

OVERVIEW OF THE CONTINENTAL PERMIAN DEPOSITS OF BULGARIA AND ROMANIA

SLAVCHO YANEV¹, MIHAI POPA², ANTONETA SEGHEDI³ AND GHEORGHE OAIE⁴

Key words – Permian; stratigraphy; tectonic evolution; correlation; Bulgaria; Romania.

Abstract – Continental Permian deposits show widespread development within the territories of Bulgaria and Romania. The Prebalkan Unit of Bulgaria can be correlated with the Danubian Unit of Romania, while the Balkan and Srednogorie Units may correspond to the Getic Nappe of Romania. This paper presents a short lateral and temporal overview of the lithostratigraphy and sedimentology of the Permian continental sedimentation in the Balkan Mountains, Moesia, Kraishte, the South Carpathians and Apuseni Mountains. Many characteristics were inherited from the Late Paleozoic paleogeography. A Variscan Balkan – Carpathian system coincides with the Variscan orogenic chain and with the adjacent lowlands. In all domains of the Balkan area, the Permian System can be divided into two well-differentiated sedimentary groups (cycles), separated by a clear unconformity. Many similarities with the Romanian territory are established. In both countries, the Lower Permian in particular shows mostly molasse features. Terrigenous, volcanic, volcanoclastic and locally evaporitic sediments accumulated in various depositional systems, such as fluvial, alluvial-plain to palustrine, lacustrine, proluvial, playal, colluvial and sabkha facies.

Parole chiave – Permiano; stratigrafia; evoluzione tettonica; correlazione; Bulgaria; Romania.

Riassunto – I depositi continentali permiani mostrano un esteso sviluppo nei territori della Bulgaria e della Romania. L'unità pre-Balcanica della Bulgaria può essere correlata con l'unità Danubiana della Romania, mentre le unità dei Balcani e di Srednogorie possono corrispondere alla falda Getica della Romania. Questo lavoro presenta un breve panorama spaziale e temporale della litostratigrafia e sedimentologia relative alla sedimentazione continentale permiana nei Monti Balcani, in Moesia, in Kraishte, nei Carpazi meridionali e nei Monti Apuseni. Molte caratteristiche furono ereditate dalla paleogeografia tardo-paleozoica. Un sistema balcano-carpatico varisico coincide con la catena orogenica varisica e con le basse terre limitrofe. In tutti i domini dell'area balcanica, il Permiano può essere suddiviso in due ben differenziati gruppi sedimentari (cicli), separati da una chiara discontinuità stratigrafica. Sono precise molte somiglianze col territorio romeno. In entrambi i paesi, in particolare il Permiano inferiore mostra soprattutto aspetti molassici. Sedimenti terrigeni, vulcanici, vulcanoclastici e localmente evaporitici si accumularono in vari sistemi deposizionali, come facies fluviali, di piana alluvionale, palustri, lacustri, proluviali, di playa, colluviali e di sabkha.

INTRODUCTION

This paper presents a short overview of the Permian continental sedimentation in the Balkan Mountains, Moesia, Kraishte, the South Carpathians and Apuseni Mountains. The continental Permian deposits show widespread development in the study area – the present day territories of Bulgaria and Romania.

OCCURRENCE OF PERMIAN DEPOSITS IN BULGARIA AND ROMANIA

In Bulgaria, the Permian deposits occur mainly in five of

the present-day morphotectonic units (from north to south): the Moesia, Prebalkan, Balkan, Sredna Gora and Kraishte units (Fig. 1). In Romania, Permian deposits are recorded in the South Carpathians (with Getic and Danubian units), the Apuseni Mountains (with Bihor Autochthonous and Codru Nappe systems), North Dobrogea, and the Moesian and Scythian Platforms (Fig. 1). Sedimentation took place in several basins – Resita (Getic Nappe), Sirinia and Presacina (Danubian Units) in the South Carpathians, Codru-Bihor Basin in the Apuseni Mountains, Carapelit Basin in North Dobrogea, the Scythian Basin (with Aluat and Lower Danube sub-basins) and the Moesian Basin within the Carpathian foreland.

Surrounded by the Carpathians and the Balkans, the

¹ Geological Institute of the Bulgarian Academy of Sciences, "Acad. G. Bonchev" Str., Bl. 24, 1113 Sofia, Bulgaria.

² University of Bucharest, Faculty of Geology and Geophysics, Laboratory of Palaeontology, 1, N. Balcescu Ave., 70111, Bucharest, Romania.

³ Institute for Geology and Geophysics, 1, Caransebes Str., 79678, Bucharest, Romania.

⁴ Institute of Marine Geology and Geocology, 23-25, D. Onciu Str., 70318, Bucharest, Romania.

Moesian Platform extends over both Romania and Bulgaria (Figs 2, 3). The variations of Permian sedimentation in the Bulgarian part of the Moesian Platform can be distinguished, based on borehole data (Yanев, 1992, 1993a) from the following areas: Vidin-Rasovo (west), Pleven-Tarnovo-Targovishte (centre), Mirovo-Komunari (southeast) and South Dobrogea (northeast).

The Prebalkan Unit of Bulgaria can be correlated with the Danubian Unit of Romania, while the Balkan and Srednogorie Units may correspond to the Getic Nappe of Romania (Figs 2, 3). During the Permian, the Prebalkan Unit represented the former foredeep of the Variscan or-

ogen. In the best exposed, western part of Bulgaria, this unit comprises the localities of Vrashka chuka, Belogradchik, Smolyanovtsi and Vratsa (Tenchov & Yanев, 1963; Yanев & Tenchov, 1978).

The Balkan and Sredna Gora Units coincide with the position of the Variscan orogenic belt, crossing the Balkan Peninsula from WNW to ESE (Figs 2, 3). Within these units occur intramontane basins separated by grabens and half-grabens. They are confined to several diagonally extended, tectonically bounded belts. Within the northern belt (from northwest to southeast) the following localities occur: Stakevtsi, Prevala, Melyane, Draganitsa-Lyu-

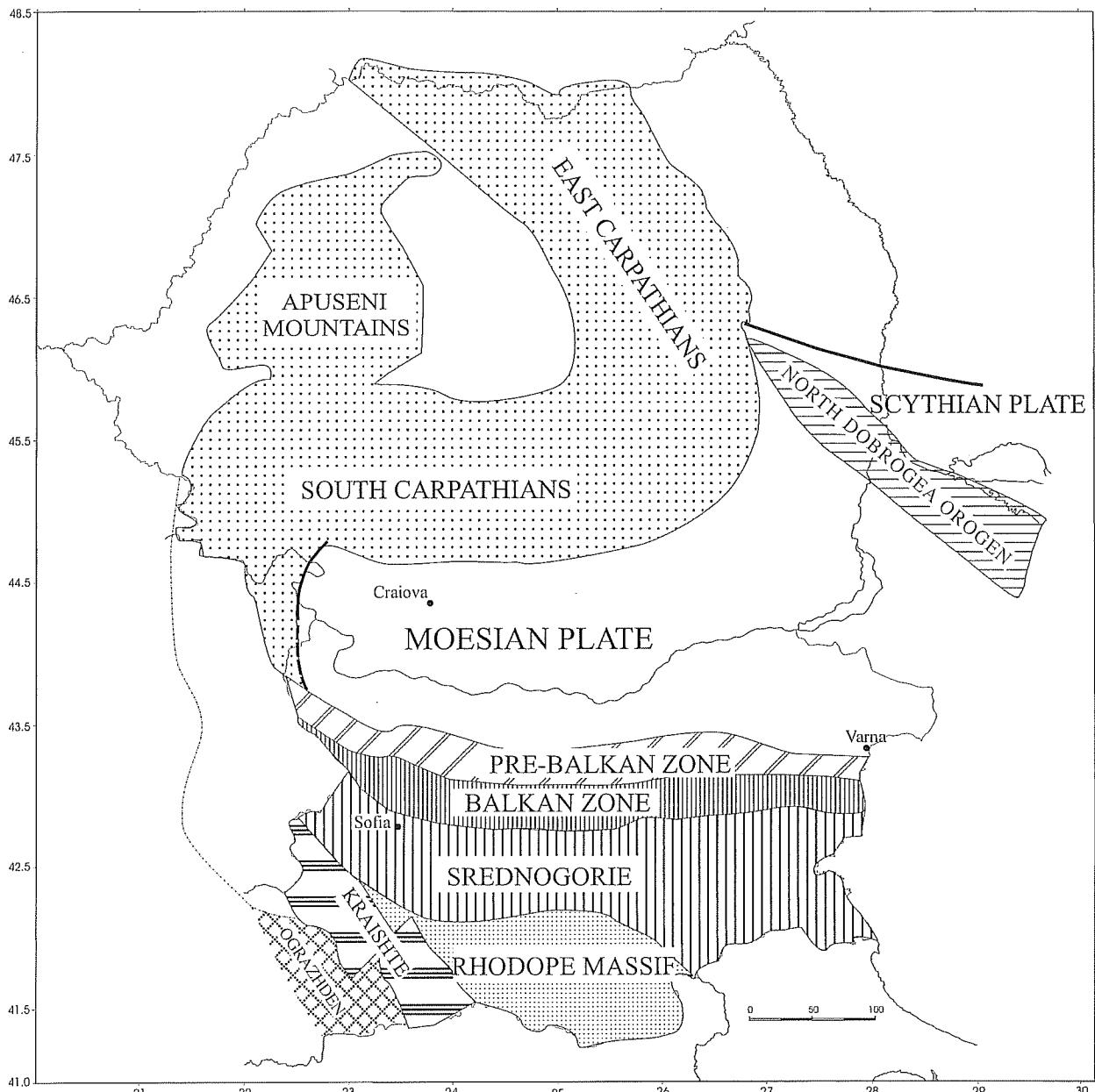


Fig. 1 – Main structural units for Bulgaria and Romania.

tadzhik, Zverino-Ignatitsa, Teteven, Troyan Mountain, and Sliven (Spassov & Zafirov, 1961; Yanev & Tenchov, 1962, 1972, 1978; Chatalov *et al.*, 1962, 1963; Zhukov *et al.*, 1971). The peaks of Midzhur-Kopren, Godech-Buchino Pass, Svoge, and the Sveti Iliya Hills mark the middle

zone (Tchumacenko & Shopov, 1965; Yanev, 1981, 1982 a; Chatalov, 1985). The next belt includes localities in Sofioter Stara Planina Mountain, Bunovo area, Lozenska Mountain area, and Chernogorovo (Kulaksazov *et al.*, 1966; Kozhukharov *et al.*, 1980; Yanev, 1982 a).

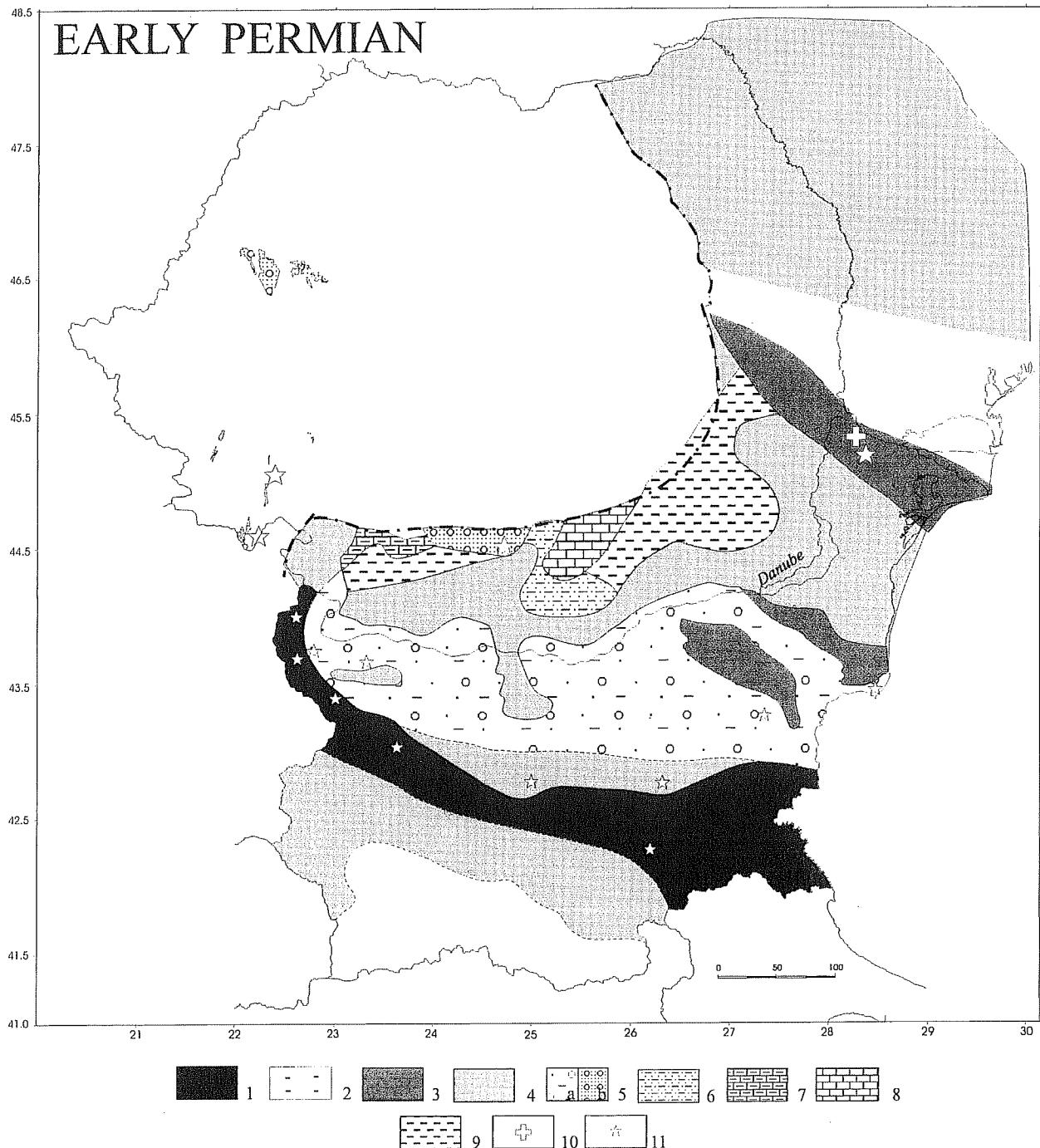


Fig. 2 – Scheme for the main palaeogeographic zones during the Early Permian and their dominating lithology. 1 to 5: Zones of continental sedimentation. 1 - high relief, deposition in intramountain basins of conglomerates, breccia-conglomerates, sandstones and siltstones or non-deposition. 2 - coal bearing deposits in the intramountain basins; 3 - moderate relief, deposition in grabens and half-grabens of conglomerates, sandstones, siltstones, mudstones; 4 - low relief with deposition of more fine grained clastics (mainly sediment by-pass); 5 - low-land with isolated basins: a - with variegated lithology; b - mainly conglomerate and sandstone - bearing; 6 - deltaic, coastal and shallow marine clastics; 7 - shallow marine carbonates and shales; 8 - marine carbonates; 9 - marine shales; 10 - batholiths; 11 - volcanics.

Permian deposits in the Bulgarian Kraishte Unit (in the opinion of S.Y.) may be compared partly with the Romanian Apuseni Mountains. The main difference is the lack of intensive volcanism in the Kraishte area. Present Lower Permian outcrops in the Kraishte are confined on-

ly to the Boboshevo-Vukovo area (Yanев, 1982 b), but the earliest distribution of the Upper Permian sediments was larger since their relicts are well exposed between Tran, Noevtsi, Batanovtsi, Boboshevo, Stanke Lisichkovo, Padesh and other villages (Yanев, 1979) (Figs 2, 3).

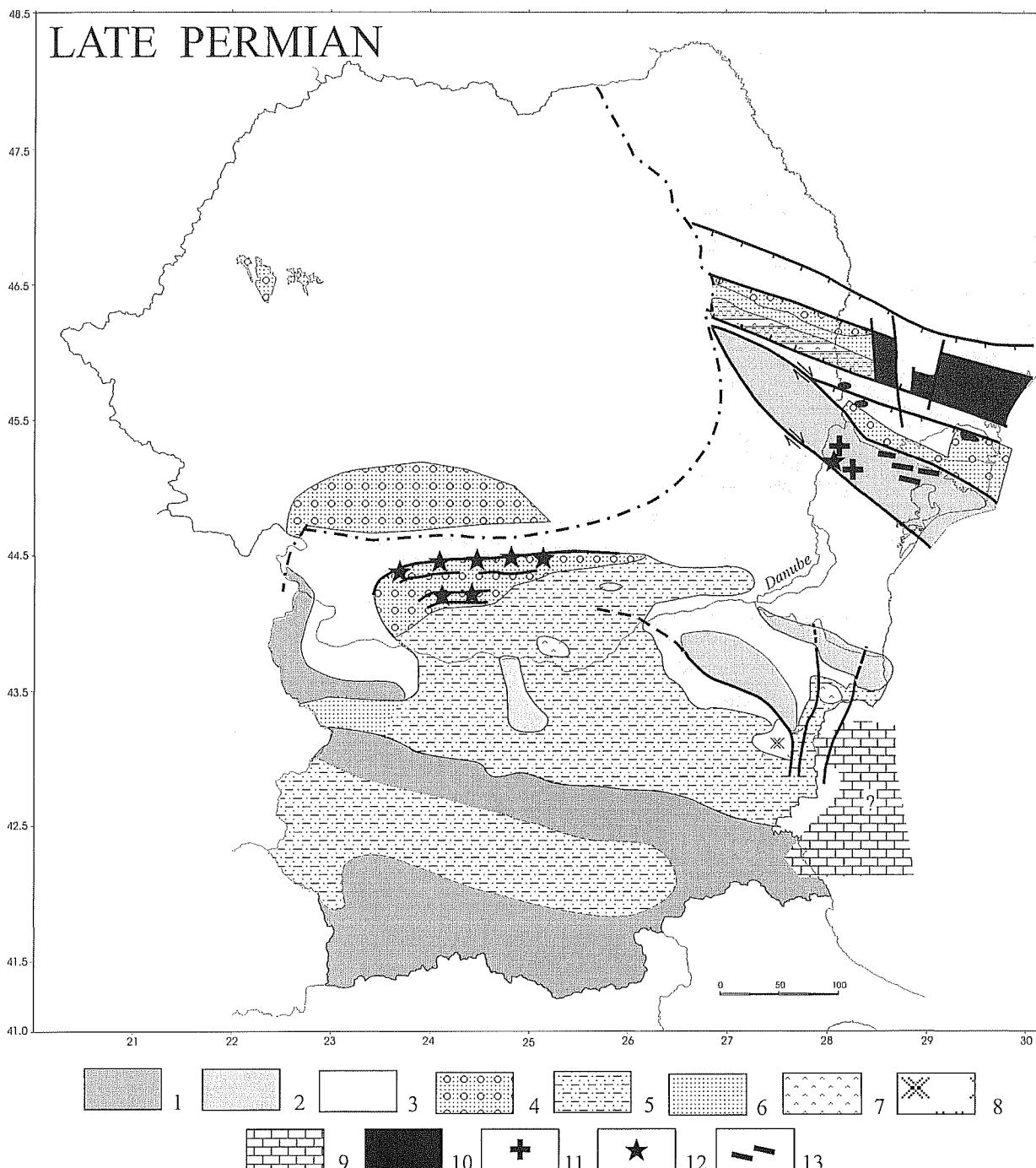


Fig. 3 – Scheme for the main palaeogeographic zones during the Late Permian and dominating their lithology. 1-3: Zones without Late Permian sedimentation - generally sediment by-pass terranes. 1 - with moderate to relatively high relief; 2 - with moderate relief; 3 - with low relief; 4 - continental coarse sedimentation of conglomerates, sandstones, mudstones (proluvial fan, alluvial fan and other facies); 5 - continental basins sedimentation (generally poorly graded red beds: mudstones, sandstones, siltstones, etc.); 6 - deltaic sediments, related with the continental basin delta - mainly sandstones; 7-8 - zones of evaporite sedimentation: 7- sulphate-bearing deposits; 8 - halite-bearing sabkha deposits; 9 - zone of supposed marine carbonate sedimentation; 10 - plateau basalts; 11 - batholiths; 12 - volcanics; 13 - dyke systems.

Permian deposits are lacking in the Rhodope Unit and the Serbo-Macedonian ("Dardan") Massif and so cannot be correlated with any Romanian units.

LITHOSTRATIGRAPHY AND STRATIGRAPHIC CORRELATION OF THE PERMIAN DEPOSITS IN ROMANIA AND BULGARIA

In all domains of the Balkan area, the Permian System can be divided into two well-differentiated sedimentary groups (cycles), separated by a marked unconformity (Yanev, 1981).

From the above general palaeogeographical schemes

(Figs 2, 3) and the following Bulgarian stratigraphical successions (Figs 4, 5 and 6), some correlations could be suggested. The NW Balkan prolongation of the Variscan belt is recognised through the western part of the South Carpathians (Banat area). Here, low-scale unconformities occur at the "Stephanian"/Lower Permian ("Autunian") boundary (Secu area), while sedimentary gaps are recorded between the upper "Westphalian" - "Stephanian" sequences (as in the West Balkan domain). The Permian successions are unconformably overlain by Lower Jurassic deposits.

In both the Getic and Danubian Units, only Lower Permian deposits are known. The succession begins with black shaly sediments (fossiliferous, Early Permian in age

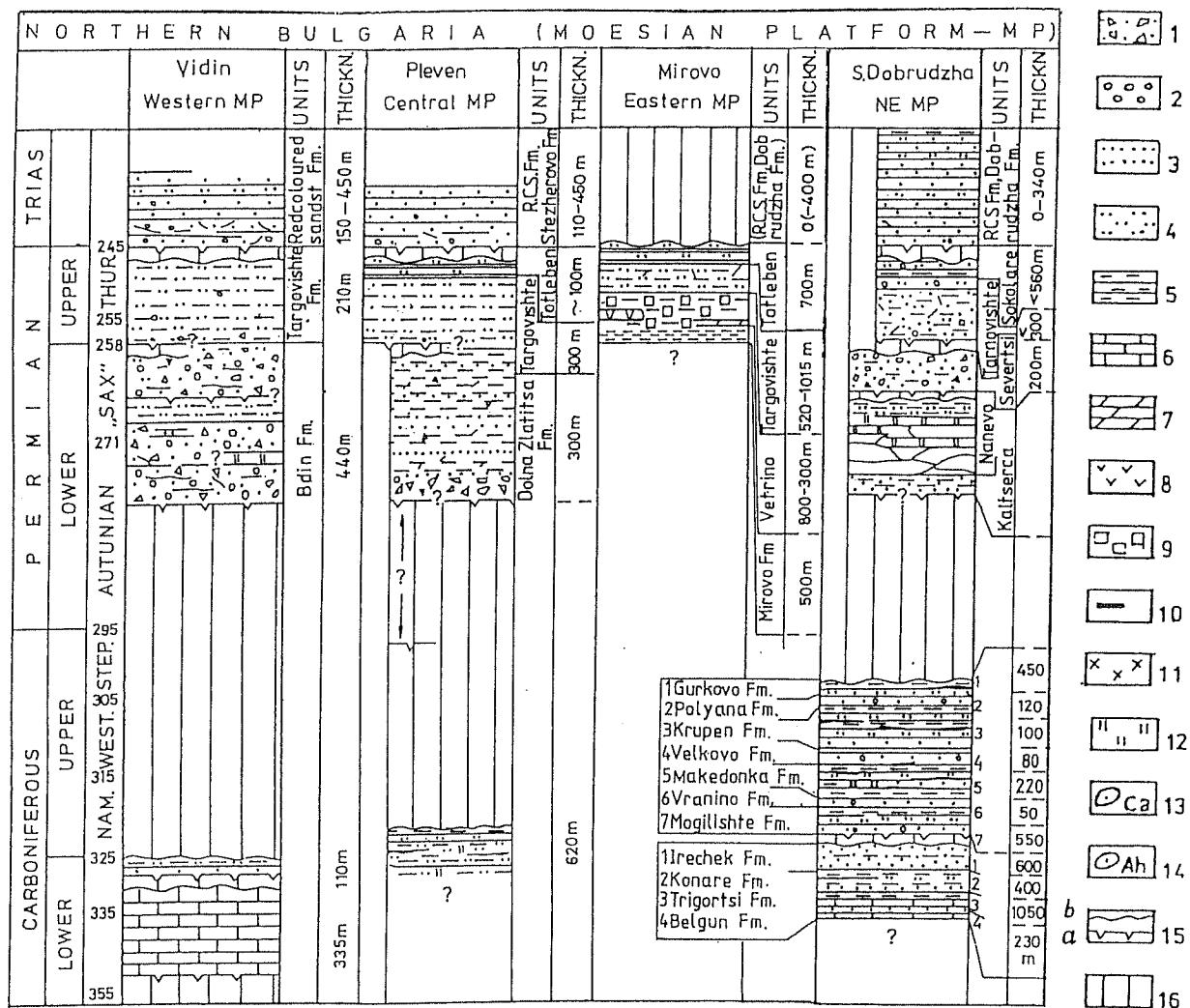


Fig. 4 – Scheme for the lithology, stratigraphic position and thicknesses of selected typical successions of the Upper Paleozoic in the boreholes from the Bulgarian part of the Moesian Plate (see Figs 2-5 in Seghedi *et al.*, this volume). The presented lithostratigraphic units are comparable with some units in the Romanian part of the Moesian Plate.

Symbols (for Figs 4, 5 and 6): 1 - breccia; 2 - conglomerate; 3 - sandstone; 4 - siltstone; 5 - shale; 6 - limestone; 7 - dolomite; 8 - anhydrite; 9 - halite; 10 - coal; 11 - volcanics; 12 - volcaniclastics; 13 - carbonate concretions; 14 - anhydrite concretions; 15a - unconformity; 15b - erosional surface; 16 - stratigraphic gaps.

with Autunian type flora), conformably overlain by red beds and volcaniclastic facies, at least late Early Permian (late "Autunian") in age (Raileanu, 1953; Nastaseanu, 1975, 1987; Nastaseanu *et al.*, 1973; Stan, 1987; Stanoiu & Stan, 1986). So far, no paleontological evidence from the red beds of the upper part of the Lower Permian ("Saxonian - Thuringian" age) has been recorded (Antonescu, 1980; Antonescu & Nastaseanu, 1976).

These basins can be correlated with their Bulgarian counterparts. Along the Danube, in the Svinita zone, the Lower Permian Ieliseva Formation can be correlated with the Zelenograd Formation ("Autunian"; Yanev & Tenchov, 1972) and both the Vrantska Formation and the lower two members of the Smolyanovtsi Formation (Variscan orogen zone, Lower Permian; Yanev, 1981). The volcaniclastic sequences of the Sirinia Basin exposed along the Romanian tributaries of the Danube (*e.g.* Staristea Valley) are similar to part of the Vrantska Formation near the Vrashka Chuka Hill, the town of Belogradchik and the village of Ozirovo, to the Gyurgich Member of the Smolyanovtsi Formation, and especially to volcanicogenic units in the Central Balkan Mountains (Zhukov *et al.*, 1971, 1976; Yanev, 1981, 1982 a).

The Permian sequences of the Resita Basin (Getic

Nappe) can be correlated with their Bulgarian counterparts in the following way: the Ciudanovita Formation, mainly the basal Girliste Member (lowest Lower Permian - lower "Autunian", mainly black pelites) is similar to the Levitsa Formation (cropping out around Stakevtsi and Prevala), the Dalgi Del Formation (cropping out near Melyane village), the Lyutadzhik Formation cropping out in the Ozirovo-Lyutadzhik areas) and the Buk Formation (cropping out in the Zverino-Ignatitsa areas). The topmost member of the Ciudanovita Formation, the Lisava Member (at least the upper part of the Lower Permian - upper "Autunian"), in red-bed facies, is rather similar to some sequences of the Milinska Formation (Tchumacenko & Shopov, 1965) and the Koritarska Member of the Smolyanovtsi Formation (Yanев, 1981). For the Upper Carboniferous sequences in Resita Basin (Resita Formation), the similarity points to the Starchovdol Formation (Stakevtsi area), the Melyane Formation (near the village of Melyane), the Ekimska and Draganitsa formations (Draganitsa-Ozirovo-Byala Rechka areas) or the Ochindol Formation (Zverino and Ignatitsa areas).

The Permian of the Codru-Bihor Basin conformably overlies the Upper Carboniferous deposits, or unconformably covers various older basement rocks. The Per-

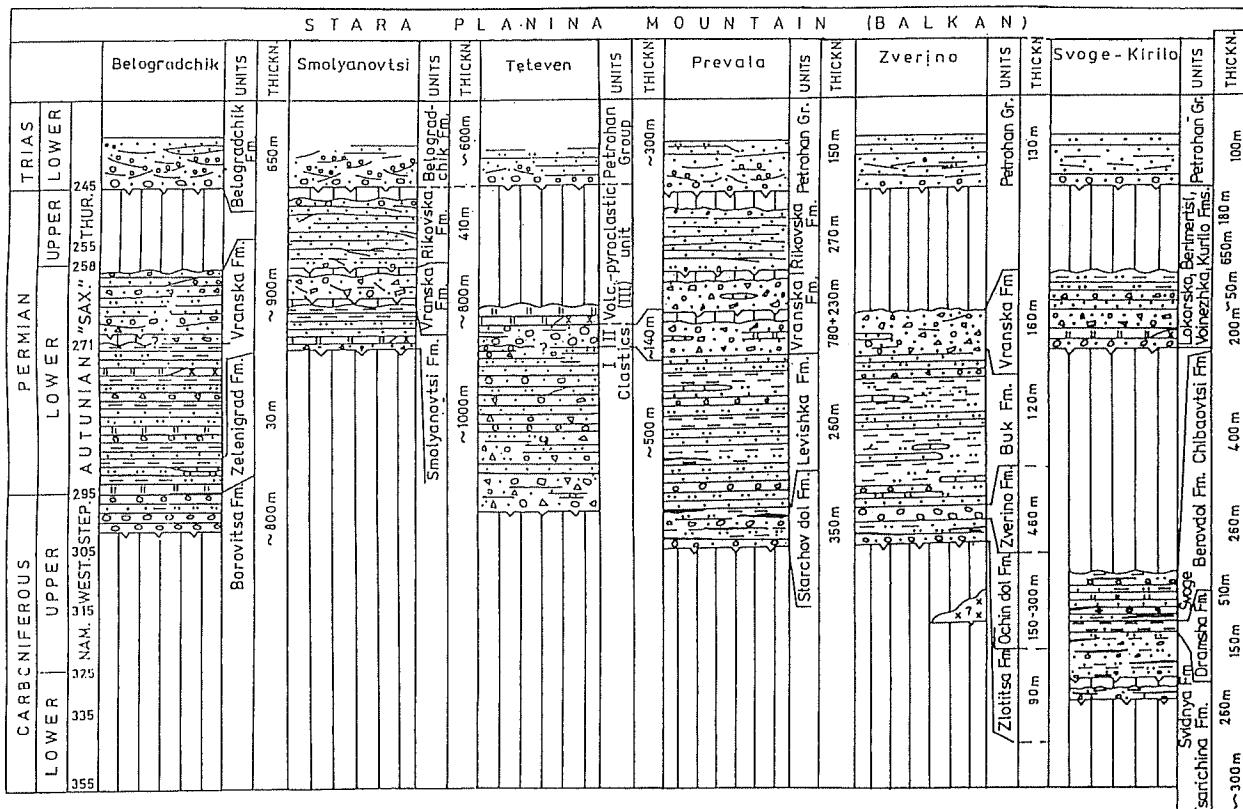


Fig. 5 – Scheme for the lithology, stratigraphic position and thicknesses of selected typical successions of the Upper Paleozoic related to the Variscan Orogen (Stara Planina Mountain System in Bulgaria). The presented lithostratigraphic units are compared with some units mentioned in the text for the Romanian part of the Variscan Orogen (Carpathian Mountain System) (symbols as in Fig. 4).

mian red-beds grade upwards (?) to Lower Triassic (Buntsandstein) quartzitic sandstones (Bleahu, 1963; Bleahu *et al.*, 1985; Bordea & Bordea, 1982; Mantea, 1985). The sequences can be correlated to the Permian from the southern basins in Bulgaria (the area south of the Balkan Mountains, including Kraishte and present-day Sredna Gora Units). The Lower Permian in this domain also conformably overlies upper "Stephanian" sediments or unconformably covers older basement rocks. The Upper Permian red-bed clastic and silty-shaly deposits are separated from the Lower Permian sediments by an erosional surface, or they lie unconformably on various older metamorphic, igneous or sedimentary rocks. In the Kraishte area a narrow unconformity between the Upper Permian and Triassic sediments is recorded (Yanev, 1964).

Facial similarities between the red beds of the Aries Valley (close to Arieseni) and their Bulgarian counterparts

are the following: the upper part of the Gabra Formation - upper "Stephanian" to Lower Permian in age (transition between the "Autunian" and "Rotliegend" facies; Kozhukharov *et al.*, 1980), the Tarnavská Formation (Lower Permian) and the Ravulya Formation (Upper Permian) in Lozenska Mountain, the Boboshevo Formation (Lower Permian), in the Vukovo area (Yanev, 1982 b), the Skrino Formation (Zagorchev, 1980), or the Noevtsi, Kislichka and Nepraznentsi formations (Upper Permian or (?) Upper "Rotliegendes" in Yanev, 1979).

The age and lithology of the Permian deposits from the northern part of the Moesian Platform (Romania) generally corresponds to those on the southern, Bulgarian part (Yanev, 1992, 1993 a). This is caused by the mirrored positions of both zones - in the foreland of the Variscan chain, relatively close to the Balkan part southwards and to the Carpathian part, northwards. The distribution of the coarse, proximal facies in the northern and southern areas of the "Platform" suggests tectonically controlled deposition, related to E-W to NW-SE trending extensional faults. A second control on Permian sedimentation was the active subaerial volcanism, which according to Bulgarian authors was developed only in the Early Permian (lower part of the Rotliegend facies). In the Romanian part of the Moesian Platform, bimodal volcanism continued during the Triassic, as indicated by boreholes.

For Bulgaria during Late Paleozoic times, two main cycles of continental sedimentation can be again envisaged in the whole eastern part of the Balkan Peninsula. The first group (generally spanning Late Carbonifer-

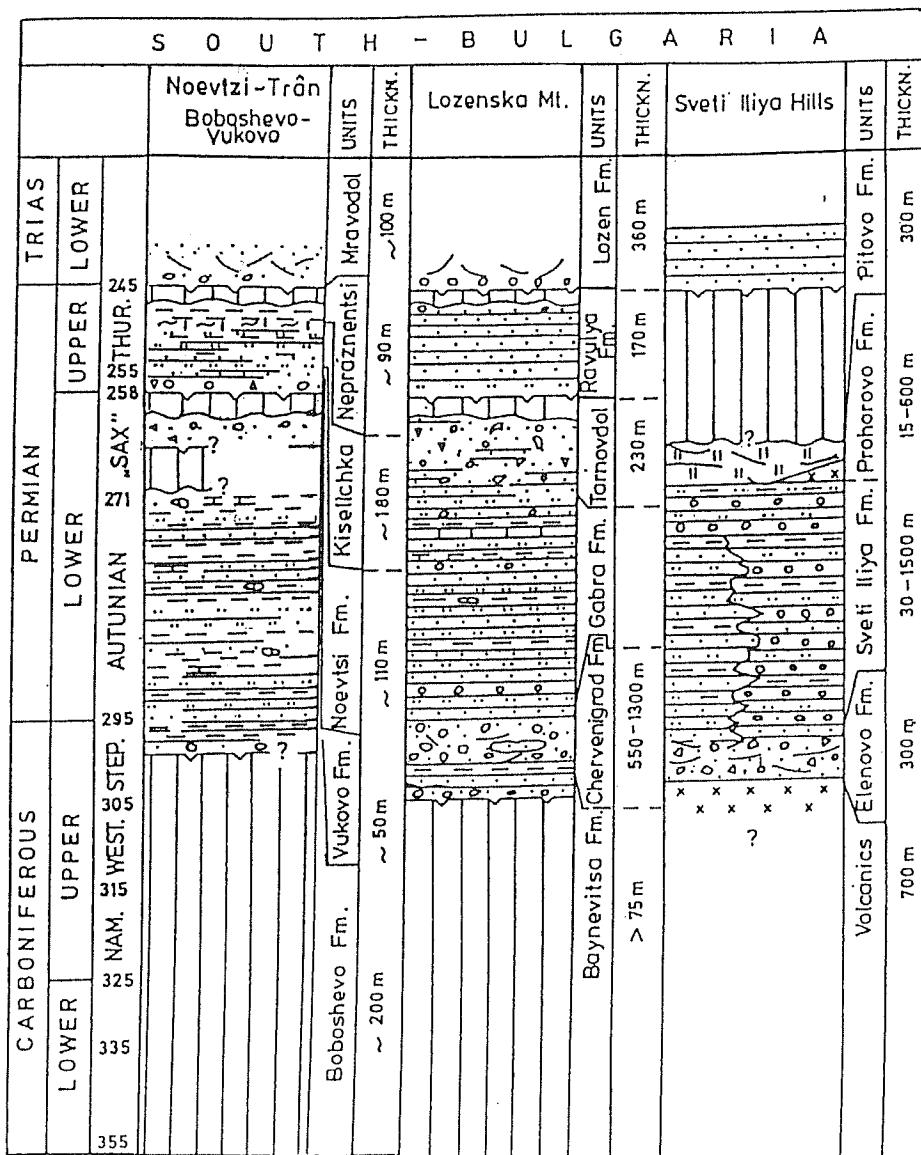


Fig. 6 - Scheme for the lithology, stratigraphic position and thicknesses of selected typical successions of the Upper Paleozoic in South Bulgaria (for symbols see Fig. 4)

ous, mainly late Stephanian to Early Permian times) consists of lacustrine, fluvial and proluvial fan deposits, as well as of volcanic rocks, both infilling intermontane and foremontane grabens or semigrabens (Yanev, 1969, 1988, 1989). The basins were separated by highs of Lower Paleozoic, metamorphic and igneous basement rocks. The boundary faults generally have WNW-ESE trends and often coincide with long-lived tectonic structures reactivated as late as the Alpine orogeny.

The second group (Late Permian, from the Tatarian (?) to the P/T boundary after data from Schirmer, 1960 and Yanev, 1993 a) is represented by deltaic and continental clastics and, only in the southeastern part of the Moesian domain (in the Provadia depression), by halite evaporites, as well as by sulphate evaporites in a zone north of the town of Varna (Yanev, 1993 a). These deposits form a widespread blanket, covering both basins of the first group and the surrounding highs of western Bulgaria (Moesian Platform). The continuity of tectonic control is documented by strong thickness variations - from a few metres (or total absence in many localities of the former Variscan Orogen, such as over the NE-Bulgarian Uplift) to more than 1200 m in the depocentres and in areas with evaporite sedimentation (former foremontane depression).

SEDIMENTOLOGY, FACIES AND SOME PALEOGEOGRAPHICAL ASPECTS OF THE PERMIAN DEPOSITS OF BULGARIA AND ROMANIA

Permian deposits in both Romania and Bulgaria generally show molasse features, mainly and more typically for the Lower Permian in the Balkan, the Prebalkan, the Sredna Gora, the Kraishte, the South Carpathians, the Apuseni Mountains and the Carapelit Basin. In the Moesian and Scythian Platforms, as well as in the Kraishte area, the molassic character, especially of the Upper Permian sediments, is not so obvious, since both continental-basins and partly transitional facies occur. The Permian sequences from the present-day Alpine fold-belts show clear Variscan molasse features. This evidence is related to sedimentation in relatively narrow, deeper intramontane basins and half-grabens within a folded terrain with steep relief. Those sequences from the Moesian and Scythian Platforms are fault-related, since deposition occurred in shallower, sometimes larger grabens and half-grabens inside a hilly terrain.

Terrigenous, volcanic, volcaniclastic, and locally evaporitic sediments accumulated in various continental environments: from fluvial, proluvial, playa, colluvial and alluvial-plain to palustrine, lacustrine, continental-basin and sabkha conditions (Yanev, 1970, 1989).

For Bulgaria, the chain of the Variscan Orogen extended NW-SE across Bulgaria, bordered by lowlands both to

the north and the south. In intramontane valleys within the orogen, as well as to its borders were deposited clastic, shaly and coal-bearing sediments in river-beds, terrace, lacustrine, palustrine and other facies (Yanev, 1969, 1989). They follow from proluvial cones and playa sediments during the late Early Permian (two clastic successions separated by erosional surfaces, and as facies corresponding to the early Rotliegend and late Rotliegend). During the Late Permian, two larger continental basins formed to the north and the south, controlled by a lower-altitude main watershed (Yanev, 1981).

For Romania, the molassic character is well defined in intramontane basins in the South Carpathians (Resita, Sirinia and Presacina basins) and in the Apuseni Mountains. The molassic sedimentation was controlled by alluvial, fluvial, lacustrine, and swampy (with no significant coal seams as a result) depositional environments, to which volcanic and volcaniclastic material was added. For the South Carpathians, the ratio of clastic vs. volcaniclastic sedimentation is high in the Resita Basin and low in the Sirinia and Presacina basins, where volcanic and volcaniclastic rocks predominate.

In the Apuseni Mountains, terrigenous and volcaniclastic sedimentation occurs as well, the dominance of one sedimentological type over the other depending on area. The Permian deposits conformably overlie Upper Carboniferous deposits, the terrigenous facies often presenting typical red-bed features. The terrigenous vs. volcaniclastic sedimentation continued until the Triassic, the Permian/Triassic boundary being difficult to establish within the red-bed facies.

TECTONIC EVOLUTION OF THE PRE-LATE PALEOZOIC TERRANES DURING THE PERMIAN

The various regional, lithological, paleoclimatic, paleomagnetic, paleobiogeographical and other data show a peri-Gondwana provenance for the basement of the Upper Paleozoic successions in Bulgaria (Yanev, 1997 and cited references). Three Lower Paleozoic terranes (from north to south): Moesian, Balkan and Thracian are distinguished (Yanev, 1990, 1993 b, 1997). At the start of the Late Carboniferous, the *en echelon* movement from Gondwana to Paleo-Europa brought the Moesian and Balkan (+ Thracian?) terranes into collision. The building of the Variscan Orogen was related to the collisional accretion between both Moesian and Balkan terranes. The development of the Late Carboniferous and Permian molasse sedimentation took place in late-orogenic and post-orogenic conditions. During the Late Permian, the formerly variable relief decreased in energy and deposition was controlled particularly by transtensional movements. As a whole, the Perm-

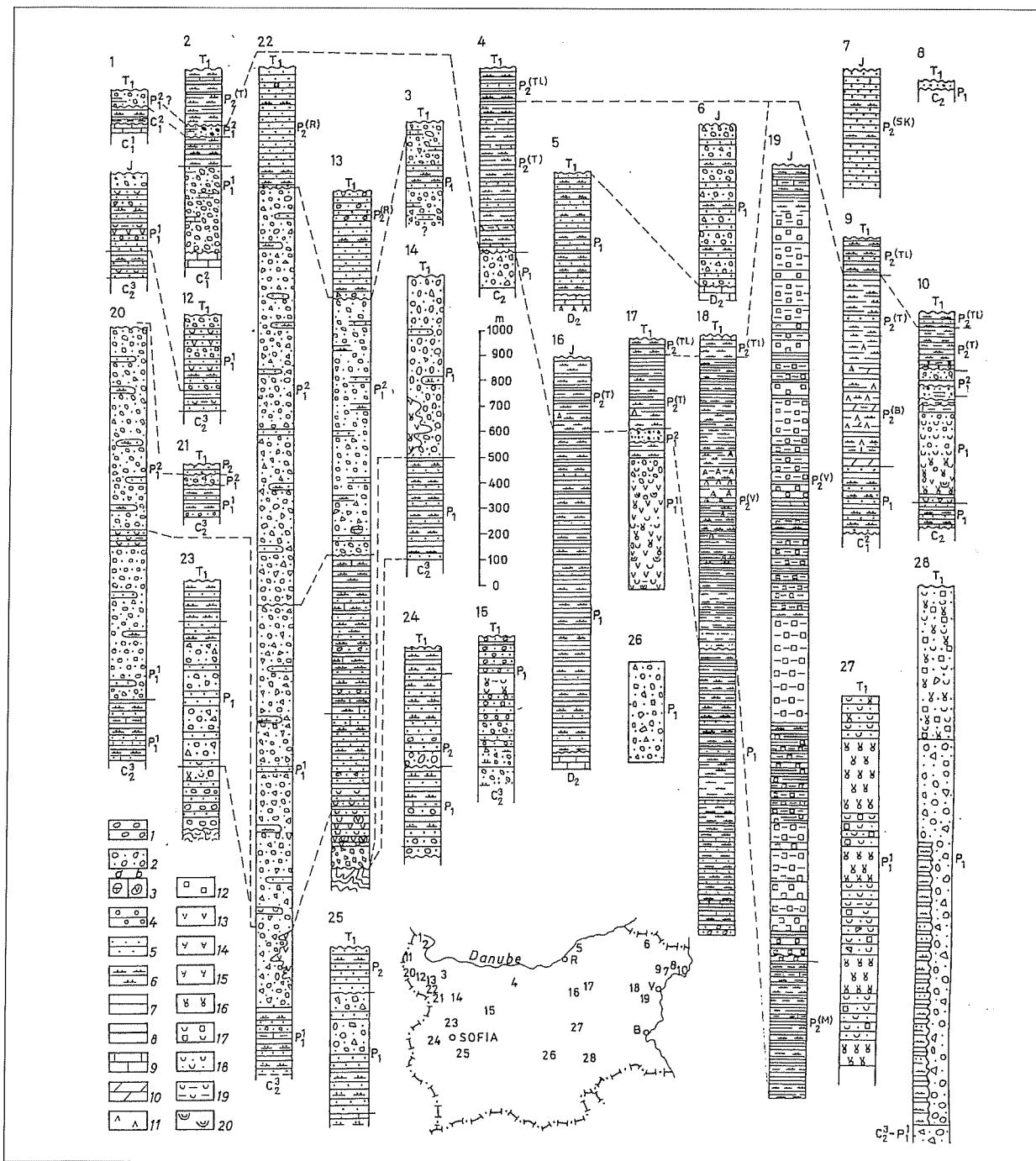


Fig. 7 – Schematic logs of some typical Permian successions in Bulgaria (based on outcrops and borehole data) presented with their comparable real thicknesses.

Lithological symbols: 1 - conglomerate; 2 - breccia; 3 - concretions: a - limey, b - anhydritic; 4 - gravelite; 5 - sandstone; 6 - siltstone; 7 - argillite; 8 - coal; 9 - argillaceous limestone; 10 - dolomite; 11 - anhydrite; 12 - halite (salt); 13 - andesite; 14 - trachyte; 15 - latite; 16 - dacite; 17 - xenotuffs; 18 - tuffs; 19 - tuffites; 20 - ignimbrites.

Stratigraphic symbols: D₂ - Upper Devonian; C₁ - Lower Carboniferous; C₁¹ - Lower Carboniferous, Tourniasian; C₁² - Lower Carboniferous, Visean; C₂ - Upper Carboniferous; C₂¹ - Upper Stephanian; P₁ - Lower Permian (Rotliegend); P₁¹ - Lower Rotliegend; P₁² - Upper Rotliegend; P₂^(TU) - Upper Permian, Targovishte Fm.; P₂^(R) - Upper Permian, Tottleben Fm.; P₂^(R) - Upper Permian, Rikovska Fm.; P₂^(V) - Upper Permian, Vetrino Fm.; P₂^(M) - Upper Permian, Mirovo Fm.; P₂^(SK) - Upper Permian, Sokolevo Fm.; T₁ - Lower Triassic; J - Jurassic.

Sketch: distribution of sections. Localities: 1 - Gomotartsi; 2 - Vidin; 3 - Rasovo; 4 - Tottleben; 5 - Chereshovo; 6 - Severtsi; 7 - Sokolovo; 8 - Gurkovo; 9 - Bezvoditsa; 10 - Kaliakra; 11 - Kiryaev; 12 - Belogradchik; 13 - Smolyanovtsi; 14 - Ozirovo; 15 - Teteven; 16 - Dolna Zlatitsa; 17 - Vasil Levski; 18 - Vetrino; 19 - Mirovo-Hrabrovo; 20 - Stakevtsi; 21 - 22 - Prevala; 23 - Kurilo; 24 - Kraishte (Boboshevo-Noevtsi); 25 - Lozen Mt.; 26 - Chernogorovo; 27 - Sliven; 28 - Sakar Mt.

ian basins evolved from narrow zones (the Variscan Orogen and locally the Moesian and Kraishte lowlands) into wider depositional areas, due to lower relief and the increase of accumulation areas at the expense of source areas.

CONCLUSIONS

As parts of the Carpathian-Balkan chain, Romanian and Bulgarian territories recorded the influence of Variscan and Alpine orogenies in the same way, with almost the same

evolution, stratigraphy and depositional features. This fact is demonstrated by the possibility of correlation between the South Carpathians and the Balkans. In the Moesian Platform, shared by Romania and Bulgaria, the structure and stratigraphy could well be correlated, this prospect remaining valid for the Permian deposits presented here. At the same time, the comparison between Permian deposits from Apuseni Mountains and the Kraishte area is not so certain. Those from North Dobrogea and Bulgarian zones without Late Paleozoic sedimentation (Thracian and Dardan massifs) are difficult to correlate.

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