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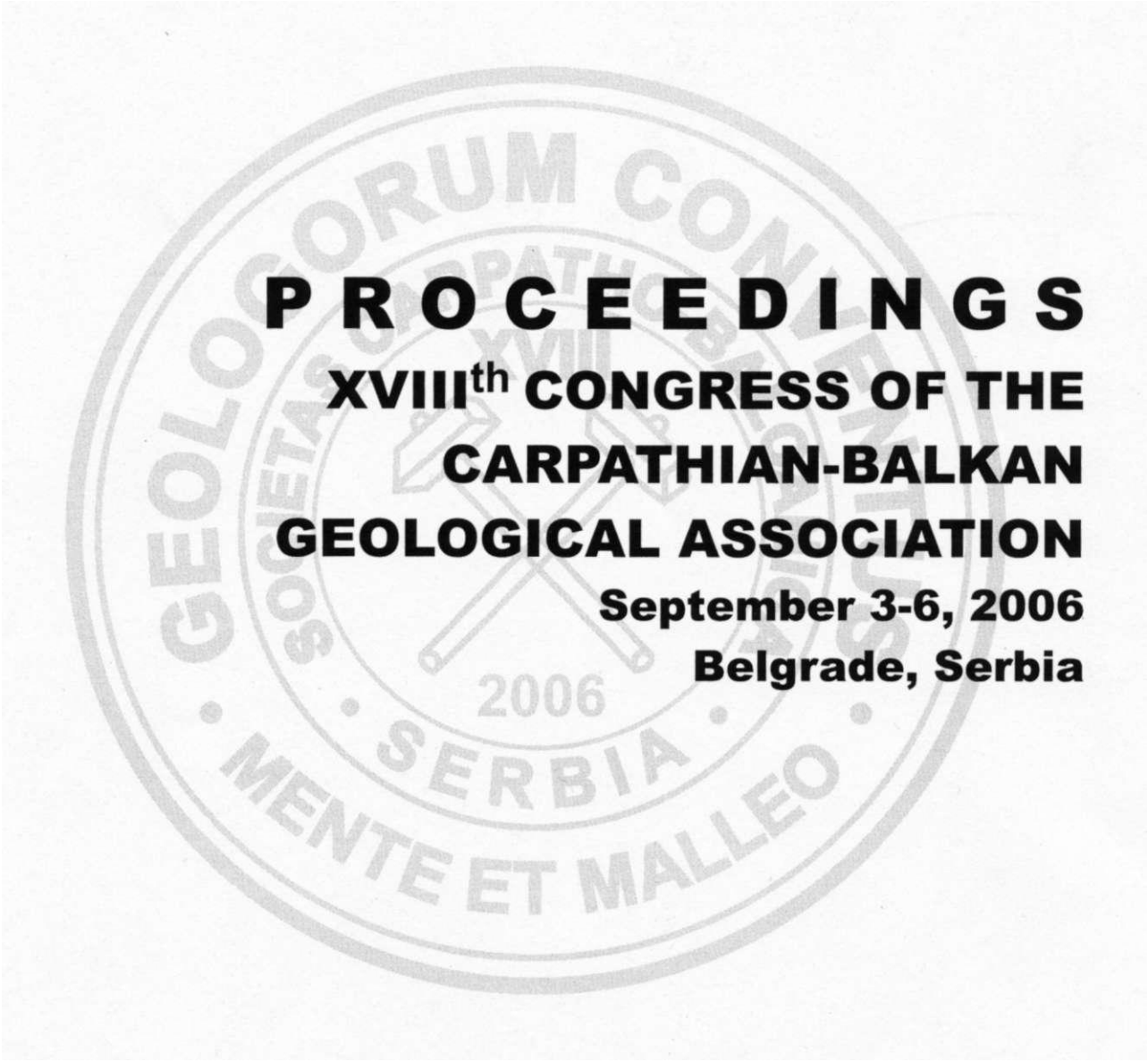

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DEVONIAN - CARBONIFEROUS PRE-FLYSCH AND FLYSCH ENVIRONMENTS IN THE CIRCUM PANNONIAN REGION

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Abstract. For unravelling the relationships of the Alpine Belts surrounding the Pannonian Basin a set of tectonostratigraphic terrane and paleogeographic maps of the Circum Pannonian Region (CPR) were prepared in a joint venture. The explanations to the map of Devonian - Lower Carboniferous pre-flysch environments also include the flysch-stage. The Devonian-Carboniferous of the CPR was attributed to oceanic domains, carbonatic/siliciclastic continental margins, intracontinental rift zones, siliciclastic flysches and post- to synorogenic sediments in foredeeps and remnant basins related to zones affected by early Carboniferous orogeny. The intensity of the Variscan orogeny is variable. Early Carboniferous Variscan orogeny with medium grade metamorphism is evident in parts of the Eastern Alps, Tisia, and the Carpatho-Balkanids. Intra-Late Carboniferous Variscan orogeny with deformation and up to low grade metamorphism is documented in the Eastern and Southern Alps, the Carpathians and Eastern Serbia. Domains with very weak or missing Variscan tectonothermal overprint are the Pelso Composite Terrane, the Jadar Block and the Bosnian Paleozoics.

Key words: Devonian, Carboniferous, Circum Pannonian Region, facies, paleogeography, Variscan orogeny.

Introduction

The Circum Pannonian Region (CPR) is made up of various tectonic units derived from different paleogeographic realms. Within IGCP No. 276 the outcropping elements of this tectonic puzzle were identified and classified in terms of terranes (PAPANICOLAOU ed., 1997). In a joint venture of CPR geoscientists geological relationships of this region were demonstrated in a set of "Tectonostratigraphic Terrane and Paleoenvironment Maps of the Circum Pannonian Area" presented at the 32nd IGC in Florence (KOVACS *et al.,* 2004). These maps show the geological evolution in four selected time slices from Devonian to Late Jurassic according to the present-day position and arrangement of the Paleozoic and Mesozoic tectonostratigraphic units and their affiliation to oceanic or continental paleogeographic domains. Our paper is an explanation to the map dedicated to the Devonian - Lower Carboniferous pre-flysch stage (EBNER *et al.,* 2004). Besides, it also includes the Carboniferous flysch stage because the Variscan flysch stage is not presented on a separate map.

The Devonian - Carboniferous sedimentary and low grade metamorphic sequences (D/C) reflect the final stage of Variscan orogenic cycle. We analysed lithostratigraphy, biostratigraphy and facies characteristics of the D/C from Alcapa, Tisia, Dacia and Dinaridic/Adriatic domains in order to show their present-day distribution, regional variations in intesity of Variscan metamorphic overprint and to give an attempt for a reconstruction of their facies/paleogeographic affiliation to particular paleogeo-graphic domain or Variscan terranes (Fig. 1).

D/C in the CPR

In the *Eastern Alps (Fig. 1:1)* fossiliferous marine carbonate/(volcano-)clastic D/C occur within the Noric Composite Terrane of the Austroalpine units. These pelagical sequences continue until the Namurian/Westfalian and are partly unconformably covered by post-Variscan continental elastics. Typical flysch sequences are missing. After the Variscan tectonothermal event in the internal Variscan zones a shallow marine, molasse-like foredeep environment began to evolve during the late Early Carboniferous in the Notsch-Veitsch zone. In the *Southern Alps (Fig. 1:2)* the facially strongly differentiated carbonate-clastic sequences lack any pyroclastics. The pelagic Early Carboniferous is followed by well established flysch sediments which are unconfomably overlain by late Moskovian shallow marine carbonate and terrestrial postorogenic sediments.

In the *Western Carpathians (Fig. 1:3)* the Variscan pre-flysch units, including also units of oceanic(?) affiliation, are incorparated within the metamorphic complexes. After the first Variscan (Early Carboniferous) tectonothermal event in the Northern Gemeric unit, flysch-like deep water sediments were deposited in a remnant basin. They are followed by neritic - littoral shallow water sediments (Upper Visean - Serpukhovian). Synorogenic (Namurian B - Westphalian B) olistostrome and flysch sediments are known form the Turnaicum Unit in the Brusnik anticline.

In the *Pelsonia (Zagorje-Bukk-Gemer) Composite Terrane (Fig. 1:4)* D/C shows comparable development like in the Eastern and Southern Alps. Devonian is dominated by carbonate sediments. Flysch sediments are known from the Uppony, Biikk and Szendro Mts. starting within the Latest Visean. In the Biikk Mts. the flysch is followed by Late Moskovian - Gzhelian shallow marine fossiliferous carbonate to siliciclastic sediments. However, an unconformity or a thermal overprint is not known here. In the *Transdanubian Range* Lower Carboniferous fossiliferous shallow marine sediments are known from Szabadbattyan. Further to the SW at *Mt. Medvenica* in NW Croatia D/C is represented by protolith sequences composed of medium to fine grained elastics, calcarenites and fossiliferous limestones of Silurian to Early Permian age originated from marine shelf and pelagic environments (RAMOVS *et a!.,* 1989, with older references; BELAK *et ah,* 1995). These sequences are intruded by diabase dykes and sills of probable Middle Triassic age, and the whole complex is later affected by a very low to low-grade metamorphism of Early Cretaceous age (122-110 Ma; BELAK *et al.,* 1995a).

The *Tisia Terrane (Fig. 1:5)* is made up of several medium-high grade metamorphic units which were indruded by huge bodies of Early Carboniferous granitoids. D/C metaclastic sequences are known from the North Apuseni Mts. in Romania and from the Slavonian Mts. in northern Croatia. The onset of deposition of continental cover in N Apuseni Mts. is within Westphalian D - Permian. In Slavonian Mts. metaclastic sequences originally represent the Late Devonian to Early Permian sedimentary cover (JAMICIC and BRKIC, 1987) on top of the pre-Variscan metamorphic complex.

From the *Eastern (Fig. 1:6)* and *Southern Carpathians (Fig. 1:7)* D/C sequences are known from Infrabuccovinian, Supragetic and Upper Danubian units. There, Devonian volcaniclastics are followed by a very thick Lower Carboniferous fossiliferous dolomite and limestone which are in turn overlain by partly rhythmitic flysch-like siliciclastics. Variscan overprint is of low grade character, the post-Variscan cover began earliest within Westphalian D.

In *Eastern Serbia (Fig. 1:8)* the very thick D/C is mainly siliciclastic, partly olistostromatic and turbiditic. Especially, in the Kucaj unit it shows a flysch type character. In the Luznica/Western Kraishte unit the Devonian is dominated by pelagic carbonate rocks followed by Late Devonian terrigenious flysch sediments including olistolithes. The Variscan metamorphism is of low grade character, the post-orogenic continental cover started within the Westphalian/Stephanian.

There are no D/C occurrences in the polymetamorphic *Serbian-Macedonian Massif (Fig. 1:9)* which was equalized under Variscan medium grade metamorphic conditions. The oldest post-Variscan continental cover belongs to the Permian.

In the *Vardar Zone (Fig. 1:10)* the low grade metamorphic volcaniclastic Veles Series includes D/C; the age of metamorphism is supposed as Middle Carboniferous - early Permian.

In the *Jadar Block (Fig. 1:11)* Middle Devonian - Visean swells with pelagic limestones are contrasted by siliciclastic flysch deposits. These are followed by continental and marine molasse sediments and thick massive limestones with fusulinids (upper Moskovian - lowermost Asselian). Neither the unconformity, nor the tectonometamorphic overprint are proven between flysch and post-flysch sequences.

Another monotonous volcaniclastic sequence including D/C is within the *Drina-Ivanjica Paleozoic (Fig. 1:12).* Siliciclastic flysch sedimentation lasted until the Late Serpukhovian to Early Bashkirian. The thermal overprint from anchi-metamorphic to low grade conditions took place during the Middle Carboniferous - ? Lower Permian. The beginning of the Alpine cycle is marked by Early Triassic continental elastics.

In the *East Bosnian Durmitor Paleozoic (Fig. 1:13)* (Praca, Lim, Tara areas) Mississippian and lowermost Bashkirian is formed by thick turbiditic siliciclastic sequences, overlain by Middle Carboniferous shallow water massive limestones and olistostromes. Only in the Javorje Mt. the lower part of the sequence contains pelagic and hemipelagic deposits that very likely are pre-flysch sediments of earlier Mississippian, and possibly, also Devonian ages.

In the *Central Bosnian Mts. (Fig. 1:14)* the Devonian to Tounaisian is represented by carbonate platform deposits rich in fossils. The topmost parts are composed of shales and sandstones intensivly influenced by rhyolitic volcanics.

In the *Sana-Una Paleozoic (Fig. 1:15)* clastic sequences with intercalations of pelagic limestones are covered by bedded conodont-bearing limestones of Early Devonian and Visean age followed by a sequence of limestones/ siltstones with Bashkirian fusulinids and brachiopods (RAMOVS *et al.,* 1989, with older references).

Therefore, in the External Dinarides a Variscan deformation and metamorphism can be hardly recognized. The post Carboniferous cover began within the Middle/Late Permian.

Restoration of Devonian - Carboniferous facies in the CPR

Vast areas of Alcapa (Eastern Alps, Western Carpathians), Tisia and Dacia (Eastern and Southern Carpathians, Serbian-Macedonian Massif) are composed of medium - high grade metamorphics which are intruded pervasively by syn- to postorogenic I- or S-type granitoids. The major metamorphic event was Variscan. However, pre-Variscan elements and additonal Alpine retrograde or prograde overprints are frequent. The protoliths derive from different tectofacies which mostly can not be restored or are quite speculative.

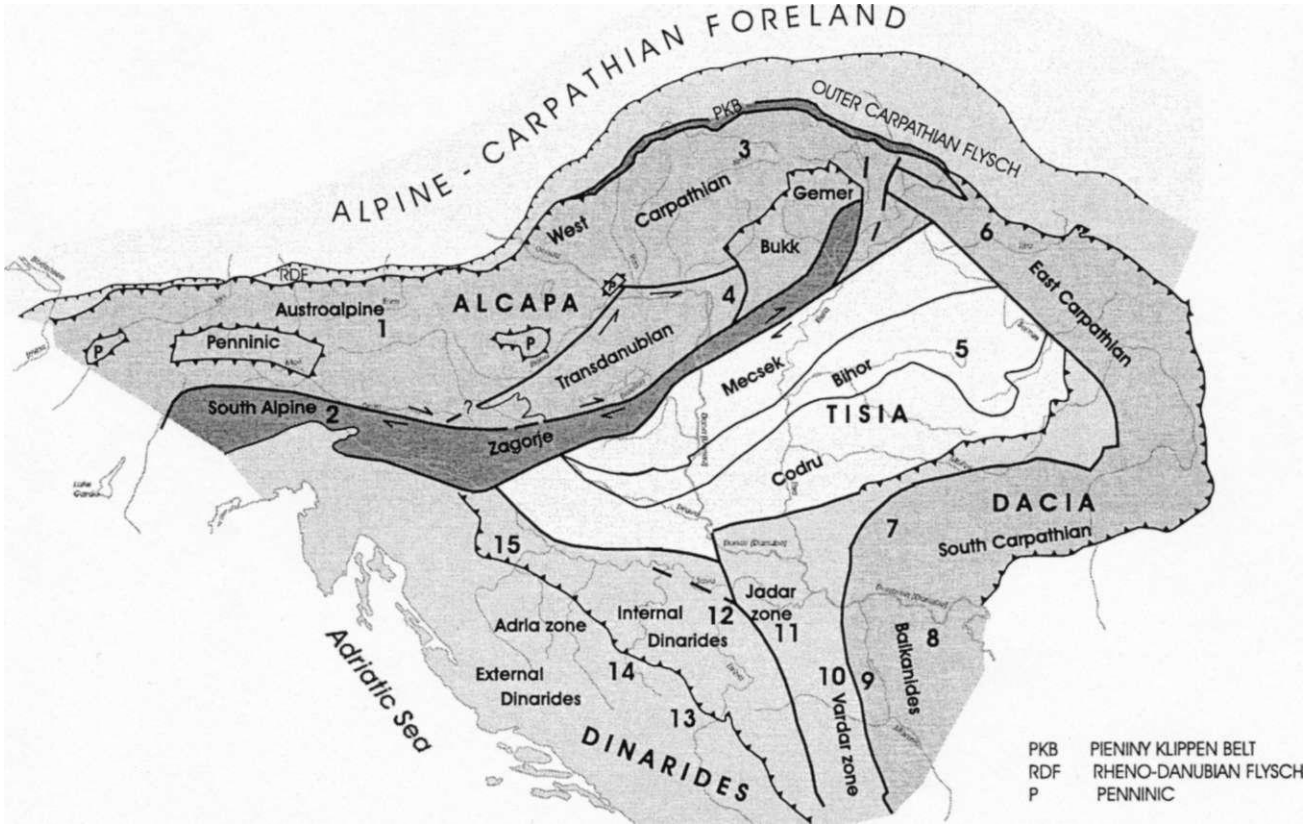

Fig. 1. Devonian/Carboniferous in the major Alpine units of the Circum Pannonian Region: 1. Eastern Alps; 2. Southern Alps; 3. Western Carpathians; 4. Pelsonia Unit; 5. Tisia; 6. Eastern Carpathians; 7. Southern Carpathians; 8. Eastern Serbia; 9. Serbian-Macedonian Massif; 10. Vardar Zone; 11. Jadar Block; 12. Drina [vanjica Zone; 13. East Bosnian Durmitor Paleozoic; 14. Central Bosnian Mts.; 15. Sana-Una Paleozoic.

The D/C reflects the termination of Variscan pre-flysch and the synorogenic flysch environments. According to FLUGEL (1990) and EBNER (1991 a, b) the following paleogeographic domains/facies can be recognized:

- *Noric-Bosnian zone:* a carbonate dominated shallow marine to pelagic Devonian - Lower Carboniferous passive continental margin (Eastern and Southern Alps, Pelso Composite Terrane, Dinarides, Jadar Block).

- *Betic-Serbian zone:* a long lasting stable siliciclastic continental margin with remnants of deep sea fan complexes (Drina Ivanjica zone).

- Beside these well defined continental margin domains long lasting *oceanic environments* are represented by the Veles Series derived from the Paleozoic precursor of the Vardar ocean and the W-Carpathian Gelinica Group which originated from a fore arc basin related to an active continental margin.

- *E and S-Carpathian rift-zone:* intracontinental rift zone with Silurian/Devonian elastics. Characteristically, the synrift sediments are followed by a very thick Lower Carboniferous shallow water limestone sequence topped by rhythmic siliciclastics.

- *Notsch/Veitsch - Ochtina zone:* syn- to postorogenic shallow marine and flysch sediments deposited in marine foredeeps and remnant basins formed after the early Carboniferous Variscan orogeny (Eastern Alps, W-Carpathians, Midtransdanubian Range/Szabadbattyan).

- During the Late Devonian - Carboniferous pre-flysch sediments are followed by typical *siliciclastic flysch sediments.* Flysch sedimentation s.str. is synorogenic and therefore the change into the post-orogenic molasse sedimentation is often marked by a clear unconformity. Predominately they are made up of gravity-flow sediments (turbidites, mass flows, olistostroms, olistoliths, slumps) intercalated in hemipelagic deposits.

In interpretation of depositional environment of siliciclastic turbiditic sequences and submarine gravity-flow deposits of the CPR it should be considered that beside their synorogenic origin these sequences also occur at stable continental margins and their adjoining deep sea fans (as e.g. the Betic Serbian zone). In the Biikk Mts., the Jadar Block and the East Bosnian Paleozoic pre-flysch sediments are overlain by sedimentologically typical flysch environments but at the top they are followed by fossiliferous shal-

j o w water carbonate/siliciclastic sediments without any signs of syn-orogenic deformation/metamorphism.

The Variscan event in the CPR

The existence of Variscan events in the CPR is clearly proven by radiometric age determinations in metamorphic units in parts of Eastern Alps, Carpathians, Tisia and Serbian/Macedonian Massif and by unconformable post-Variscan sedimentary cover. In the sedimentary units it is indicated by the unconformable superposition of Carboni-fours flysch covered by continental/shallow marine molasse sediments and in some parts by the low grade metamorphic overprint of the Variscan sedimentary sequences.

Metamorphism of the metamorphic domains was generally during the Lower Carboniferous and the Notsch/Veitsch--Ochtina zone formations originated from forland or remnant basin are clearly related to these internal metamorphic zones formed during the early Carboniferous orogeny. In the Eastern Alps the post-orogenic character of the Veitsch zone is demonstrated by the lack of any Variscan deformation.

The second climax of Variscan orogeny was during the Westphalian as indicated by unconformities within the sedimentary sequences of the Eastern and Southern Alps, Carpathians and Eastern Serbia. The third characteristic feature is the lack of a clear unconformity and a break in the thermal overprint within the Pelso Composite Terrane, the Jadar Block and the Bosnian Paleozoics. In these areas the evidences of the Variscan orogeny are weak or absent. In the relevant positions there is a change from siliciclastic to shallow marine sedimentation. Howerver, it is a matter of discussion if this change is due to vertical syn-sedimentary movements or glacio-eustatic changes of the sea level.

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