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THE MOESIAN AND BALKAN TERRANES IN BULGARIA: PALAEOZOIC BASIN DEVELOPMENT, PALAEOGEOGRAPHY AND TECTONIC EVOLUTION

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(3 figures)

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ABSTRACT. This paper is a review of recent stratigraphical, biogeographical, palaeoclimatical, palaeofacial and palaeomagnetical data and represents a basis for paleogeographical and geodynamical interpretations. The geological development and palaeogeography of the Moesian and Balkan Terranes are here regarded in the scope of the geodynamical evolution of Baltica-Gondwana interface from Ordovician to Carboniferous. It is concluded that the Balkan Terrane was a part of the Armorican Terrane Assemblage during its whole Palaeozoic evolution. The origin and palaeogeographical affinities of the Moesian Terrane during the Early Palaeozoic remain unclearly determined. It is probable that during the Early Devonian the Moesian Terrane was at closer position to Armorica and Avalonia and moved northward to reach and collide to Baltica at the end of Devonian. The accretion of the Balkan Terrane to Moesia-Baltica occurred during the Late Carboniferous and Permian. Since the late Carboniferous to the end of the Palaeozoic, both the Moesian and Balkan Terranes were situated within the equatorial zone and had the same depositional history in the Permian.

KEYWORDS. Palaeozoic, Bulgaria, Balkan peninsula, Moesian Terrane, Balkan Terrane, stratigraphy, palaeogeography

1. Introduction and previous palaeogeographical reconstructions

The Variscan orogenic belt of Europe is characterised by a mosaic of terranes of Avalonian, Armorican, Perigondwanan or Baltican affinities**,** which were accreted during the Late Devonian and Carboniferous. The far eastern part of the Variscides remains relatively less known. The regional palaeogeographical reconstructions which include the Moesian Terrane and the Rhodopes are not always based on comprehensive stratigraphical evidence and remain contradictory.

Palaeogeographical reconstructions regarding the eastern prolongation of European Variscan orogeny include the Moesian Terrane in various interpretations or uncertain continental origin and affinities. Classically, Moesia was regarded as a southern margin of Baltica or the East European Craton (Ziegler, 1986). A recent Palaeozoic terrane map of Europe shows the Moesian Terrane as a sliver of the ancient East European Craton (Ozclon, 2004). Correlations with terranes of the Avalonian Terrane Assemblage that detached from Gondwana in Cambrian and collided to Baltica by Late Ordovician (i.e. Moravo-Silesia, Lysogory, Malopolska) were proposed by Burchfiel (1975), Matte *et al*. (1990), Kalvoda (2001). This view is further developed by von Raumer *et al*. (2002, 2003) on a global reconstruction of the Late Ordovician placing Moesia, Istanbul, Lysogory and Malopolska Terranes together within Avalonia.

Yanev (1990, 1993, 1997, 2000) and Haydutov & Yanev (1996) defined the Moesian and Balkan Terranes and proposed a hypothesis of their North Gondwanan origin, successive northward migration to Baltica and subsequent collision during the Variscan orogeny (Fig. 1).

Another group of reconstructions has related the Moesian terrane to Gondwana-derived terranes of the Armorican Terrane Assemblage (i.e. Moldanubian Zone, Saxo-Thuringian Zone) which detached from Gondwana later than Avalonia and collided to Baltica-Avalonia by late Devonian – early Carboniferous times (Pharaoh, 1999; Golonka, 2003)

The Balkan Terrane (Yanev, 1990) which separates the Moesian and Thracian terranes is absent from most published palaeogeographical maps.

The Thracian Terrane, as we call the Rhodopes and Serbo-Macedonian Terrane, occupies territories of Bulgaria, Serbia, Macedonia and Greece and was assigned to Avalonia (von Raumer *et al*., 2003) or to Gondwana-derived terranes (Yanev, 1993, 1997).

The purpose of this paper is to provide a review of the stratigraphical, sedimentological and palaeogeographical data accumulated recently on the Paleozoic evolution of Moesian and Balkan Terranes in Bulgaria. The terrane analysis, palaeogeographical and tectonic evolution of the Moesian and Balkan Terranes are also based on the similar histories of basin development in different terrane groups. The sedimentary development and geodynamics of the Moesian and Balkan Terranes during the Palaeozoic is discussed related to the evolution of the Rheic Suture, separating Avalonia-Baltica from the terranes of the Armorican Terrane Assemblage, accreted to Laurussia in late Palaeozoic time.

2. Stratigraphy, sedimentology and basin development of the terranes

2.1. Moesian Terrane

The Moesian Platform in Romania and Bulgaria is overthrusted by the Carpathian and Balkan segments of the Alpine belt. The northern boundary of Moesia with the Carpathians is the Pericarpathian Fault, and the southern boundary with the Balkan is the North-Forebalkan Fault. To the north-east, Moesia is juxtaposed with the North Dobrogea Orogen along the Peceneaga-Camena Fault. The latter is regarded as a major crustal and terrane boundary within the Tornquist-Teisseyre Zone, along which large horizontal motions took place (Visarion *et al.,* 1988). The Intramoesian Fault of NW-SE direction divides the Moesian Platform into a West Moesian (=”Valachian”) block and an East Moesian (=”Dobrogean”) block. Since the Intramoesian Fault runs along the Bulgarian-Romanian terrestrial boundary in Dobrudgea, the whole Bulgarian part of the Moesian Platform belongs to the West Moesian block.

All the information concerning the Palaeozoic rocks of the Moesian Terrane in Bulgaria comes from deep hydrocarbon wells (Fig. 2) as there are no outcrops of Palaeozoic rocks in this area. The Moesian Terrane has a complex block structure as a result of vertical movements and the Palaeozoic sediments were eroded to various degree**.** The subsurface data on Palaeozoic sediments in Bulgaria reveal the presence of Silurian (Pridoli), Devonian (Lower,

Fig. 1. Sketch of the Paleozoic terranes in the eastern part of the Blakan Peninsula.

Middle and Upper) and Lower Carboniferous (up to Visean) marine sediments and continental cover of Serpukhovian to Permian age.

2.1.1. Stratigraphy and sedimentology

a) Western and central part of the Moesian Terrane (West Moesia Block)

In the western and central part of the West Moesian Terrane in Bulgaria the Palaeozoic sediments consist of Upper Silurian to Visean marine deposits (Fig. 3) and a Permian continental cover. In Romania, according to Seghedi *et al*. (2004) in the West Moesian block Silurian sediments unconformably overly the Ordovician. The Silurian is a succession of graptolitic shales in the Llandovery and shallow marine shelly fauna sediments without graptolites in the Pridoli.

The oldest marine sediments in Bulgaria are Pridoli and Lochkovian black shales about 200 m thick (Dalgodeltsi borehole) with bivalves and trilobites and rich in palynomorphs - chitinozoans, acritarchs and miospores. The palynological evidence proved the uppermost Silurian and Lochkovian assignment on chitinozoans and spores (Lakova, 1993, 2001a; Steemans & Lakova, 2004) and a continuous sedimentation across the Silurian-Devonian boundary. There is no biostratigraphical evidence on sediments of Pragian to Emsian age. The Middle Devonian is about 800-1000 m thick and comprises dolomitic limestones, calcareous dolomites and micritic limestones. The Givetian age was determined on foraminifers, brachiopods and conodonts (Vdovenko *et al.,* 1981, Spassov *et al.,* 1978, Boncheva *et al*., 2002). The Eifelian represents 300 m thick limestones and dolomites (Totleben borehole). Both the lower and upper boundaries of the Eifelian are marked by unconformities and calcirudites at the base. The Givetian to Visean succession (without Upper Devonian) is of thick dolomites and variegated limestones with several unconformities, overturned strata and tectonical displacement in Gomotartsi. The Givetian is represented by 500 to 700 m dolomites and limestones. The Middle Givetian is covered with tectonic boundary by older Upper Eifelian – Lower Givetian strata on conodont evidence (Boncheva *et al*., 2002).

The boundary between the Middle Devonian and Lower Carboniferous is an erosional surface as proven on conodont and sedimentological data (Boncheva *et al*., 2002). In the western part (Gomotartsi borehole), the Tournaisian and Visean consist of intraclasitic and organogenic limestones with crinoids, algae, ostracods, foraminifers, up to 900-1000 m thick. The Early Carboniferous age was proved on conodonts and foraminifers (Spassov, 1987, Vdovenko *et al*., 1981, Boncheva *et al*., 2002). The Upper Carboniferous is not documented on palaeontological data.

In the central part, the Middle Devonian carbonate sequence is unconformably covered by 600 m thick Carboniferous continental shales, siltstones, sandstones and coal-bearing shales of Tournaisian to Lower Serpuchovian age based on macro- and microflora (Novachene borehole). These are the only coal-bearing Carboniferous sediments outside Dobrudgea Coal Basin in east Bulgaria (Nikolov *et al*., 1990, Dimitrova, 1996).

With contrasting lithological boundary and clear discordance, the Permian continental clastics cover either Middle Devonian or Visean-Serpukhovian deposits. The Permian consists of reddish breccia-conglomerates, sandstones and siltstones 50 to 800 m thick. This drastic variation in thichness is due to a varied pre-Permian basement and different erosional depth.

b) Eastern part of the Moesian Terrane (West Moesian Block)

The Palaeozoic consists of marine sequence from Ordovician to Visean (with numerous local discontinuities) covered unconformably by continental Carboniferous and Permian.

The oldest subsurface sediments of the eastern part of the West Moesian Terrane in Bulgaria are Ordovician pelitic rocks about 100 m thick. They do not contain fossils and are covered by Silurian with slight unconformity (Yanev, 1972). In Romania, the Ordovician is 750 m thick and dated on graptolites, brachiopods and palynomorphs (Iordan, 1992). The Silurian is represented by mainly dark shales and siltstones with minor limestones and marls, up to 1000 m thick. Conodont and graptolite faunas proved the Llandovery and Wenlock Series in Vetrino (Spassov & Yanev, 1966). The Lower Devonian consists of about 800 m black shales with clayey limestones, upwards chiefly limestones (Kardam and Mihalich boreholes). Chitinozoan data proved the Pridoli, Lochkovian, Pragian and Emsian (Lakova, 1993, 2001a). The spore evidence confirmed the presence of Lochkovian and Emsian (Steemans & Lakova, 2004).

Fig. 2. Geographic position of the described subsurface sections of the Moesian Terrane and the outcrops of the Balkan Terrane.

Locally, thin quartzites and sandstones of possible Emsian/Eifelian age cover the Lower Devonian shaly-carbonate sequence. In Romania, these quartzites and sandstones are of Eifelian age and of mixed subcontinental – marine origin (Seghedi *et al*., 2004). In other areas of Bulgaria (Ograzhden, Kardam and Vaklino boreholes), the quartzites are missing and the Lower Devonian shaly-carbonate sediments are directly covered by Eifelian carbonate sequences (Spassov, 1987; Yanev & Boncheva, 1995).

The Middle-Upper Devonian to Visean carbonate sequence is subdivided into six informal lithostratigraphical series: carbonate-sulphate, dolomite, banded limestones, intraclastic limestone, organogenic limestones, clastic limestones (calcrudites) (Yanev, 1972). The total apparent thickness of carbonate platform deposits is 1200 to 2000 m, thickenning from NW to SE. The interpretated stratigraphical thickness may reach 3000 m. Fossil data on conodonts (Spassov, 1983; Boncheva, 1995; Yanev & Boncheva, 1997; Boncheva *et al.,* 1994, 2000) proved Eifelian, Givetian, Frasnian, Famenian and Visean stages. Throuhout the carbonate sequence, the stage boundaries represents unconformities proved on both microfossils and sedimentological data (Yanev, 1972, 1976; Yanev & Boncheva, 1995).

The Eifelian consists of carbonates and sulphates up to 200 m thick (Kardam, Ograzhden, Dulovo, Chereshovo and Vaklino boreholes) and the age is proven on corals, brachiopods, ostracods, trilobites (Spassov, 1987) and conodonts (Yanev & Boncheva, 1995; Boncheva, 1995). The conodont assemblages suggest a dynamic shallow marine environment (Boncheva, 1995, 1997). The Givetian is represented in most subsurface sections by the same limestones and dolomites as the Eifelian but it is more than 1000 m thick (Fig. 3). The conodonts prove the age, as well as numerous sedimentation breaks and overturned strata. Eifelian strata overlay the Givetian in Nikola Kozlevo and Vaklino boreholes.

The Frasnian and Famennian stages represent chiefly banded limestones, intraclastic and pelletoidal limestones (Ograzhden and Vaklino boreholes), locally covered by organogenic limestones (Preslavtsi and Dulovo boreholes). The age was proved on conodonts and foraminifers (Spassov, 1987; Konigshof & Boncheva, 2005). The Frasnian is restricted in the area of Ograzhden and Chereshovo (900 m thick), whereas the Famennian is more widespread but the tickness varies from 20 to 250 m. A continuous section of Frasnian-Famennian is proved only in Chereshovo. Based on the stratigraphical position and sedimentological features, it is assumed that the Upper Devonian occurs also in Kardam, Ograzhden and Vaklino boreholes.

The Tournaisian is missing in north-east Bulgaria. The Lower Visean represents organogenic limestones 150 m thick in Preslavtsi borehole proved on conodonts and foraminifers (Spassov, 1974). The Upper Visean consists of polydetrital limestones at the base about 300 m thick (Vaklino), unconformably covered by a predominantly dark shale sequence with thin sandstones and coal layers 500 m thick (Ograzhden borehole). The age is proved on conodonts and miospores (Boncheva *et al*., 1994).

In contrast to this, a more than 2000 m thick sequence of paralical sediments formed to the south within the Dobrudgea Coal Basin (Fig. 3, Dogrudgea). The section consists at the base of sandstones and siltsones with some limestones. Upwards, mainly siltstones and shales occur with coal seams. In the upper part, sandstones and siltstones predominate, with coal fragments (Koulakssazov & Tenchov, 1973).

Continental deposits of the Upper Carboniferous are present only within the Dobrudgea Coal Basin. The Middle to Upper Devonian carbonates are here unconformably overlain by Upper Serpukhovian (Namurian)-Westphalian coal-bearing terrigenous strata.

The Permian consits of conglomerates, sandstones, shales and evaporates. The great variations in the thickness of the Carboniferous (0-3000 m) and Permian (0-3500 m) deposits resulted of erosion and differential subsidence of the separate zones.

2.1.2. Basin development

The Ordovician to Lower Devonian pelitic rocks were deposited in a shelf area, in relatively deep-water, as suggested by sporadic benthic faunas. The occurrence of clayey limestones, brachiopods and spores in the upper part indicates a transition to somewhat shallower environment.

During the Middle-Late Devonian and Visean, carbonate sedimentation developed varying from shallower environment in the eastern periphery (Eifelian-Givetian) to

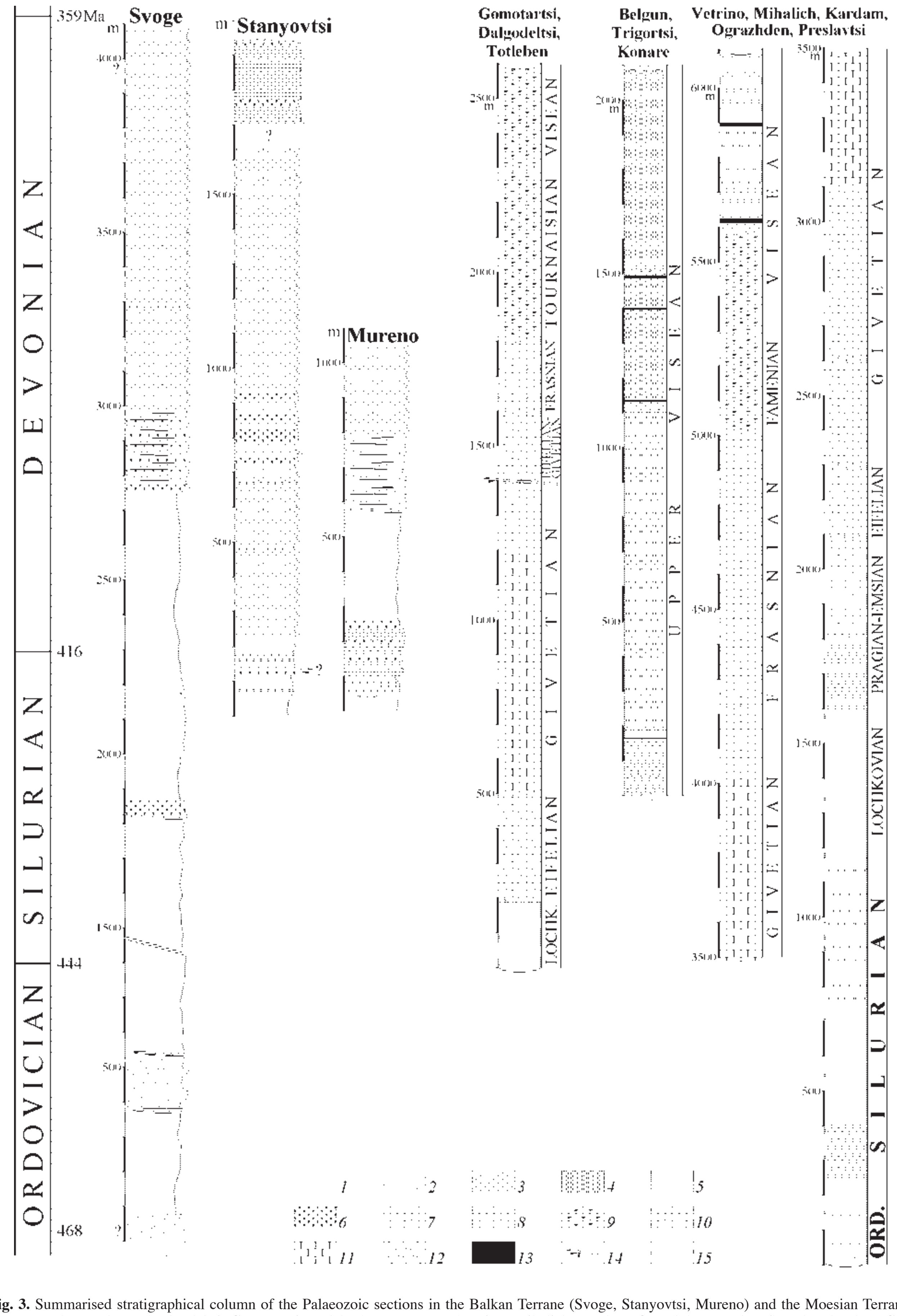

Fig. 3. Summarised stratigraphical column of the Palaeozoic sections in the Balkan Terrane (Svoge, Stanyovtsi, Mureno) and the Moesian Terrane: western and central part (Dalgodeltsi, Gomotartsi, Totleben), eastern part (Vetrino, Mihalich, Kardam, Ograzhden, Preslavtsi) and Dobrudgea Coal Basin (Trigortsi, Belgun, Konare). 1 – olistostromes; 2 – conglomerates and sandstones, 3- sandstones, 4 – siltstones, 5 – shales (light shales and black shales), 6 – lydites, 7 - limestones, 8 – clayey limestones, 9 – organogenic limestones, 10 – clastic limestones, 11 – dolomities, 12 – evaporates, 13 – coal, 14- tectonic boundary, 15 – discontinuity.

deeper-water in the central part of the carbonate platform (Late Devonian). Laterally, during the Middle Devonian sulphate accumulation developed to the northeast in lagoons. Similarly, Eifelian conodont associations suggest shallow-water nearshore environment. Typical carbonate platform developed again in the Late Tournaisian to Early Visean. The two successive Middle Devonian and Visean carbonate sequences are divided by considerable stratigraphical gaps in different areas (lack of parts of the Frasnian, Famennian and Tournaisian). The occurrence of overturned strata, mainly in the eastern periphery, resulted of active collisional tectonics within the basin in the Late Devonian and Early Carboniferous.

The Upper Carboniferous sedimentation occurred in isolated continental basins. The succession of Dobrudgea Coal Basin formed over the Lower Carboniferous delta, connected with a marine basin to the east-southeast. The Permian continental clastics deposited on variegated pre-Permian relief forms, locally after huge wash-out or non-deposition even over the Lower Devonian. Later in the Permian, these isolated basins increased and connected with evaporite lakes or sabkha deposits.

2.2. Balkan Terrane

The Balkan Terrane consists of Paleozoic volcano-sedimentary, marine sedimentary and continental rocks, outcrouping in the West Balkan Mountain and the Kraishte area both units of the Carpathian-Balkan Alpine belt. The Balkan Mountains are bounded to the north by the Fore-Balkan and Moesian Platform and to the southwest and south first by the Srednogorie Zone belonging to the Balkan Terrane and then by the Thracian Terrane. To the north, its continuation represents the Southern Carpathians as a part of the Alpine Belt.

In the West Balkan Mountains and the Kraishte area, specific stratigraphical and sedimentological developments could be recognised: entirely terrigenous sediments on a subsiding shelf in the Late Silurian and Devonian in West Balkan Mountains and coeval relatively shallower shelf carbonates, shales and lydites in the Kraishte region.

2.2.1. Stratigraphy and sedimentology

a) West Balkan Mountains

An island-arc association of cumulates, dikes and pillow lavas metamorphosed to green-schist facies outcrops in the Western Balkan Mts. Recent zircon dating of intrusive rocks indicated about 493 Ma, confirming Cambrian-early Ordovician age of the island-arc (Carrigan *et al.*, 2003). These ages are similar of Young Pan-African ages and provide further evidence on Gondwana origin of the Balkan Terrane. The island-arc complex is transgressively and unconformably overlain by an Arenigian olistostome sequence dated on acritarchs.

Unmetamorphosed marine sedimentary rocks of Middle Ordovician to Visean age cover the Arenigian olistostromes (Fig. 3, Svoge). The Middle and Upper Ordovician grey shales and sandstones with brachiopods and trilobites are totally 1800 m thick. The age assignment is based on graptolites and trilobites (Spassov, 1960; Sachanski, 1993; Gutierrez-Marco *et al.*, 2003). At the top of the Ordovician succession there is an indication of diamictites of glaciomarine origin.

Following a continuous transition from the Ordovician proven on graptolites, a Silurian pelagic succession developed, 400-500 m thick, of lydites, silicitic shales, black graptolitic shales and laminated shales-siltstones (Spassov, 1960; Sachanski, 1993; Sachanski & Tenchov, 1993). At the base of Silurian, Llandoverian lydites, silicitic shales and some black shales occur 50 m thick. Upwards, the black shale succession rich in graptolites, 100 m thick, corresponds to the Upper Llandovery, Wenlock and Lower Ludlow. The overlaying Ludlovian-Pridolian series of laminated shales and siltstones is 200-250 m thick. The upper part of the Pridolian, as well as the Lochkovian and Pragian represent a continous uniform black siltstone succession, up to 380 m thick, dated on graptolites and tentaculites (Sachanski, 1993). The succession of graptolite zones established evidenced a complete Silurian section and transitional sedimentation across the Silurian-Devonian boundary (Sachanski, 1998).

The overlaying series of greenish-grey shales with dark spots is 380 m thick, lacks macrofossils and was assigned to the Lower-Middle Devonian on its stratigraphical position (Tenchov & Yanev, 1987). Only at the base there is palynological evidence on Emsian age (unpublished data on chitinozoans). Upwards, a pre-flysch series of lydites, shales and silicitic shales, 380 m thick, outcrops. This series does not contain fossils and is tentatively assigned to the Middle Devonian. Conformably, a flysch succession occurs, up to 1000 m thick, consisting of sandstones and shales. It belongs to the Upper Devonian – Visean based on macroflora and on conodonts in single carbonate layers (Yanev, 1985, 2000; Boncheva & Yanev, 1993).

The continental cover consists of Upper Carboniferous and Permian sediments and pyroclastics which overlay variable sedimentary and metamorphic rocks of different ages. The Serpukhovian-Westphalian and Stephanian coal-bearing deposites rich in macroflora outcrop in isolated basins. Permian reddish siliciclastics 0-3000 m thick accumulated over folded basement including the Upper Carboniferous sedimentary, volcanic and intrusive rocks.

b) Kraishte Region

In the region of Kraishte, low-grade metamorphic rocks (phylites, schists, quartzites, marbles) supposedly of pre-Silurian age, crop out extensively.

The oldest Palaeozoic sedimentary rocks in the Kraishte region are Silurian black shales with lydites at the base. The age was proved on graptolites (Spassov, 1963, 1964) as Silurian (Wenlock and Ludlow) and Early Devonian (Lochkovian). A succession of shales and clayey limestones is represented across the Silurian-Devonian boundary. The total thickness of the Silurian and Devonian is hard to be estimated due to tectonic displacement and lack of outcrops.

The Lower Devonian is a non-rhythmic succession of limestones and shales, the shales being predominant (Fig. 3, Mureno). The Lochkovian, Pragian and Emsian were established on conodonts and tentaculites (Boncheva, 1991; Sachanski & Boncheva, 1994). Upwards, two terrigenous series of black shales with lydites and light-coloured shales without fossils of total thickness of 300 m outcrop. At the base of the overlying thick flysch succession, mosaic conglomerate and coarse flysch sediments developed, followed by an alternation of sandstones and shales.

In other areas, above the Lower Devonian limestones, shales and lydites (Fig. 3, Stanyovtsi) dated as Lochkovian on graptolites, there is a flysch succession of sandstones and shales of proved Givetian age on conodonts (Spassov, 1973). It is questionable whether the contact between these two formations is a tectonic boundary or is related to stratigraphical gap. The flysch succession is represented by about 1500 m thick alternation of shales and sandstones with rare limestone layers (Yanev & Spassov, 1985; Yanev, 1985). In the middle part, packets of lydites and sandstones occur. Upwards, a limestone and lydite succession outcrop in which conodonts proved Frasnian-Famennian and Visean (Spassov, 1973; Yanev & Spassov, 1985, Boncheva & Yanev, 1993).

The Upper Carboniferous and Lower Permian are missing. The continental cover is of Upper Permian sandstones, siltstones and scarce breccia-conglomerates about 300-400 m thick.

2.2.2. Basin development

Starting from the Middle Ordovician, a shelf marine basin was established over the Pan-African island-arc basement.

During the Ordovician silicilastic deposits accumulated poor in macrofossils. At the end of Ordovician, sandstones deposited due to emersion and diamictites related to melting of polar icecaps (Gutierrez-Marco *et al*., 2003). From the Early Silurian widespread transgression formed a deeper water basin in which organic-rich anoxic graptolitic black shales accumulated. The mainly pelitic sedimentation continued on the shelf during the Early and Middle Devonian where dark and greenish shales formed. Significant change in the depositional environment occurred through the Middle-Late Devonian when turbidites and fluxo-turbidite began to accumulate on the slope zone. Typical flysch sedimentation developed from the Late Devonian to Visean. Since the Late Carboniferous, due to emersion the marine sedimentation was replaced by separate coal basins. In the late Permian proluvial sediments accumulated and a continental basin developed.

3. Palaeogeography

3.1. Moesian Terrane

The palaeogeographic interpretation and reconstruction of the Moesian Terrane is based on combined analyses from two main sources - palaeobiogeographic and palaeoclimatic data.

The biogeographical affinities of benthic faunas from the Romanian part of the Moesian Terrane (Cambrian trilobites) are rather controversial (Iordan, 1992) and show similarities to different palaeocontinents and terranes - Baltica, Avalonia and the Armorican Terrane Assemblage (Bohemia).

In Bulgaria, the only palaeobiogeographical interpretations are made on planktonic microfossils (chitinozoans, acritarchs, miospores) of the Upper Silurian and Lower Devonian and on miospores of the Middle Devonian. The Lochkovian to Emsian chitinozoan faunas of the Moesian Terrane are quite similar to those in North Africa, Spain and Brittany (Lakova, 1995). More than a half of all chitinozoan species are known from North Gondwana (North Africa and the Armorican Terrane Assemblage). The coeval acritarchs (Lakova, 2001b) are very similar to Armorica, Avalonia and Northern Gondwana (e.g. Brittany, Spain, Southern England and Algeria). The North Gondwanan affinities of the acritarchs are less pronounced than that of the chitinozoans. Recently, paleobiogeographical analysis of Lochkovian spores revealed somewhat controversial affinities with associations from Avalonia (Steemans & Lakova, 2004). This closer position of the Moesian Terrane to Avalonia during the Lochkovian, as indicated on paleophytogeography supports, may imply a progressive narrowing of the Rheic Ocean which did not acted as a barrier for the planktonic acritarchs and chitinozoans.

The miospore assemblages of the Givetian in the Moesian Terrane (Boncheva *et al*., 2000) contain cosmopolitan species and allow correlations with Avalonia and North Gondwana. Kalvoda (2001) concluded on the basis of Early Carboniferous foraminiferal palaeogeography that the Moesian Terrane showed close relationships with the East European Craton and Avalonia. Consequently, these miospore and foraminiferal evidence support the concept that during the Middle and Late Devonian the Moesian Terrane approached Baltica and during the Early Carboniferous was already situated at its southern margin.

The palaeoclimatical conclusions are based on the presence in the Palaeozoic strata of minerals and rocks indicating specific climatical conditions and zones, and thus palaeolatitudes (Yanev, 1990, 2000). In the Ordovician to Early Devonian successions the abundance of organic matter in the predominantly shaly sequence and the presence of Fe-oolithic minerals evidences sedimentation in a temperate zone. The occurrence of anhydrites in the Givetian suggests a transition to the arid zone. The interpretation of Upper Carboniferous coal-bearing succession and floral diversity shows deposition in the humid zone close to the equator. These palaeoclimatical reconstructions support a northward migration of the Moesian Terrane depositional environment from the southern temperate zone in the Silurian to the southern arid zone in the Devonian and in the equatorial zone in the Late Caboniferous. In the Permian, the presence of reddish carbonate clastics, anhydrites and evaporates in the eastern part suggests sedimentation in the northern arid zone.

3.2. Balkan Terrane

The combined biogeographical, palaeoclimatical and palaeomagnetical data on the Ordovician of the Balkan Terrane give arguments in favour of its peri-Gondwanan origin and its position at higher latitudes within the temperate cool zone. The Middle Ordovician benthic faunas (brachiopods and trilobites) of the Balkan Terrane in west Bulgaria and east Serbia are of Bohemian and North African affinities (Gutierrez-Marco *et al*., 2003). Additional data supporting Armorican and North African affinities are the Emsian chitinozoans from the Balkan Terrane.

The palaeoclimatical interpretations for the Ordovician are based on Fe-oolithic rocks and diamictites which suggest depositional environment in the temperate humid zone at about 40° south. The Silurian anoxic graptolitic shales were deposited in the cool temperate zone. The abundance of diverse macroflora and coal deposition in the Late Carboniferous is characteristic of equatorial humid zone. The presence of anhydrite and carbonate matrix in the reddish Permian clastics indicates deposition in the arid climatic zone. Thus, these data may support a continuous migration from temperate southern latitude in the Ordovician to the equator in the Carboniferous and to the northern arid zone in the Permian.

Paleomagnetical data are available for the Balkan Terrane on the territory of Serbia (Milicevic, 1993, 1994). They indicate a position between 50° and 29° south during the Tremadocian, of 30°-40° south in the Middle Ordovician and 38° in the Late Ordovician. In the Early Devonian, the Kucaj "Terrane" in Eastern Serbian (considered to be of same sedimentological development as the Balkan Terrane) was located at about 16° south of the equator.

4. Discussion and correlations

This overview of the existing stratigraphical, biogeographical and palaeoclimatological data represents a basis for determination of the affinities and origin of the Moesian and Balkan Terranes and their motions in the Baltica-Gondwana interface during the Palaeozoic.

Previous palaeogeographical reconstructions regarded the Moesian Terrane as the southern margin of the East European Craton, or as a terrane belonging to the Avalonian Terrane Assemblage or Armorican Terrane Assemblage. The evidence from the Bulgarian part of Moesia alow to make conclusions about its evolution only during the Silurian to Carboniferous. In what concerns the Early Palaeozoic (Cambrian and Ordovician) history of the Moesian Terrane, the only stratigraphical and biogeographical sources are available from Romania.

During the Pridoli and Early Devonian the Moesian Terrane shows clear biogeographical affinities on chitinozoans with the Armorican Terranes and northern periphery of Africa (Northern Gondwana). On the other hand, the affinities of coeval miospores with Avalonia rised the question whether the Moesian Terrane was situated in rather northern position between Avalonia and Armorica during the Lochkovian.

In the Moesian Terrane, among the considerable number of unconformities, a significant one is related to deep erosion between the Devonian and Carboniferous and indicates a collision between the Moesian Terrane and Baltica. The post-collisional carbonate sedimentation started in the late Tournaisian to the west and in the Visean to the east. During the Late Carboniferous and Permian the Moesian Terrane moved through the equatorial and northern arid zone together with Laurussia.

The Balkan Terrane is characterized by the presence of Pan-African oceanic lithosphere and arc-type magmatism in the Latest Neoproterozoic and early Cambrian. These Pan-African affinities of the basement imply that the Balkan Terrane originated from Gondwana. Within the Middle and Late Ordovician sedimentary sequence there are reliable palaeogeographic indicators such as diamictites and benthic faunas (trilobites and brachiopods of clear North African affinities), suggesting a higher latitude, cool zone characteristic of the Armorican Terrane Assemblage. The lack of deformatiom, magmatism and metamorphism related to the Caledonian orogeny in the Late Ordovician and Late Silurian makes unlikely that the Balkan Terrane was a part of Avalonia. The occurrence of Upper Carboniferous continental deposits and magmatic rocks of collisional type can be related to a collisiont between the Moesian and Balkan Terranes during the Variscan orogeny.

It is likely to assume that the Balkan Terrane shared the same stratigraphic, palaeogeographic and paleoclimatic features as the Armorican Terrane Assemblage including the Bohemian, Saxo-Thuriangian and Iberian Zones in Europe.

The correlations that we recently made have shown a striking similarity in the sedimentary development from Ordovician to Carboniferous between the Balkan Terrane and the Istanbul Terrane in Turkey. This is in contrast with most reconstructions regarding the Istanbul Terrane together with the Moesian Terrane as an eastern prolongation of Avalonia (Kalvoda, 2001; von Raumer *et al*., 2003).

5. Conclusions

This review of recent stratigraphical, biogeographical, palaeoclimatical and palaeomagnerical data is a firm basis for paleogeographical and geodynamic interpretations. They should be combined with geophysical data for the subsurface of the Moesian Terrane, as well as a more complete and detailed biostratigraphical and biogeographical dataset on the whole Palaeozic sequence in Romania and Bulgaria.

The existing data and their palaeogeographical interpretation could not answer univocally the question of the affinities of the Moesian Terrane. However, in the Early Devonian the Moesian Terrane was situated at higher latitude close to the Armorican and Avalonian Terrane Assemblages. Following a progressive northward migration during the Middle and Late Devonian, the Moesian Terrane approximated and collided to Baltica before the late Tournaisian.

The Balkan Terrane is of clear Gondwanan origin and could be assigned to the Armorican Terrane Assemblages during its whole Palaeozoic evolution. The accretion of the Balkan Terrane to Moesia-Baltica occurred during the Late Carboniferous and Permian. Since the late Carboniferous both the Moesian and Balkan Terranes were situated within the equatorial zone and had the same depositional history in the Permian.

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