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THE TRIASSIC AND JURASSIC OF EAST STARA PLANINA (BULGARIA), TULCEA ZONE (NORTH DOBROGEA, ROMANIA) AND SOUTH CRIMEA (GORNIY KRIM, UKRAINE). ESSAY OF CORRELATION

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Abstract

The parautochthonous and allochthonous Triassic and Jurassic rocks in East Stara Planina Mountains (Bulgaria) are relatively deep marine sediments of Tethyan type, deposited in a rift basin (Kotel, East Balkan or Mator Basin). They are referred to the following lithostratigraphic units: (1) Mayadere Formation – irregular alternation of marls, shales, silstones, sandstones and limestones (Olenekian Stage, Spathian Substage); it can be correlated with Tulcea Veche Formation from North Dobrogea similar Triassic rocks being not known in South Crimea; (2) Gyurgenliya Formation – grey, grey-greenish, reddish limestones (Lower Anisian-Lower Carnian); they are correlated with the calcareous-dolomitic Murighiol Formation from North Dobrogea; (3) Glogova Formation – irregular alternation of marls with thin-bedded limestones, calcareous siltstones and peloidal limestones (Upper Carnian-Norian); it can be correlated with the upper part of the Cataloi Formation from North Dobrogea; (4) Sinivir Formation – a flysch-type siliciclastic alternation of sandstones, siltstones and shales to marls containing sideritic concretions (Middle Norian-Toarcian); it is correlated with the Nalbant Formation from North Dobrogea and with the Crimea Formation and the lower member of Eski-Orda Formation from South Crimea; (5) Balaban Formation – thick bedded sandstones (Toarcian?), correlated with the Denis Tepe Formation (North Dobrogea) and the upper member of the Eski-Orda Formation in South Crimea; (6) Kotel Formation (Aalenian-Middle Bathonian?) – black shales with huge olistolites (Wildflysch) that is correlated with the Zebil Formation (North Dobrogea) and Ourgoulya Formation and upper parts of the Ay-Vassil Formation (South Crimea); the Ourgoulya and Ay-Vassil Formations are separated by the basic effusive rocks of the Upper Bajocian-Lower Bathonian Karadag Formation. The latter has no correlates in North Dobrogea and in East Stara Planina. There are many similarities between the Triassic and the Lower and Middle Jurassic rocks

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in the three areas, and namely: (a) superposition of comparable rocks; (b) similar lithology of the lithostratigraphic units; (c) high degree of coincidence of the ages of similar lithostratigraphic units. The differences consist in the lack of volcanic activity in East Stara Planina Triassic and Jurassic, whereas volcanics are abundant in South Crimea within the Karadag Formation, and are present as interbeds in the upper member of the Crimea Formation.

Key words. Tethyan Triassic, Lower and Middle Jurassic, East Stara Planina – Bulgaria, North Dobrogea – Romania, South Crimea – Ukraine, correlation

Introduction. The present paper aims to correlate Triassic and Lower and Middle Jurassic rock units from three well-known areas situated around the Black Sea: East Stara Planina (Balkan) Mountains (Bulgaria), Tulcea Zone of North Dobrogea (Romania) and the South Crimea (Gorniy Krim) of Ukraine (Fig. 1). These rock units have been included in different younger Alpine zones. However, similarities between them allow for correlations and for some palaeogeographic and palaeogeodynamic comparisons. We will try to expose basic information about the Triassic and the Lower and Middle Jurassic rocks issued from the new results of the study of the rocks in East Stara Planina [1–5] and from the published data – for North Dobrogea [6–8] and South Crimea [9, 10, 19].

Triassic and Lower and Middle Jurassic stratigraphy. East Stara Planina Mountains, Bulgaria. The study of the Triassic and Jurassic rocks in East Stara Planina Mountains started in the beginning of the 20th century [11, 12] when it

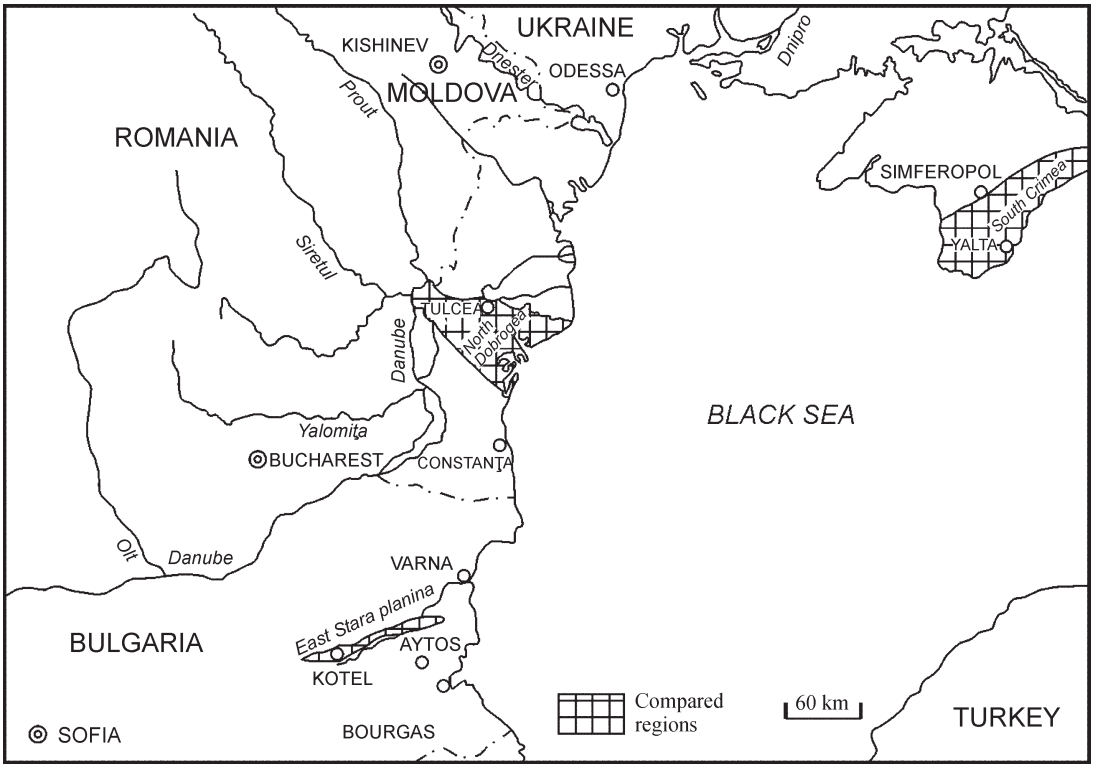

Fig. 1. Location of the Triassic and Lower and Middle Jurassic in East Stara Planina (Bulgaria), Tulcea Zone (North Dobrogea, Romania) and South Crimea (Gorniy Krim, Ukraine)

was already demonstrated that a large number of Triassic and Jurassic outcrops represented huge exotic blocks (later named olistolites). This view was entirely or partially shared by later authors [13–15] who introduced the hypothesis that all Triassic and Jurassic rocks in East Stara Planina Mountains represented olistolites into the Upper Cretaceous [15] black shales of the Kotel Formation. Lithostratigraphic subdivisions have been established for the Jurassic [1] and for the Triassic sediments [5]. Recently [16] it has been suggested that in many localities in the Luda Kamchiya Valley the Triassic and the Jurassic rocks are in superposition, and the Triassic/Jurassic boundary is situated within the Sinivir Formation. The ages of the rock units have been determined [1, 2, 11–18] on the basis of rich ammonite, bivalve, brachiopod, coral, bryozoan, foraminifer and conodont fauna (for the Triassic), and miospores (for the Jurassic).

The Triassic and Jurassic deposits in East Stara Planina Mountains form a thrust sheet sealed by Cenomanian mature conglomerate and sandstone. Two types may be distinguished in respect to their position in the Tethyan sedimentary basin: (a) parautochthonous to allochthonous (basinal Tethyan type), and (b) allochthonous – olistolites, formed predominantly by shelf (Peri-Tethyan) Triassic and Jurassic sediments, and by exotic blocks, coming from the partly destroyed Mator Rift basin. The parautochthonous Tethyan Triassic rocks are subdivided into: Mayadere Formation (Spathian), Gyurgenliya Formation (Lower Anisian–Lower Carnian), and Glogova Formation (Upper Carnian-Norian to Rhaetian) [5] covered with a transitional boundary by the sediments of Sinivir Formation (now referred to Norian-Toarcian, p.p.), Balaban Formation (Toarcian p.p.) [1], and Kotel Formation [15] (Aalenian-Middle Bathonian?).

Mayadere Formation is an irregular alternation of marls, shales, silstones, sandstones and laminated to slightly convoluted limestones. Gyurgenliya Formation covers the Mayadere Formation with a transitional boundary. It is built up of grey, grey-greenish, reddish or yellowish limestones (usually micritic, with filaments of thin-valved bivalves), in the lower part interbedded with marls, and locally, with silicites. Probably these sediments were accumulated as peri-platform pelagic clays in the upper part of the continental slope. The Glogova Formation is deposited in two environments – on the outer shelf and on the continental slope; in the first case its cover of younger sediments is not preserved (the outcrop represents a big olistolite), and in the second one it is covered by the Sinivir Formation. Glogova Formation is represented by an irregular alternation of marls (dominating in the lower parts) with thin-bedded limestones, silty limestones, calcareous siltstones and peloidal limestones (mainly in the upper parts). The micritic limestones are interbedded by thicker bedded limestones – packstones up to rudstones with bioclasts of crinoids and/or algae and lithoclasts. Probably they are a product of calcareous debris flow. An alternation of limestones (peloidal, silty and silty-sandy, thin-bedded to laminated) and mudstones (ferriferous marls and ferriferous calcareous shales) represents the basinal part of the Glogova Formation The age of the outer shelf sediments is Late Carnian-Norian-Rhaetian, and the sediments deposited on the continental slope (where they are covered by the basinal Sinivir Formation) are of Late Carnian-Middle Norian age. The appearance of the first siliciclastic bed (at Cheshme Bair Hill) coincides with the lower boundary of Sinivir Formation. The Sinivir Formation (c. 500–950 m; Norian – Toarcian p.p.) is a siliciclastic alternation of sandstones to calcareous sandstones, siltstones and shales to marls, with abundant sideritic concretions. In the vicinities of Dropla village it contains pebble conglomerates, regarded as a paleo-delta product. In the "Black flysch" ("Schwarzflysch serie") that has recently [16] been referred to the lower parts of the Sinivir Formation, presence of Norian *Halobia* has been indicated [3, 4, 14]. The next Balaban Formation is built of thick bedded sandstones (c. 60 m). The formation is referred to the Toarcian by its stratigraphic position. The Kotel Formation (c. 1000 m) has an Aalenian-Middle Bathonian (?) age based upon pollen, spores and dinoflagellate cysts [1, 18]. It is built

up of black shales containing numerous Triassic and Jurassic olistolites. In the vicinities of Dropla Village the formation contains also many pebble mudstones due probably also to a delta or a submarine canyon. The younger parts of the Kotel Formation were subsequently eroded.

The allochthonous rocks are described as informal lithostratigraphic units ("types"). They originated from the shelf sediments of the Mator Basin, as well as from some rocks from destroyed parts of the Tethyan basin. Upper Triassic rocks of the Orta Kaya type [5] build huge (hectometric) olistolites. The big blocks of Orta Kaya type generally form two distinct packets. The lower one (14–15 m) is built of grey, thick-bedded micritic limestones, in some localities bioclastic-intraclastic grainstone to rudstone or fine bioclastic mudstone to wackstone. The upper packet consists of grey biodetritic limestones with corals.

The Jurassic autochthonous limestones belong to four types [2].

1) The Bilka type limestones (Sinemurian-Pliensbachian) cover transgressively the Triassic Orta Kaya type. Upwards they pass into quartz sandstones and calcareous conglomerates. These clastic sediments are covered by Pliensbachian reddish micritic limestones, in some localities with corals and/or brachiopods. At the end of Pliensbachian time the Bilka type sediments emerged and became dry land. During Toarcian-Bathonian times, these limestones were covered again by sea waters and open fractures and cavities have been filled with Neptunian dykes (conglomerates and oolithic limestones with brachiopods). This sedimentary type is close to the Hierlatz alpine type.

2) The Djula type (Sinemurian-Bathonian) covers transgressivelly Triassic limestones. Its section starts with few metres of sandstones, covered by reddish ferriferous bioclastic (crinoidal) limestones (packstone), grey, subnodular, micritic limestones (wackestone) with calcitized Sponge spicules, and the section ends with black to grey silty-sandy limestones or ferriferous bioclastic (crinoidal) limestones (grainstone to packstone) similar to the Gresten alpine facies.

3) The Karaveljovo type (Domerian-Toarcian) is represented by alternation of biodetritic marls and limestones.

4) The Čerkovişte type sediments (Sinemurian-Toarcian; base unknown) are grey or red ferriferous bioclastic marls and red ferriferous clayey micritic limestones, with abundant bioclasts (mostly belemnites).

5) The Middle Jurassic black shales of the Kotel Formation contain in many localities (near Strouya Village, to the North of the Kayte Hills, etc.) huge fragments (c. 3×5 m) of dark-grey to black silty shales with abundant Aalenian-Bajocian ammonites, belemnites, etc. well delimitated from the matrix; they are similar to the Etropole Formation (in the autochthonous Middle Jurassic sediments out of the Matorid basin), or to the alpine "black shales with *Bositra alpina*." This sedimentary type can be called Strouya type.

Tulcea Unit (North Dobrogean Orogen), North Dobrogea, Romania. The Triassic and the Jurassic in North Dobrogea have been already correlated to the East with South Crimea Upper Triassic and Lower-Middle Jurassic. They are traced to NNW towards the Carpathians, and then plunged under the latter. The North Dobrogean Orogen [20] is considered as a part of the "North Dobrogea-South Crimea Cimmerian Aulacogene."

The Triassic and Jurassic rocks crop out in the Tulcea Unit. The unit is limited [7] to the north-east by the Galaţi – St. Gheorghe Fault, and to the west and south-west

– by the Peceneaga-Kamenna fault [7, 8] – a prolongation of the Tornquist-Teisseyre Line.

One of the fullest sections is situated in the area Poşta-Cataloi. The oldest Mesozoic rocks are the Bogza Epiclastic Formation (Induan Stage) – white or reddish conglomerates and sandstones, thick c. 20–25 m. In East Stara Planina it has no correlates. The Bogza Formation is covered directly by the Tulcea Veche-Somova Formation (Spathian) represented by calcareous marls in alternation with clayey schists, thick c. 40 m. From this formation *Claraia aurita*, *Eumorphotis venetiana*, *Tirolites haueri*, *Danubites ellipticus*, etc., have been identified, as well as the conodonts *Neospathodus homeri* and *N. triangularis* [8]. These sediments can be correlated with the Mayadere Formation from the East Stara Planina Mountains Murighiol Formation (upper parts of Spathian – Anisian) consists of c. 200 m limestones and dolomitic limestones that cover with transition Tulcea Veche Formation In these sediments the conodonts *Neogondolella bulgarica*, *Nicoraella kockeli*, etc., were found together with algae and brachiopods which proved the Anisian age. The Murighiol Formation can be correlated partially with the lower part of the Gyurgenliya Formation from the East Stara Planina Mountains. With continuity the Murighiol Formation is covered by the Cataloi Formation (Ladinian-Carnian) built up of black, bituminous limestones (c. 50–75 m), locally with beds of reddish and nodular dolomites. The sediments of Murighiol Formation contain the Late Ladinian *Daonella lommeli*, and in the uppermost parts – the Early Carnian conodont *Paragondolella polygnathiformis*. They can be correlated with the upper part of the Gyurgenliya Formation (East Stara Planina) and with the Schreyeralm limestones (Alps). The Ladinian-Carnian limestones from the island Popina (Lake Razelm) are connected horizontally with the Cataloi Formation and are separated as Popina Formation. These limestones are close to the alpine Wetterstein facies.

Over the Cataloi Formation (and its lateral analogue – the Trestenic Formation) the sedimentation became clastic, terrigenous with a flysch aspect [7]. The Nalbant Flysch ("Flisul de Nalbant") is a siliciclastic flysch-type alternation. A Late Carnian age has been suggested [6] based on the collected bivalves, although some belemnites of Early Jurassic age have been identified, too. In this case, the sediments from Nalbant must be considered as being of Late Triassic – Early Jurassic age as the similar sediments (Sinivir Formation) described in Bulgaria. Unfortunately subsequent authors have not mentioned presence of such bivalves in the Nalbant flysch sediments. Pliensbachian fossils have been determined [7] and on their basis it was concluded that the Lower Liassic had not been deposited in the region. However, a transition and continuity between the Triassic and the Lower Jurassic has been described [7], and on the basis of lithological differences distinguished three more or less synchronous formations (Nalbant, Teliţa and Denis Tepe Formation) have been introduced. Nalbant Formation (Sinemurian-Lower Pliensbachian; c. 300 m) comprises rhythmic flysch-type sediments – alternation between quartz and quartz-feldspar sandstones and grey to black shales. The age of this formation is not proved palaeontologicaly, but in the holostratotype section it is connected to the Trestenic Formation (Sevatian-Rhaetian-Hettangian) by a lithological transition. The last could be correlated with the East Stara Planina Glogova Formation. Nalbant Formation may be regarded as a correlate to the East Stara Planina Sinivir Formation, the Crimea Formation, and the lower member of the Eski-Orda Formation in South Crimea. Teliţa Formation (Hettangian-Sinemurian-Pliensbachian) crops out between Cataloi and Poşta, where it is connected by a transition with the Cataloi Formation. Two parts have been individualized [7]: lower – Frecăţei Sandstones (Rhaetian? – Hettangian; c. 40 m) with *Psiloceras johnstoni*, *Schlotheimia angulata*, and upper one – Poşta Sandstones (Sinemurian – Pliensbachian 90 m) with *Coroniceras* sp., *Uptonia jamesoni*, *Tropidoceras masseanum*, *Acanthopleuroceras* cf. *nautiloides*. Denis Tepe Formation (Sinemurian – ?Toarcian) (400–450 m) represents a flysch alternation of sandstones and shales. Probably the lower part is connected with the Nalbant For-

mation, and only the upper part represents the Denis Tepe Formation. The Denis Tepe Formation can be correlated with the East Stara Planina Balaban Formation and with the South Crimea upper member of the Eski-Orda Formation (Fig. 2). The Lower-Middle Jurassic section in North Dobrogea ended by the recently discovered in a borehole Zebil Formation [8]. It is represented by black to grey clays and shales, the age of which is not precisely determined – it can represent [8] lithological variations of the Middle Jurassic and the Lower Malm. The Zebil Formation can be the correlate of the East Stara Planina Kotel Formation and the South Crimea Ourgoulya and the upper member of the Ay-Vassil Formations (Fig. 2).

South Crimea (Gorniy Krim), Ukraine. The Jurassic of the region of South Crimea usually referred to as Gorniy Krim (Mountainous Crimea) has been the subject of more than 150 publications [10]. A suitable basis for correlations is found in [19] although some of the other papers have been also considered.

The Triassic and Jurassic rocks in South Crimea are represented by terrigenous-clayey and volcanogenic rocks. The basal parts and the basement are unknown. Some information about the basement comes from exotic blocks included in the Triassic and the Jurassic sediments. They are represented by Lower Carboniferous and Upper Permian subplatform limestones. Abundant Middle Triassic brachiopods, bivalves and ammonites are determined in calcareous blocks, resedimented in the flysch-type sediments. The oldest sediments in South Crimea were individualized as "Tauric beds" or "Tauric series" with a range of Upper Triassic up to Toarcian, inclusive. Later on, two lithostratigraphic units have been described [19] based only on the different age: Late Triassic for the Crimea Formation, and Early Jurassic, for Eski-Orda Formation. The basis of the Crimea Formation is unknown. The Carnian and Norian stages have been proven, and the Rhaetian is supposed to be missing. The Crimea Formation is built of flysch and flyschoid type sediments – alternation between grey to black shales, siltstones, sandstones and gravel sandstones. It contains many calcareous, sideritic and clayey-calcareous concretions. The total thickness is up to 1500 m. The upper boundary cannot be traced in the field, because the above-lying Eski-Orda Formation is built of sediments with the same composition. The Crimea Formation is subdivided into two members. The lower member (up to 400 m; supposed Lower Carnian by position) is built of sandy flysch with intercalations of quartz sandstones. The upper member (up to 1100 m) is a terrigenous flysch alternation of dark grey to black shales, siltstones, sandstones, and rarely by gravel sandstones. The lower boundary is concordant, and the upper one, discordant (?). The upper member of the Crimea Formation is subdivided into two informal units: (a) beds with *Halobia septentrionalis* (Carnian; 350–400 m of a fine rhythmic alternation of dark grey shales, siltstones and sandstones); and (b) beds with *Monotis salinaria salinaria* (Norian; thickness 400–700 m of terrigenous flysch alternation of shales, siltstones and sandstones). These beds are correlated with the beds with *Monotis salinaria salinaria* of the Upper Norian (?) part of the Nalbant Formation in North Dobrogea and with the beds with *Monotis caucasica* in Northern Caucasus. In the Crimea Formation tuffs, tuffites, keratophyres, spilites locally occur.

The Eski-Orda Formation is subdivided into two members. The lower member (150–500 m) is represented by an alternation of grey and brown coarse shales, arkose siltstones and sandstones, often poorly sorted, with occasional limestone lenses. The age is Late Hettangian-Late Pliensbachian. The upper member (80–200 m) is built of light grey or yellowish quartz or arkose sandstones and conglomerates with pebbles of quartz, metamorphic and volcanogenic rocks, with intercalations of shales and siltstones with calcareous lenses. Partly in the Kachin-Salgir region and the NE Region [19] it is covered concordantly by the Ourgoulya Formation, and in parts of the SW Region, transgressively by the Beshouya Formation.

The Crimea Formation and the lower member of the Eski-Orda Formation may be correlated with Sinivir Formation in East Stara Planina and Nalbant Formation in

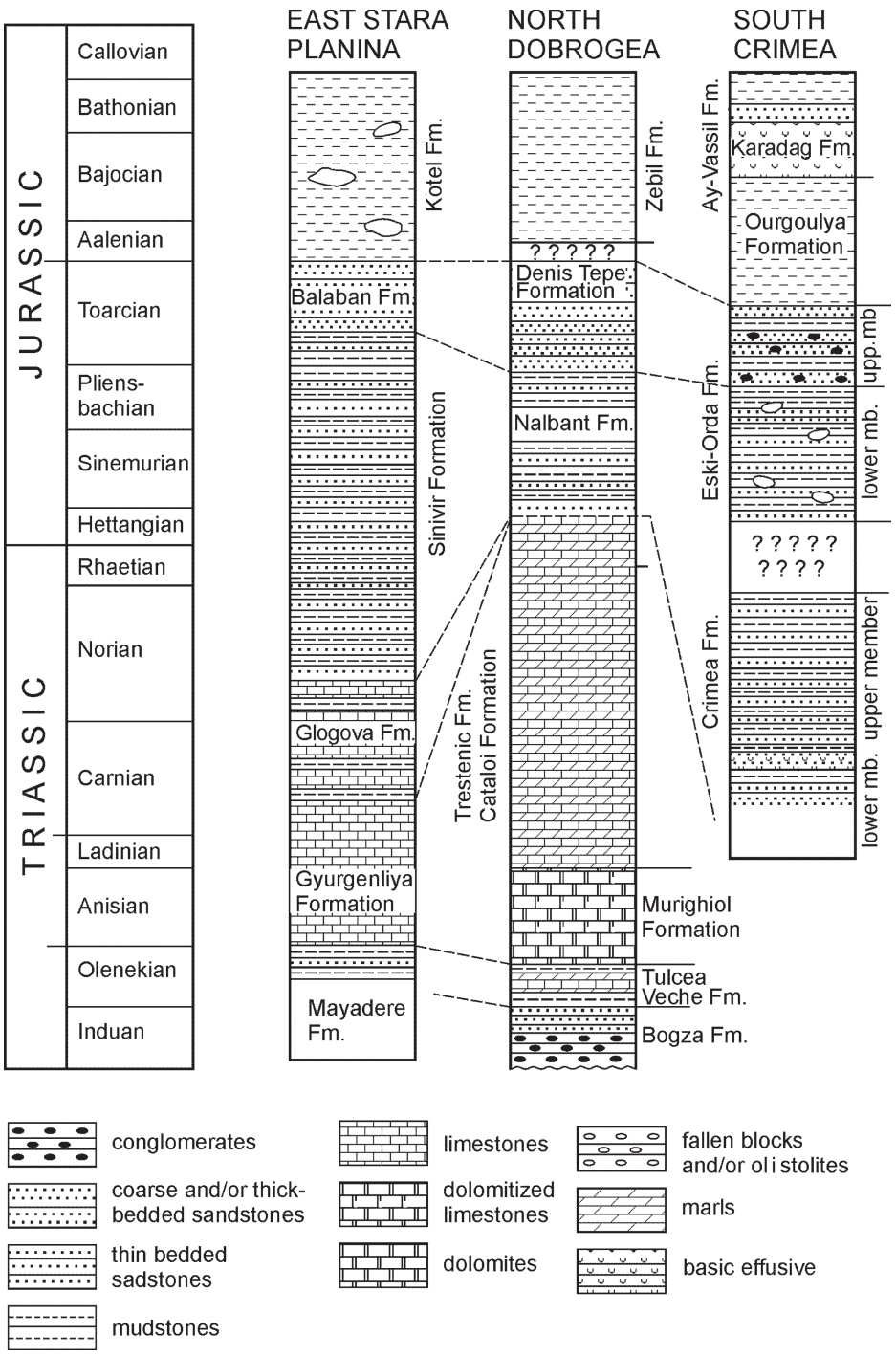

Fig. 2. Correlation chart of the Triassic and Lower and Middle Jurassic sediments in East Stara Planina (Bulgaria), Tulcea Zone (North Dobrogea, Romania) and South Crimea (Gorniy Krim, Ukraine)

North Dobrogea. The upper member of the Eski-Orda Formation may be correlated with Balaban Formation in the East Stara Planina and Denis Tepe Formation in North Dobrogea.

The Tauric series [19] is covered in the Kachin-Salgir Region and in the North-East Region concordantly by the sediments of the Ourgoulya Formation, and in the SW Region – by these of the Beshouya Formation. Correlate to the Ourgoulya Formation in the Prisivashie and the Flat Country of Crimea is Bitak Formation, which traced the north-western shallow parts of the basin during the sedimentation of the Ourgoulya Formation.

Ourgoulya Formation (300–400 m) covers concordantly the upper member of the Eski-Orda Formation and is covered concordantly by tuffs, tuffites, keratophyres, and spilites of the Karadag Formation. The age is Early Toarcian (*Hildoceras bifrons* Zone) – Early Bajocian. It is built of alternation between shales and siltstones with rare interbeds of sandstones. The Ourgoulya Formation is correlated with the Kotel Formation (East Stara Planina) and with the Zebil Formation (North Dobrogea).

Beshouya Formation (c. 600–650 m) is built of coarse-grained sandstones and conglomerates with two coal beds. It covers discordantly the sediments of the upper member of the Eski-Orda Formation. In the basal beds there are resedimented blocks of the Eski-Orda Formation. We suppose that the Beshouya Formation trace the northern board of the Ourgoulya basin.

The Ourgoulya and Beshouya Formations are covered by the effusive rocks (tuffs, tuffites, keratophyres, spilites) of the Bajocian-Bathonian Karadag Formation. This lithostratigraphic unit (c. 500 m) has no correlates in North Dobrogea and in the East Stara Planina, where no volcanic activity occurs during the Middle Jurassic. Ay-Vassil Formation (Bathonian-Lower Callovian) covers concordantly the Karadag Formation. The Ay-Vassil Formation is subdivided into two members – lower (Bathonian, 350 m; sandstones in the lower part and sandstone- shale flysch in the upper part), and upper member (Lower Callovian, 100–150 m: grey silty clays with sideritic concretions and rare intercalations of sandstones; in its uppermost parts the Lower Callovian ammonites *Macrocephalites macrocephalus* have been collected). The upper member of the Ay-Vassil Formation can be correlated with the upper parts of Zebil Formation in North Dobrogea, and with parts of Kotel Formation – in the East Stara Planina.

Conclusions. Considerable similarities exist between the Triassic and the Jurassic lithostratigraphic units of East Stara Planina, North Dobrogea (Tulcea Zone) and South Crimea although some differences may be found, too. Similar development is marked in the almost identical lithology of the calcareous Middle and Upper Triassic rocks especially in East Stara Planina and North Dobrogea as well as in the terrigenous siliciclastic Upper Triassic and Lower and Middle Jurassic rocks of East Stara Planina (Luda Kamchiya Group), North Dobrogea (Nalbant, Denis Tepe and Zebil Formations) and South Crimea (the Tauric series, Ourgoulya Formation, and Ay-Vassil Formation). Another similarity between East Stara Planina and South Crimea is the presence of almost synchronous phenomena of formation of olistostromes, their material being supplied from the uplift and destruction of exotic lands (Exotic Ridge of Zlatarski – in the area of East Stara Planina, and the Euxinia Exotic Ridge for the South Crimea) in extensional conditions. Such phenomena have not been noted in North Dobrogea. The biggest difference between East Stara Planina, on the one hand, and North Dobrogea and South Crimea, on the other hand, is the lack of effusive volcanism in East Stara Planina whereas it is present in North Dobrogea and South Crimea.

The simultaneity of these events and similarities in the type of sedimentation and its Tethyan signature gives grounds to refer the corresponding three areas to parts of a single Triassic – Jurassic Basin as a part of the Northern (Euxinian) Tethys (Fig. 3).

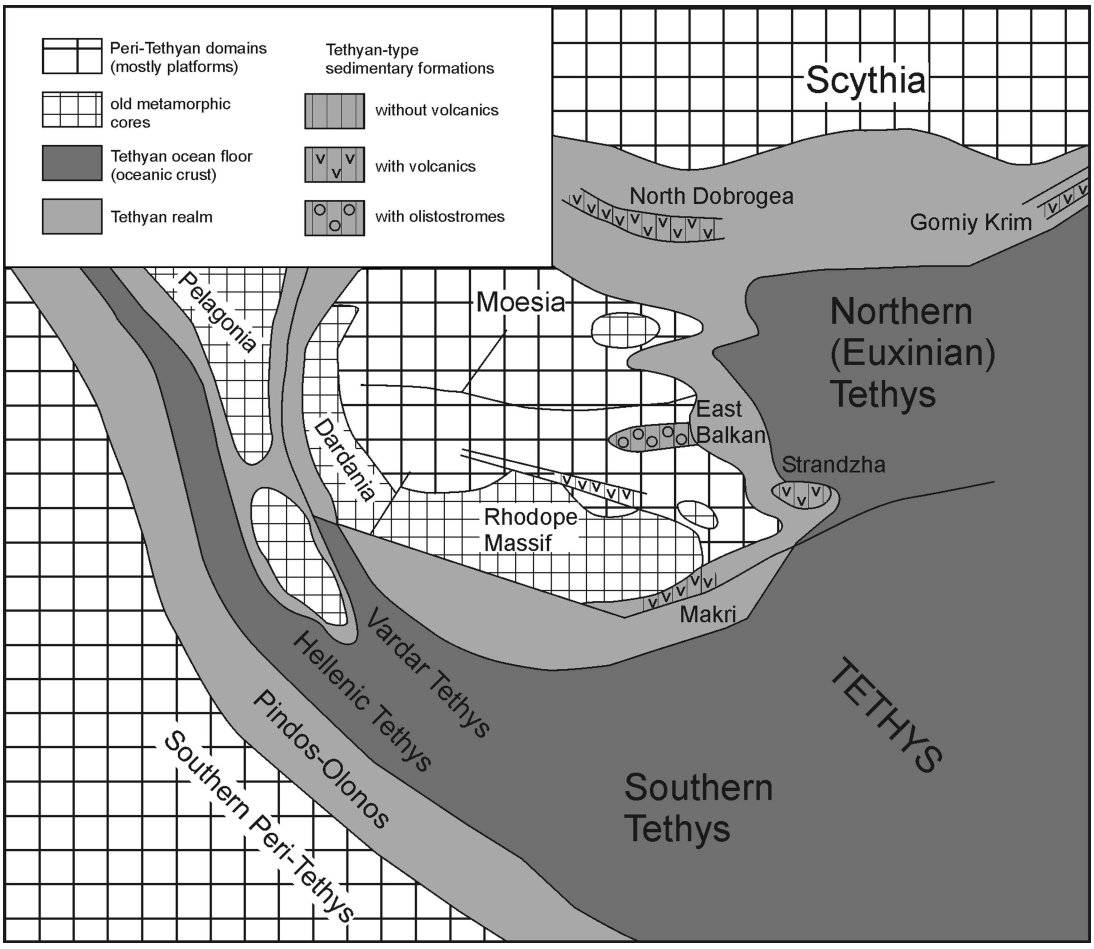

Fig. 3. Cartoon (palynspastic) for the relations of the Tethyan basins in Triassic and Early Jurassic times (partially after [20])

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