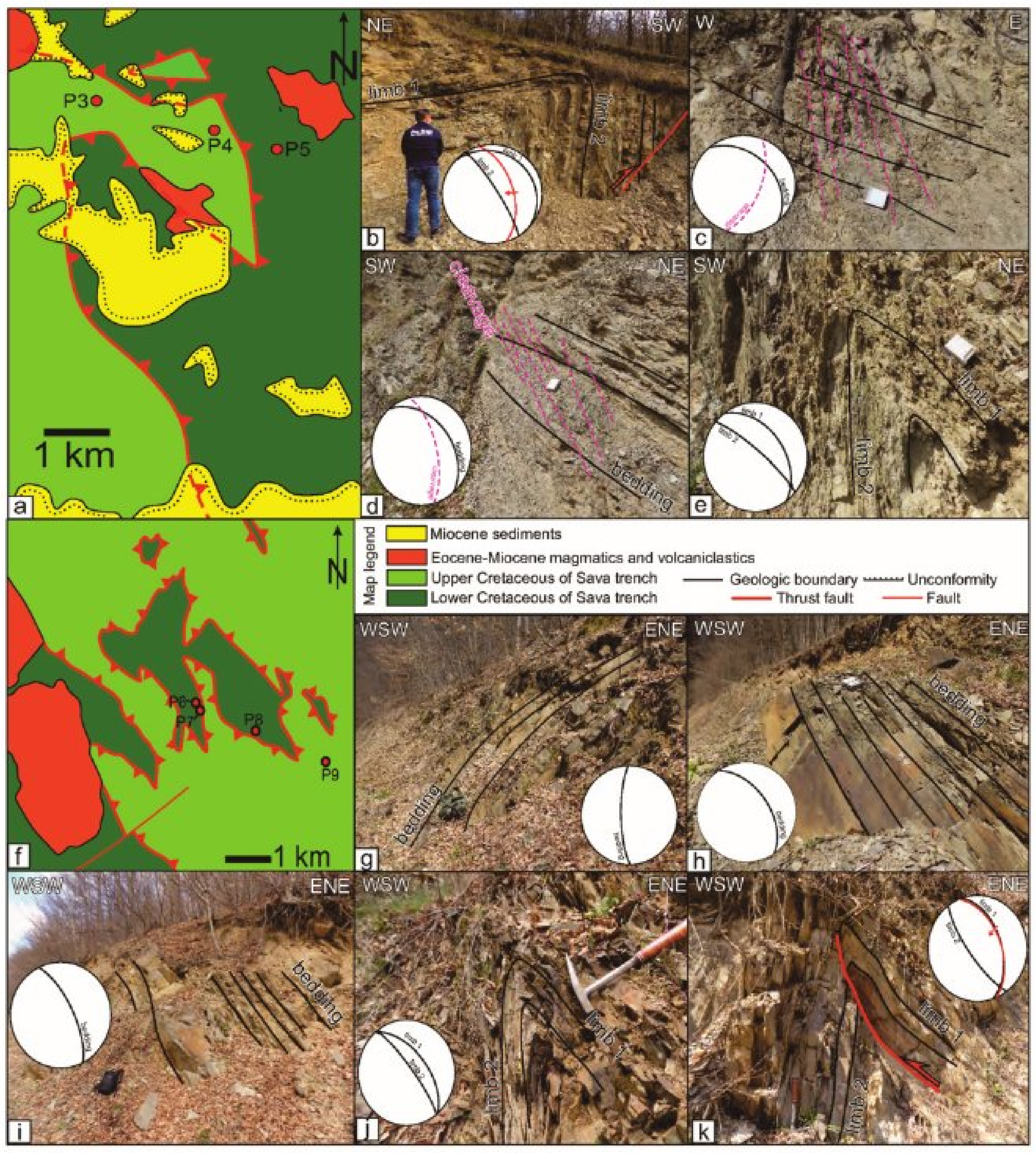

Fig. 4. ***a)*** *Local geological map of the Boljkovci area where the Lower Cretaceous sediments of the Boljkovci Formation structurally overlie the Upper Cretaceous Sava trench turbidites of the Ljig Formation along the Boljkovci Thrust (modified after Stojadinovic et al., 2022);* ***b)*** *Southwest-vergent overturned fold in the Campanian turbidites of the Ljig Formation. The overturned fold limb is truncated by top-W reverse fault. Observation point P3 (coordinates 20°31’94’’E, 44°19’07’’N);* ***c)*** *Normal bedding with cleavage in the Upper Cretaceous marls and mudstones of the Ljig Formation at observation point P4 (coordinates 20°34’24’’E, 44°18’63’’N);* ***d)*** *Normal bedding with cleavage in the Albian–Cenomanian mudstones and shales of the Boljkovci Formation. Observation point P5 (coordinates 20°35’46’’E, 44°18’35’’N);* ***e)*** *Tight southwest-vergent overturned fold in the Albian–Cenomanian mudstones and shales of the Boljkovci Formation. Observation point P5;* ***f)*** *Local geological map of the Rudnik area where the Upper Cretaceous Sava trench turbidites of the Rudnik Formation structurally overlie the Lower Cretaceous accretionary wedge sediments along the Rudnik Thrust. The Boljkovci Formation sediments outcrop west of the Rudnik Thrust and in several erosional windows;* ***g-i)*** *Bedding in the Albian–Cenomanian sediments of the Boljkovci in the footwall of the Rudnik Thrust. Bedding in g is observed at point P6 (coordinates 20°58’15’’E, 44°09’40’’N), while h and i are located tens of meters apart at point P7 (coordinates 20°58’27’’E, 44°09’33’’N);* ***j)*** *Tight to isoclinal overturned SW-vergent fold in the Albian–Cenomanian sediments of the Boljkovci Formation at observation point P8 (coordinates 20°59’69’’E, 44°09’08’’N);* ***k)*** *Top-SW reverse fault with associated fault propagation fold in the Upper Cretaceous Sava trench turbidites of the Rudnik Formation at observation point P9 (coordinates 20°61’78’’E, 44°08’37’’N).*

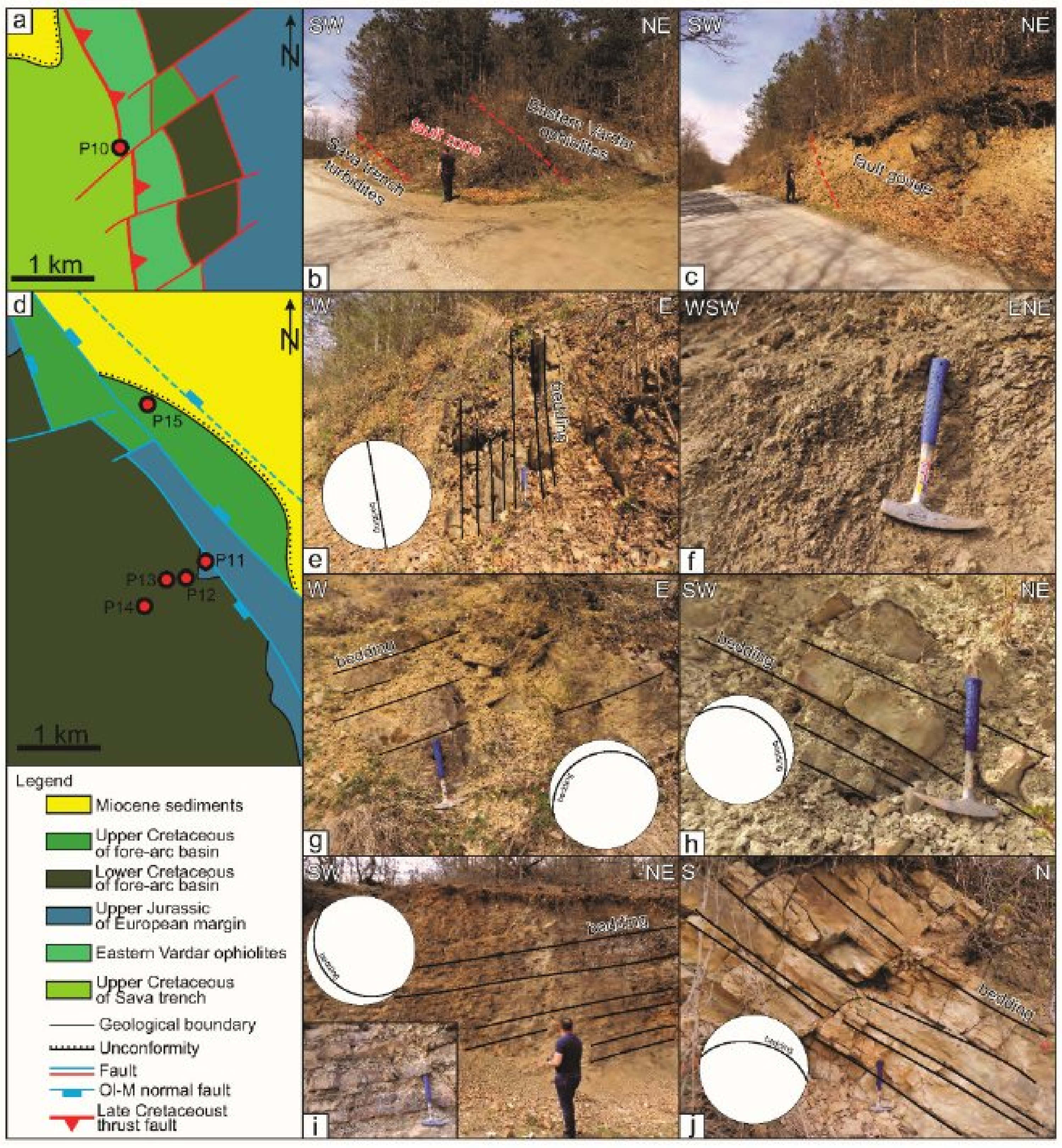

Fig. 5. a) *Local geological map of the Stragari area where the Upper Cretaceous Sava trench turbidites are thrust by the Eastern Vardar Ophiolites and their overlying Cretaceous fore-arc sediments along the Stragari Thrust (modified after* Stojadinovic *et al., 2022);* ***b)*** *The ~ENE-dipping Stragari Thrust fault zone juxtaposing the Eastern Vardar ophiolites and the Sava Trench turbidites at observation point P10 (coordinates 20°67'98''E, 44°12'35''N);* ***c)*** *Approximately 10 meters thick fault gouge zone in the immediate footwall of the Eastern Vardar ophiolites, containing large blocks of the Sava turbidites. Observation point P10;* ***d)*** *Local geological map of the Kragujevac area with the segment of the fore-arc basin along its eastern margin and contact with the Miocene sediments of the Pannonian Basin;* ***e)*** *Vertical bedding in the Upper Cretaceous Sava trench turbidites of the Rudnik Formation in the immediate footwall of the Stragari Thrust. Observation point P10;* ***f)*** *Highly fractured Upper Jurassic mudstones at observation point P11 (coordinates 20°81'27''E, 44°07'01''N);* ***g)*** *Berriasian–Hauterivian sandstones and limestones at observation point P12 (coordinates 20°80'97''E, 44°06'84''N);* ***h)*** *Barremian–Aptian deep water "para-flysch" sequence at observation point P13 (coordinates 20°80'67''E, 44°06'82''N);* ***i)*** *Albian–Cenomanian sequence of the fore-arc "para-flysch" at observation point P14 (coordinates 20°80'33''E, 44°06'53''N). Inset shows in detail the repeatable character of the "para-flysch" lithological sequences;* ***j)*** *Turonian–Santonian limestones of the fore-arc basin at observation point P15 (coordinates 20°80'38''E, 44°08'74''N).*

(Dimitrijević & Dimitrijević, 2009). The "para-flysch" type of sedimentation is characterized by Lower Cretaceous to Cenomanian cyclic shelf and slope deposits (Figs. 5 and 6). The initial Berriasian–Hauterivian coarse-clastic transgressive sequence (Fig. 5g) is deposited on the highly deformed Upper Jurassic mudstones (Fig. 5f). These are followed by the Valanginian–Aptian distal shelf clastics and proximal slope turbi-dites (Fig. 5h) indicating gradual deepening in the central parts of the basin, while the coeval deposition in shallower parts, along the basin margins, is made-up of the Urgonian carbonate facies (Fig. 6). The overlying Albian–Cenomanian sequence is regressive, dominantly represented by shelf clastics and shallow-water carbonates (Fig. 5i). The new Upper Cretaceous transgressive cycle starts with Turonian coarse clastics, which are overlain by platform carbonates (Fig. 5j). The Campanian–Maastrichtian deposition is represented by basal coarse clastics and shallow water sequences, replaced upwards by the distal turbidites (Fig. 6, see also Toljić et al., 2018).

Discussion and conclusions

During the latest Cretaceous–Paleogene Adria-Europe continental collision, the Lower to Upper Cretaceous syn-contractional turbidites from the former Sava subduction trench were highly deformed and incorporated into a system of WSW-vergent in- to- out-of-sequence thrusts (Ustaszewski et al., 2010). The same pattern of deformations associated with the collision can be recognized across the entire Adria-Europe convergence zone in central Serbia, affecting to a different extent all Cretaceous sedimentary basins and their underlying basement on both continental margins (Stojadinovic et al., 2022). Therefore, to highlight the differences between various Cretaceous sedimentary sequences across the Adria-Europe convergence zone, it is necessary to associate the effects of earlier, pre-collisional tectonic events with the evolution of Cretaceous basins developed on the two converging continental margins. While the Cretaceous sedimentation on the entire Adriatic continental margin was associated with an overall contraction, which led to the progressive subsidence

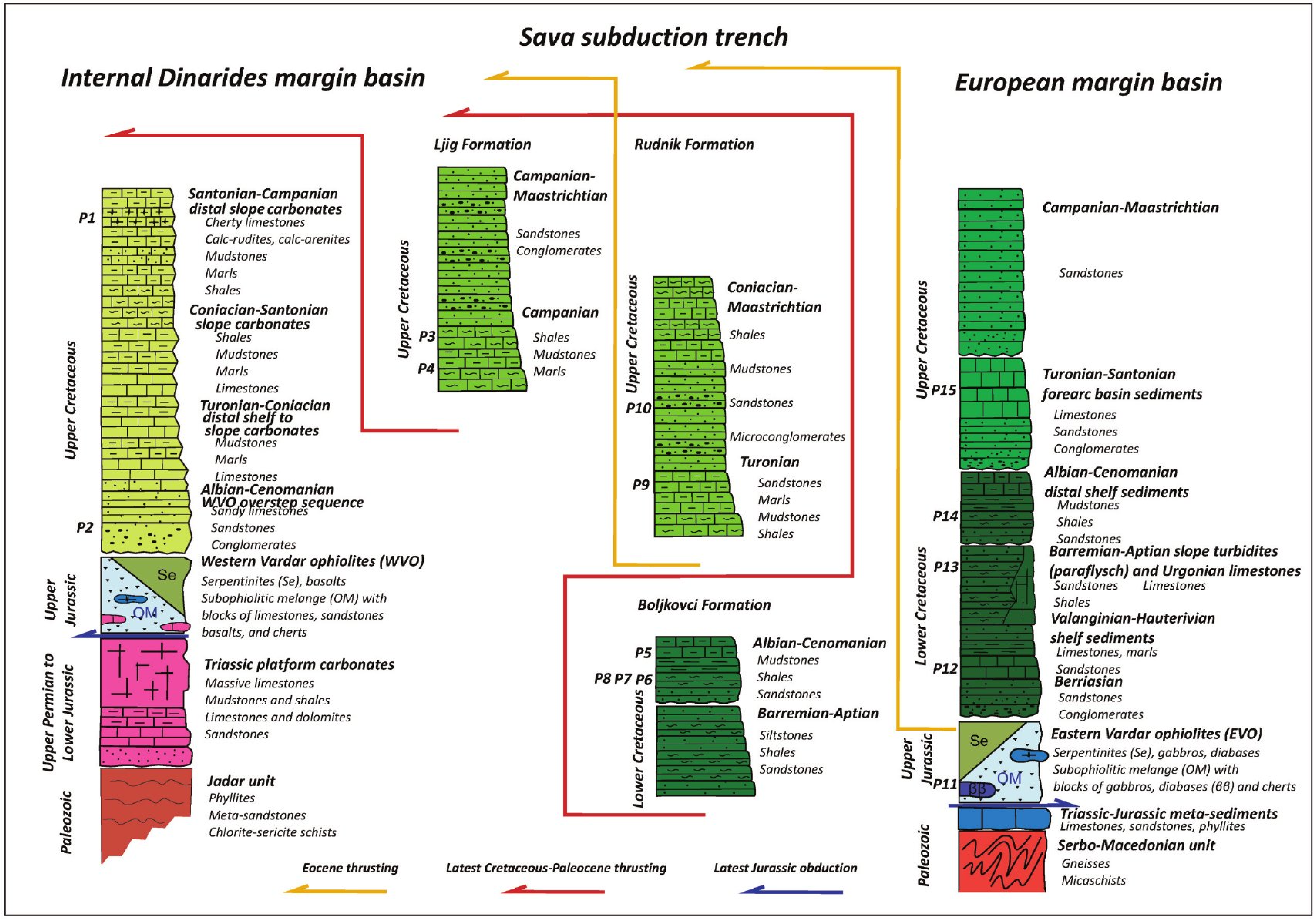

Fig. 6. *Correlation between Cretaceous sedimentary sequences in the basins along the Internal Dinarides margin, in the Sava subduction trench, and along the European margin (modified after* Filipović *et al., 1976;* Brković *et al., 1979;* Obradović*, 1987;* Djerić *&* Gerzina*, 2014;* Toljić *et al., 2018;* Bragina *et al., 2020;* Stojadinovic *et al., 2022). Blue arrows mark the latest Jurassic obduction-related thrusting. Red arrows mark the latest Cretaceous–Paleocene thrusting during the onset of the Adria-Europe collision. Yellow arrows mark Eocene out-of-sequence thrusting during the final stages of collision. P1-15 indicates the approximate position of observation points in geological columns. The spatial locations of observation points are shown in Figures 3, 4, and 5.*

towards the end of the Cretaceous (Fig. 6), the fore-arc basin on the European continental margin displays three depositional cycles during the Early Cretace-ous–Cenomanian, Turonian–Santonian, and Campanian–early Paleogene (see Toljić et al., 2018), reflecting three stages of deformation, contraction, extension, and ultimately contraction again during the Adria-Europe collision (Fig. 6).

The latest Jurassic–earliest Cretaceous obduction of the Vardar Ocean resulted in the emplacement of a ~180 km long, top-to-W oriented thrust sheet of ophiolites over the pre-obductional Mesozoic sedimentary basins in the Internal Dinarides (Fig. 6, the Western Vardar Ophiolitic Unit, Schmid et al., 2008, see also Porkolab et al., 2019). Contrarily, the effects of the latest Jurassic–earliest Cretaceous obductional event on the European continental margin are predominantly recognized in the top-to-E thrusting of significantly smaller segments of Vardar ophiolites over the Triassic–Jurassic sedimentary cover of the Europe-derived continental basement (see Maleš et al., this issue). Consequently, since the Berriasian, the fore-arc basin on the European margin displays continuous Lower Cretaceous deposition associated with regional contraction, while the Western Vardar ophiolites overstepping sequence starts only in the Albian–Cenomanian, marking the onset of Late Cretaceous transgressive depositional cycle over the distal margin of the Internal Dinarides (Fig. 6). Furthermore, the Albian–Cenomanian sequence over the European margin is regressive (Fig. 6), marked by the unconformity across the entire forearc basin, which was driven by the shortening during the continental collision in the neighbouring Carpathians (see Krstekanić et al., 2017).

Following the latest Jurassic–earliest Cretaceous obduction of the Vardar ophiolites, the renewed Early Cretaceous Europe-dipping subduction led to the deposition of turbidites in the Sava subduction trench (Figs. 2a and 6). The retreating and steepening of the subducting slab during the Turonian–Santonian times triggered syn-subductional extension in the fore-arc on the European continental margin (Toljić et al., 2018) and accelerated subsidence along the entire continental Adriatic margin, including the Sava subduction trench and the basin in the Internal Dinarides (Figs. 2b and 6). Furthermore, the Late Cretaceous extensional episode in the upper plate of the Sava subduction system was associated with syn-depositional bimodal magmatism, which was restricted in space to the fore-arc basin and can be traced along the entire European continental margin (see Toljić et al., 2020).

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Резиме

Тектонско-депозициона еволуција североисточне маргине Динарида током кредне конвергенције Адрије и Европе

Циљ овог рада је дефинисање критеријума за корелацију кредних седиментних секвенци, које су депоноване у басенима дуж североисточног обода Динарида. Седиментација у кредним басенима североисточних Динарида контролисана је субдукцијом океанске литосфере Неотетиса, која се налазила између континенталних маргина јединица адријског и европског афинитета (Сава субдукциони систем, Schmid et al., 2020). Кредна седиментација у оквиру горње плоче Сава субдукционог система одвијала се у испредлучном басену формираном у фронталним

деловима активне европске континенталне маргине (Toljić et al., 2018). Кредна седиментација у оквиру доње плоче Сава субдукционог система укључује како депонате кредног басена развијеног преко пасивне маргине унутрашњих Динарида, тако и седименте депоноване у Сава субдукционом тренчу (Stojadinovic et al., 2022). Током каснокредно-палеогене континенталне колизије Адрије и Европе, кредни син-контракциони турбидити Сава субдукционог тренча уклопљени су у систем западно-југозападно вергентних реверсних раседа и навучени преко кредног седиментног покрова пасивне маргине Динарида. Исти тип деформација изазваних колизијом заступљен је дуж читаве зоне конвергенције Адрије и Европе у централној Србији и може се, у различитој мери, препознати у кредним седиментима и јединицама у њиховој подини на обе континенталне маргине. Стога је, како би се истакле разлике у кредним седиментним секвенцама на континенталним маргинама Европе и Адрије, неопходно дефинисати ефекте ранијих, пре-колизионих тектонских догађаја на еволуцију кредних басена формираних дуж две сучељене континенталне маргине. Док је кредна седиментација у домену читаве адријске континенталне маргине контролисана контракцијом и континуираном супсиденцијом, испредлучни басен на европској континенталној маргини прошао је кроз три депозициона циклуса током доње креде до ценомана, турон–сантона и кампана до старијег палеогена, који су били контролисани контракцијом, екстензијом и финалном контракцијом током колизије Европе и Адрије.

Током обдукције сегмената Вардарског океана на прелазу из јуре у креду, око 180 км дуга, западно-вергентна, навлака офиолита пласирана је преко пре-обдукционих мезозојских седиментних басена у унутрашњим Динаридима (Западно-вардарски офиолити, Schmid et al., 2008, Porkolab et al., 2019). Насупрот томе, ефекти обдукције Вардарског океана на европску континенталну маргину углавном се препознају у формирању источно-вергентних реверсних раседа, дуж којих су значајно мањи сегменти офиолита пласирани преко тријаско-јурског седиментног покрова континенталних јединице европског афинитета (Maleš et al., 2023). У складу са тиме, почев од беријаса, испредлучни басен на европској маргини одликује континуирана депозиција током доње креде, док 'over-step' секвенца Западно-вардарских офиолита, која означава почетак горње-кредног трансгресивног циклуса у унутрашњим Динаридима, настаје тек почев од алб-ценомана. Поред тога, алб-ценоманска секвенца на европској континенталној маргини је регресивна, карактерисана дискорданцијом у читавом испредлучном басену, која је контролисана континенталном колизијом у суседним Карпатима (Krstekanić et al., 2017).

Након обдукције на прелазу из јуре у креду, обновљена субдукција Адрије под Европу у доњој креди резултирала је депозицијом турбидита у Сава субдукционом тренчу. Повлачење субдукујуће плоче током турон–сантона довело је до син-субдукционе екстензије у испредлучном басену на европској континенталној маргини (Toljić et al., 2018) и до убрзане супсиденције дуж читаве адријске континенталне маргине, укључујући Сава субдукциони тренч и басен у унутрашњим Динаридима. Такође, горње-кредна екстензиона епизода у оквиру горње плоче Сава субдукционог система довела је и до појаве син-депозиционог бимодалног магматизма, који је просторно ограничен на домен испредлучног басена, и може се пратити дуж читаве европске континенталне маргине (Toljić et al., 2020).

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