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LATE VARISCAN (LATEST CARBONIFEROUS - EARLY PERMIAN) LATE- AND POST-OROGENIC ENVIRONMENTS IN THE CIRCUM PANNONIAN REGION

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Abstract. The explanation to the map of tectonostratigraphic terranes and the Latest Carboniferous-Early Permian late-orogenic paleoenvironments of the Circum Pannonian Region (CPR) also includes the Upper Bashkirian-Moscovian marine early molasse stage as well as the Upper Permian post-orogenic stage, with gradual connection to the beginning of the Alpine orogenic cycle. Shallow marine siliciclastic or carbonate siliciclastic overstep sequences started in the internal part of the Variscan orogenic belt during the Serpukhovian and Uppermost Bashkirian-Moscovian. They unconformably overlapped the variably metamorphosed Variscan basement or weakly deformed and metamorphosed syn-orogenic Lower to Middle Carboniferous flysch sediments. Post-Variscan rifting largely affected the Variscan orogenic belt by reactivation of the weak Variscan lithosphère. Terrestrial overstep sequences started within internal part of the Variscan orogenic belt during the Latest Carboniferous with graduate continuation to terrestrial-shallow water carbonate-siliciclastic sequences in its external part through the Permian. The Alpine northward shifting transgression started during the Middle/Upper Permian in the south and during the Lower Triassic in the north.

Key **words:** Late Carboniferous, Permian, Circum Pannonian Region, paleoenvironments, paleogeography, Variscan post-orogenic stage.

Introduction

The Late Carboniferous-Permian succession of the Circum Pannonian Region (CPR) records the change from a Pangaea configuration and compressive regime inherited from the Variscan orogeny, to the development of a broad zone of strike-slip and extensional basins. Subsequent thermal subsidence led to the gradual coalescence of these isolated basins to form the large evaporitic to shallow water environments at the beginning of the Alpine orogenic cycle, which caused the Late Permian-Early Triassic extension of the shallow Tethys Sea across the large CPR area.

The geological relationships of the CPR were demonstrated in a set of "Tectonostratigraphic Terrane and Paleoenvironment Maps of Circum Pannonian Region" (published by Geological Institute of Hungary, Budapest, KOVACS *et al.* **eds., 2004) for four selected time slices. The presented text is a short explanation which is dedicated to the Late Carboniferous-Permian late- and post-Variscan orogenic stages. The C/P sequences were analysed in their present position within the Alcapa, Tisia, Dacia, Vardar Zone and Adria megaunits with respect of their facial and lithostratigraphic development, sea-level fluctuation, palinspastic reconstruction and disconformities.**

C/P environments in the Circum Pannonian Region

In the *Alcapa - Adria Megaunits,* **within the main part of the Central Western Carpathians and Eastern Alps the continental post-orogenic sedimentation started during the Westphalian D - Stephanian or within the Early Permian. Transtensional/transpresional and rift-related sedimentary basins were filled up by continental (alluvial, lacustrine and aeolian arid/semiarid facies) siliciclastic sediments, derived from surroundings. These Latest Carboniferous-Early Permian post-orogenic sediments unconformable over-**

stepped Variscan basement, which fragments were recognized in the present Alpine structure and classified in terms of terranes (PAPANIKOLAU ed., 1996). The climax of metamorphism was during the Late Devonian-Early Carboniferous. Volcanites and their volcaniclastics are an integral part of the basin fillings (calc-alkaline bimodal volcanism and within the mature continental rift andesite-basalt continental tholeiites). In the Eastern Aps Early Permian is disconformably superposed by Middle to Later Permian elastics formed in braided rivers and playas. Above the low grade metamorphic Austroalpine Paleozoic domains the Alpine cycle begins with the Lower "Buntsandstein" and "Werfen" facies and in some zones of intensive extension by thick Late Permian evaporites. The Alpine cycle started by quartzite formations within the metamoiphic basement units, where Permian/Triassic lithospheric extension caused HT-LP metamorphism and anorogenic magmatic intrusions.

Within the internal Variscan zone along the supposed Variscan collision suture, the shallow marine volcani-siliciclastic or carbonate-siliciclastic sediments occur in the Eastern Alps and Internal Western Carpathians. This shallow marine molasse-like foredeep sedimentation started during the late Early Carboniferous in the Notsch-Veitsch-Ochtina Zone (according to FLUGEL 1990; North Gemeric-Veitsch zone after NEUBAUER and VOZAROVA 1990). In the Northern Gemeric Unit the whole Early Carboniferous sequence was deformed before the Bashkirian. Basal part of the Uppermost Bashkirian-Moscovian shallow water sequence overlapped discordantly high- to low-grade Variscan crystalline basement or deep- to shallow water Early Carboniferous sediments. Sedimentation is characterized by fluctuation of the sea level, starting from the coarse-grained delta-fan sediments in basal part through shallow marine carbonate-siliciclastic and volcani-siliciclastic sediments with TH basalts up to paralic siliciclastic formation with conglomerate/sandstone and black shales. The termination of this Late Carboniferous shallow marine basin was earlier than Kasimovian. Weak Variscan deformation with distinct Alpine oveiprinting is supposed for the Western Caipathians whereas the Notsch-Veitsch Zone of the Eastem Alps lacks any Variscan deformation. These fossiliferous marine sequences are disconformably overlain by the Permian red-beds associated with huge mass of bimodal volcanics, which also unconformable overstepped different part of the high- and low-grade northgemeric Variscan basement. Within the Tumaicum Unit the Permian red-beds overstepped directly the Bashkirian flysch sediments. The red-beds relieved by the Zechstein sabkha-lagoonal evaporites in the Latest Permian, which reflect the beginning of Alpine cycle.

The marine Middle to Late Carboniferous carbonate - siliciclastic sequences are characteristic for the external part of the Variscan orogenic zone, preserved within the Zagorje-Biikk Zone and the Southern Alps. Within the Zagorje-Biikk Zone the Late Moscovian-Gzhelian shallow marine fossiliferous deposits were gradually developed from the deep water Visean-Bashkirian flysch sediments. An unconformity and thermal overprint is unknown. After the Early Permian hiatus, the new sedimentary cycle began during the Kungurian with the siliciclastic terrestrial sediments. Comparing to this in the Southern Alps (Carnic Alps, Karavanke Mts.) as well as in the northernmost Julian Alps, the shallow marine Late Carboniferous and Early Permian siliciclastic and carbonate sediments unconformably overlay the weakly metamorphosed and deformed Variscan basement and/or the Early Carboniferous flysch sediments. The marine post-Variscan sedimentation started gradually during the Serpukhovian - Moscovian and prograde up to the Sakmarian - Artinskian. The beginning of the Alpine sedimentary cycle with the Kungurian terrestrial sediments is followed by the evaporitic and shallow marine carbonate sedimentation in the Upper Permian.

In the Transdanubian Unit the post-orogenic sedimentation is represented by the Westphalian - Stephanian conglomerates, which after hiatus were followed by the Thiiringian red-beds on the SW, and evaporites and Belerophon carbonates on the NW, simiralely to the Southern Alps (HAAS and BUDAI, 1995).

In the Dolomites and western Southern Alps (Lombardy) post-Variscan sedimentation is strongly controlled by the extensional and rift-related tectonics. The Late Carboniferous-Early Permian or Early Permian continental (fluvial and lacustrine) sequences are associated locally with huge mass of synsedimentary acid to intermediate volcanic rocks. These rock formations unconformably overlay the Variscan basement (mostly low-grade with increasing the grade of metamorphism to the west). The Middle-Late Permian sediments unconformably overlie the post-Variscan sequence. As in the Southern Alps they started with continental coarse-grained sediments, which were followed by the Bellerophon facies.

In the the Sana-Una Unit and SE Bosnia, the Velebit and Lika Units the Latest Carboniferous-Permian sedimentation has similarities to the Southern Alps. Fossiliferous shallow water carbonate-siliciclastic sediments either prograde continually from the D/C flysch or concordantly lie on the Carboniferous platform carbonate. The common feature is the Middle Permian terrestrial event followed by the sabkha-lagoonal grading into shallow marine facies, as the beginning of the Alpine cycle. The Variscan deformation and thermal overprint were not recognized (RAMOVS *et al.*, 1990).

In the *Tisia Megaunit* the molasse-like overstep sequence overlay unconformably the Variscan crystalline rock complexes. These overstep sequences started during the Late Carboniferous in the Kunsagia Unit and during the Permian in Bekesia Unit. The Late Carboniferous siliciclastic alluvial-lacustrine sediments contain thin layers of coal in some places. Peimian sediments are typical arid/semiarid facies associated with acid volcanites and their volcaniclastics. The Alpine evolutionary stage started with the Early Triassic coarse-grained clastic sediments. On the other hand, in the Slavonian Mts. of the Southern Tisia, a continuoues sequence of Late Devonian to Early Permian siliciclastics is recorded as an unconformable, molasse-like cover on top of the pre/Variscan metamorphic complex (JAMICIC and BRKIC, 1987). This sequence which is affected by

a very low-grade metamorphism is in turn unconformably covered by Permian-Triassic clastic-carbonate succession.

Within *Dacia Megaunit,* in the Getic and Danubian Units, the Upper Carboniferous-Permian continental deposits unconformable overstep gneiss-amphibolite and micaschists (the Getic Unit) as well as low-grade to anchimetamorphosed crystalline rock complexes (the Danubian Units). Thin coal seams are associated within the Westphalian D-Stephanian part of this molasse sequence. In the upper parts of these sequences deposited coarse-grained red-beds associated with acid volcaniclastic material.

Similar to the Southern Carpathians, in the *Eastern Serbia* (the Ranovac, Kucaj, Stara Planina, and Vrska Cuka Units) is low-grade to anchimetamorphosed Early Paleozoic crystalline basement unconformable overstep by the Westphalian C, Stephanian - Permian or Permian alluvial and lacustrine formations, associated with intermediary to basic rift-related volcanism in some places.

Within the *Vardar Zone* the siliciclastic flysch sedimentation is lastening until the Middle Carboniferous in the Drina-Golija region. This sequence is unconformably overlain by Late Permian/Triassic conglomerate and sandstone. Within the shallow marine part of the Veles Serie the Carboniferous sediments were identified biostratigraphically. The Late Variscan (?Middle Carboniferous-?Permian) anchi- to epizonal metamorphism is presumed. In the Jadar Block the Middle and Late Carboniferous shallow marine fossiliferous carbonate-siliciclastic sediments prograde continuously from the D/C siliciclastic flysch environment. Middle Permian elastics followed by demonstrate hiatus and the beginning of the Alpine cycle. The presumed Variscan metamorphism was not proved.

Restoration of Upper Carboniferous-Permian facies in the CPR

Modification of the convergence direction between Gondwana and Laurussia may have been a consequence of collisional lithospheric thickening in the domain of the Variscan fold belt. The subsequent disintegration of the Variscan fold belt is probably the combined effect of dextral shear, gravitational collapse of the over-thickened crust, and possibly back-arc extension. The post-Variscan period was one of intense crustal re-equilibration and reorganisation under an alternating transtensional and transpressional tectonic regime. Subsequent basin evolution involved extensive, predominantly clastic sedimentation and some of the newly-formed rifts became the loci of extensive intraplate magmatism. In some areas lithospheric extension was accompanied by metamorphism.

Following the main phases of Variscan compression, thermal relaxation of the crust occurred in Late Carboniferous Early Permian times, creating the rifts and grabens that allowed accumulation of the first phase of terrestrial sedimentation.

The C/P reflects the late and post-orogenic stage, in which the following facies and depositional zone can be recognized depending to the position to the Variscan collisional suture:

- *Internal zone of the Variscan orogeny:* the Westphalian D-Stephanian terrestrial siliciclastic facies with seldom coal seams in some places and the thick Permian redbeds associated with acid to basic volcanites (Ca-Alk to TH magmatic trend) and their volcaniclastics and seldom alkaline magmatites (Alcapa, Dacia and Tisia Megaunits and Serbian Carpatho-Balcanides); the beginning of the Alpine cycle started by the Early Triassic continental quartzose or marine siliciclastic sediments or in some areas by thick evaporites already within the Late Permian;

- *Variscan foredeep:* the Late Bashkirian-Moscovian shallow marine carbonate-siliciclastic facies, with intermediate to basic volcanites and their volcaniclastics, which overlay unconformably weakly metamorphosed and deformed Variscan flysch formations or directly low- to high-grade Variscan crystalline basement (Nötsch-Veitsch-Ochtina Zone in the Western Carpathians and Eastern Alps); they are overlapped by the Early Permian red-beds; beginning of the Alpine cycle started by the Late Permian evaporites;

- *External zone of the Variscan orogeny:* the Late Bashkirian/Moscovian to Early Permian shallow marine carbonate-siliciclastic facies unconformably overlay weakly deformed Devonian/Early Carboniferous flysch (Southem Alps: Dolomites, Carnic Alps and Turnaicum Unit in the Western Carpathians); beginning of the Alpine cycle started by the Middle Permian red-beds, which were followed by the evaporate-carbonate facies;

- *Passive continental margin of the Adria plate:* the Late Carboniferous-Early Permian fossiliferous shallow marine carbonate-siliciclastic sediments prograde continually from the deep-water flysch or concordantly overlay D/C carbonate platform (Bükk-Zagorje, Sana-Una Unit, Jadar Block, Paleozoic of the Central and SE Bosnia, Velebit and Lika); the beginning of the Alpine cycle started with the Middle Permian elastics, which were dominantly followed by the shallow water carbonate deposits.

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