INFLUENCE OF TERRESTRIAL SEDIMENTATION IN PENNSylvANIAN ROCKS
OF CROATIA

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ABSTRACT

Sedimentary rocks of Pennsylvanian age outcrop at several regions in Croatia. Most of these rocks were deposited in marine environment, in different tectonic units: Karst (External) Dinarides, Internal Dinarides and Tisia. Pennsylvanian deposits contain significant amount of terrestrial debris, related to the uplift of Hercynian mountain belt and its intense erosion. Remnants of land flora are not common, but are present at almost all localities. The most diverse and the best preserved Pennsylvanian land flora in Croatia was found in the Velebit Mt. and Lika Region. It was dominated by ferns, pteridosperms and cordaitales. Fossil flora from Banovina is less diverse, with pteridosperms, scarce ferns, horsetails and lycopods. Sporadic occurrence of lycopods and horsetails was reported from the mountains of NW Croatia. In Gorski Kotar Region only plant detritus was found. Ferns and pteridosperms from the Papuk Mt. were found in older, Mississippian deposits.

Palaeobotanical data reopen the discussion about the palaeogeographic position of research areas.

Key words: Pennsylvanian, terrestrial sedimentation, megaflora, Croatia.
1. INTRODUCTION

Carboniferous rocks are present on surface at several scattered areas in Croatia (RAMOVŠ et al., 1990; SREMAC, 2005) (Fig. 1). In all these areas Pennsylvanian deposition was influenced by the input of terrestrial debris, and by the occurrence of land flora.

The most interesting Pennsylvanian outcrops are described from External (Karst) Dinarides (Figs. 1, 3). A rather continuous Carboniferous-Permian succession of sedimentary rocks is exposed as a core of the Velebit anticline (locality 1). Late Palaeozoic rocks are present as scattered outcrops with tectonic boundaries in Gorski Kotar region (locality 2). Mountains of NW Croatia (Medvednica, Samoborska Gora and Marijagorička Brda) (locality 3), are situated in Zagorje-Mid-Transdanubian zone, a dislocated section of Internal Dinarides with mixed clastic-carbonate deposition during the Palaeozoic era. Banovina region (locality 4), with deposits ranging from the Devonian to the end-Permian age, belongs to Internal Dinarides, representing the platform edge (e.g., PAMIĆ & JURKOVIĆ, 2002) (Figs. 1, 3).

Slavonian Mts. (Papuk Mt.) and Moslavačka gora Mt. (locality 5) with metamorphic Palaeozoic complex belong to the Tisia Unit (Figs. 1, 3) (PAMIĆ & JURKOVIĆ, 2002; VOZAROVA et al., 2009).

Late Palaeozoic rocks were first studied in Croatia for the purpose of geologic mapping in Austro-Hungarian monarchy during the 19th century. The first collections of Carboniferous land flora in Croatia were found due to the ore exploitation in the area of Trgovska Gora Mt. (GEINITZ, 1868; STUR, 1868) and Lika Region (NEMĚJC, 1939).
M. Salipec and his team performed detailed geologic studies of Late Palaeozoic deposits. They prepared precise maps of the Velebit Mt. and Lika and Gorski Kotar Regions (SALOPEK, 1942, 1948, 1949, 1960) and collected numerous samples for further palaeontological studies. Carboniferous marine fossils were determined by KOCHANSKY-DEVIDÉ (1955, 1970), KOSTIĆ-PODGORSKA (1956), KOCHANSKY & HERAK (1960), ĐURĐANOVIĆ (1968, 1973), RUKAVINA (1973), BALAŽ (1981) and MILANOVIĆ (1982). During the field work in Northern Croatia JENKO (1944) and HERAK (1956) reported sporadic findings of terrestrial megaflora in Marijagorička Brda Hills and Samoborska Gora Mt.

A new cycle of mapping for Basic Geologic Map of Yugoslavia 1:100 000 yielded new information. Carboniferous areas in Croatia were presented at sheets...

The last mapping cycle in Croatia resulted in the new Geologic map of Croatia 1:300 000 and Explanatory text with description of stratigraphic units (VELIĆ & VLAHOVIĆ, eds., 2009).

2. CARBONIFEROUS OUTCROPS IN CROATIA

2.1. Velebit Mt. and Lika Region

The most complete succession of clastic and carbonate deposits from the Pennsylvanian (Moscovian) to the end of the Permian and the beginning of the Triassic (RAMOVŠ et al., 1990; SREMAC, 2005) can be derived from an elongate ca. 50 km long Palaeozoic belt, striking NW-SE, exposed as a core of the Velebit anticline in External Dinarides (Figs. 1, 3). Carboniferous outcrops are presented at Basic Geologic Map of Yugoslavia, sheets Gospić L33-127 (SOKAČ et al., 1974, 1976), Obrovac L33-140 (IVANOVIĆ et al. 1973, 1976) and Udbina L33-128 (ŠUŠNJAR et al., 1973; SOKAČ et al., 1976).

Pennsylvanian deposits in the Velebit Mt. and Lika Region are represented with shallow marine clastic-carbonate rocks of Moscovian to Gzhelian age (Fig. 2).
Fossiliferous clastic-carbonate rocks: (Moscovian - Kasimovian)

The lowermost Carboniferous horizon outcrops at the area of Štikada and Sv. Rok (VELIĆ et al., 2009). Dark-grey finely bedded shale contains quartz greywacke and crinoid limestone/dolomite intercalations (SALOPEK, 1942, 1948). Numerous brachiopods and bryozoans are present in yellowish-weathered shale. Moscovian age was first determined on the basis of fusulinids and calcareous algae (KOCHANSKY-DEVIDÉ, 1955, 1970). It can be considered as the equivalent of Fusulinella-Protriticites zone (MERINO-TOMÉ et al., 2009). Lower Kasimovian sediments contain the first fusulinid taxa with keriothecal wall-structure, such as Protriticites (KOCHANSKY-DEVIDÉ, 1955, 1970). Phylloid algae (Eugonophyllum, Anchicodium) and Shamovella (Tubiphytes) are common in limestone intercalations. Contact with younger deposits is partially tectonic, and partly exhibits continuous transition (VELIĆ et al., 2009).

Fusulinid ("Triticites") sandstone: (Kasimovian)

Shale, sandstone and conglomerate rhythmically alternate within this horizon. Fine-grained well sorted greywacke dominates in lower portion and shale is more common in upper layers. Input of terrestrial debris is significant. Elongate fusulinids are often dissolved and washed out, with dark brown film covering empty casts, due to the fresh-water influence and activity of iron bacteria. Conglomerate appears in form of lenses or intercalations within shale, sometimes with gradation or oblique bedding. Quartz pebbles predominate, but radiolarian chert, pyroclastic and siltite material are also present. Fossiliferous limestone lenses are scarce, also containing terrigenous quartz grains (VELIĆ et al., 2009). Late-diagenetic dolomitization is common. On the basis of fusulinids: Eoparafusulina pusilla, E. pseudosimplex and
"Triticites" brevispira (KOCHANSKY-DEVIDÉ, 1955) this horizon can be considered as an equivalent of Montiparus zone (MERINO-TOMÉ et al., 2009).

Shale and sandstone with land flora: (Late Kasimovian – Gzhelian)

Late Kasimovian deposits are highly fossiliferous and comparable to Auernig beds of Carnic Alps (FRITZ & KRAINER, 2006) and partly to some localities in Karavanke Alps in Slovenia (KOCHANSKY-DEVIDÉ & RAMOVŠ, 1966; KOLAR-JURKOVŠEK & JURKOVŠEK, 2002). They can be considered as equivalent of Raurserites zone (MERINO-TOMÉ et al., 2009).

These rocks are lithologically similar to previous units, but with evidence of increased terrestrial influence. Shale, slate and sandstone with scarce intercalations of limestone and quartz conglomerate contain numerous fossils. Limestone intercalations are the most fossiliferous. They contain dasyclad Anthracoparella spectabilis (KOCHANSKY-DEVIDÉ & HERAK, 1960; KOCHANSKY-DEVIDÉ, 1970), crinoids, brachiopods, bivalves, corals and foraminifera (SIMIĆ, 1935; SALOPEK, 1942, 1948; RUKAVINA, 1973; BALAŽ, 1981).

Diverse plant fossils (Table 1) occur within shale and greywacke. Well preserved lycopods (Lepidodendron), sphenophytes (Sphenophyllum), ferns (Asterotherca, Pecopteris, Seftenbergia, Remia), pteridosperms (Callipteridium, Laveineopteris, Linopteris, Nemejcopteris, Taeniopteris, Sphenopteris) and conifers (Pseudomariopteris, Cordaites) were collected by coal-mining company in early 20th century and described by NĚMEJC (1936). SALOPEK and his team found some new plant fossils during the mapping in the area (SALOPEK, 1942, 1948) and Croatian Museum of Natural History recently discovered one new locality with terrestrial megaflora (DEREK, 2011, unpublished).
<table>
<thead>
<tr>
<th>TABLE 1. CARBONIFEROUS TERRESTRIAL FLORA IN CROATIA:</th>
<th>V</th>
<th>SG</th>
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<td>Taeniopteris (Sphenopteris) carnoti ZEILLER</td>
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<td>Sphenopteris cf. weissi (POTONIÈ) NÉMEJC</td>
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<td><strong>CORDAITALES</strong></td>
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<td>Cordaites principalis GERMAR</td>
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<td>Cordaicarpus ovoides (GOEPPERT &amp; BERGER) SEWARD</td>
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<td>Pseudomariopteris busqueti (ZEILLER) DANZÉ-CORSIN</td>
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<td>P. ribeyroni (ZEILLER) DANZÉ-CORSIN</td>
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<td>Carpolites sp.</td>
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Table 1. List of Carboniferous megaflora from different localities in Croatia.

**Dinarides**: V - Velebit (NĕMEJC, 1936); **Internal Dinarides**: SG - Samoborska Gora Mt. (HERAK, 1956); MGB - Marijagorička Brda Hills (JENKO, 1944); TG - Trgovska Gora Mt. (STUR, 1868); **Tisia**: P - Papuk (BRKIĆ et al., 1974). Taxa revised after LAVEINE (2005), ZODROW et al. (2006) and BASHFORT et al. (2010).

Zagreb plant collections were exhibited to participants of IGCP 575 Zagreb meeting (2011) and examined in detail by Y. TENCHOV and C. CLEAL (plants), as well as E. JARZEMBOWSKY (insect traces).

List of previously published land flora is presented at Table 1.

**Lower Rattendorf limestone (Gzhelian)**

In eastern part of the Velebit Palaeozoic belt terrestrial influence is prolonged into the Permian, resulting in carbonate-siliciclastic deposition. Western localities are characterized with dominantly carbonate rocks (equivalent of Rattendorf group) with large spherical preudoschwagerinids, small benthic foraminifera and calcareous algae (SALOPEK; 1942, 1948; KOCHANSKY-DEVIDÉ, 1959) (Fig. 2).

### 2.2. Gorski Kotar Region

Late Palaeozoic rocks in Gorski Kotar Region (Fig. 1) outcrop as tectonically isolated blocks. Salopek and his team prepared the first detailed maps and lithofacies descriptions (SALOPEK, 1949, 1960). The area is presented on Basic Geologic Map of Yugoslavia, sheets Crikvenica L33-102 (GRIMANI et al., 1970, 1973) and Delnice L33-90 (SAVIĆ & DOZET, 1985 a, b). Pennsylvanian rocks are interpreted as marine turbidite deposits (ŠPARICA, 2009).
The oldest autochthonous rock on surface is **Fusulinid sandstone**, with *Fusulinella* sp. div., some peculiar "Triticites" species and small schubertellids and endothyroids. Greywacke type of sandstone contains significant amount of terrestrial debris. Greywacke probably belongs to the Moscovian and/or Kasimovian age (MILANOVIĆ, 1982; ŠPARICA, 2009).

Dark-grey, solid sandstone at the first glance seems similar to Fusulinid sandstone of the Velebit Mt. (KOCHANSKY-DEVIDÉ, 1955). It is brown at the weathering surface, with numerous small cavities appearing after the dissolution of fusulinids. Parallel orientation of fusulinids or their moulds is typical for these rocks, indicating postmortal transport (MILANOVIĆ, 1982). Small, unrecognizable fragments of land flora can be found sporadically, probably transported down the slope by turbidite currents.

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**Fig. 2.** Schematic stratigraphic columns at different Carboniferous regions in Croatia. Deposit thickness not to scale (partly after RAMOVŠ et al., 1990; PAMIĆ & JURKOVIĆ, 2002; VOZAROVA et al., 2009, revised).
Carboniferous fossils appear also in clasts and pebbles of younger clastic deposits (SREMAC & ALJINOVIĆ, 1997; ALJINOVIĆ & KOZUR, 2003, ALJINOVIĆ et al., 2006).

2.3. **Medvednica, Samoborska Gora and Marijagorička Brda Mts.**

Northwestern Croatia with Medvednica, Samoborska Gora and Marijagorička Brda Mts. belongs to Zagorje-Mid-Transdanubian Zone (Fig. 1). This tectonostratigraphic unit, striking SW-NE, was interpreted as a dislocated part of Internal Dinarides (PAMIĆ & TOMLJENOVIĆ, 1998; TOMLJENOVIĆ et al., 2003).

Area is mapped at Basic Geologic Map, sheets Ivanić-Grad (BASCH 1981, 1983) and Zagreb L34-98 (ŠIKIĆ et al., 1978, 1979). Contacts with surrounding Mesozoic rocks are tectonical.

Parametamorphic, previously clastic and carbonate rocks of Late Palaeozoic age surround the orthometamorphic core of the Medvednica Mt. Some of these rocks are ore-bearing, originating from chert, tuffitic shale and sandstone. Black low-metamorphic complex of dominantly phyllite appears in different areas (BELAK, 2009), and ranges from Early Silurian to Pennsylvanian in age, based upon conodonts and graptolites (ĐURĐANOVIĆ, 1973; SREMAC & MIHAJLOVIĆ-PAVLOVIĆ, 1981). Recrystallized carbonate rocks outcrop in scattered areas. They contain conodonts in lower portions (Devonian, Mississippian) and shallow marine stromatoporids and bryozoans in upper portions (Pennsylvanian) (ĐURĐANOVIĆ, 1973, KOCHANSKY-DEVIDÉ, 1981). The whole complex is highly tectonized and it is hard to reconstruct a stratigraphic column (Fig. 2) of this area (ŠIKIĆ et al., 1978; BASCH, 1981; ŠIKIĆ, 1995). Metamorphism is linked with alpine tectonic cycle (BELAK, 2009).
West from Medvednica Mt., in Marijagorička Brda Hills, clastic deposits contain remnants of Carboniferous horsetail *Calamites* (*Diplocalamites*) cf. *carinatus* STERNBERG (JENKO, 1944). This horsetail occurs in Namurian and Westfalian deposits of Europe. Coarse-grained greywacke, sandstone and black shale indicate significant terrestrial influence and resemble the protolite rocks in parametamorphic Medvednica complex. Pennsylvanian rocks outcrop in profound gorges and creeks. Palynomorph analysis performed in 2011 did not provide new results (BRAJKOVIĆ, pers. comm.). Going westwards, finding of lycopod *Sigillaria* was reported from Samoborska Gora Mt. by HERAK (1956). Dominant sedimentary rocks are litoclastic greywacke and quartz greywacke. Quartz conglomerate appears sporadically, sometimes with lenses of shale and siltite. Limestone and dolomite are developed laterally (ŠPARICA, 2009). Detritic quartz in carbonate rocks indicates the continuous terrestrial input. Palynological probes performed in late eighties were sterile (KOCH, pers. comm.). Carboniferous marine fossils were not found in this area, but uppermost limestone intercalations contain Late Permian marine calcareous algae (HERAK & ŠKALEC, 1967). Shallow marine dolomites and limestones are ore-bearing, with meso-epithermal Fe-Cu-Ba SEDEX type deposits (PALINKAŠ et al., 2010).

### 2.4. Banovina-Kordun Region

Clastic Middle-Late Palaeozoic deposits with intercalations of fossiliferous carbonate rocks occur at Trgovska Gora Mt. in Banovina-Kordun Region (Fig.1). This region is presented at Basic Geologic Map, sheet Orahovica L33-96 (JAMIČIĆ et al.,...
Detailed Palaeozoic stratigraphy of this region was not studied, but fossils belong to the Devonian and Carboniferous periods. Shale, siltstone and sandstone dominate, containing scarce conglomerate lenses in upper horizons. Rhythmic alteration and gradation indicate turbidite origin of these deposits (ŠIKIĆ, 2009). Organic matter and chert lenses are common in lower parts of the succession, and terrigenous input is more significant in upper portion. Conodonts, radiolarians and scarce ostracods from pelagic dark-grey argillaceous limestone range from the Devonian to Early Carboniferous (Viséan) age (ĐURĐANOVIĆ, 1968, 1973). Ba-F mesothermal mineralization and Fe replacement are reported from these deposits (BOROJEVIĆ-ŠOŠTARIĆ et al., 2009).

Pennsylvanian uplift processes changed the mode of deposition. MILANOVIĆ studied dark-grey, mosaic-textured dolomite from this horizon and determined small foraminifera and calcareous algae (*Tuberitina bulbacea* GALLOWAY & HARLTON, *Dvinella (Trinodella) variolonga* KULIK and *Solenopora* sp.), crinoids and echinoids. He presumed shallow marine deposition during the Moscovian (MILANOVIĆ, 1982). Kasimovian-Gzhelian carbonate rocks contain coral fauna, described by KOSTIĆ-PODGORSKA (1955), and are comparable to Carnic Alps. Ba epithermal and Fe SEDEX ore deposits from these rocks represent the prolongation of ore-bearing horizon from Sana-Una Unit and are connected with opening of the Tethys Ocean (PALINKAŠ et al., 2009).

Terrestrial land flora ranging from Pennsylvanian to Early Permianin age was discovered in 19th century, due to the ore exploitation in Trgovska gora (GEINITZ, 1868; STUR, 1868). Pennsylvanian flora is represented with horsetail *Calamites suckowi* BRONGNIART, lycopsid roots *Stigmaria ficoides* BRONGNIART and pteridosperms: *Sphenopteris cf. haidingeri* ETTINGSHAUSEN, *Neurodontopteris*
auriculata (BRONGNIART) and Alethopteris aquilina (SCHLOTHEIM) (Table 1) and shows similarity with Euroamerican palaeoprovince. Early Permian taxa are Odontopteris obtusiloba NAUMANN and Calamites gigas BRONGNIART (STUR, 1868).

2.5. Slavonian Mts.- Moslavačka Gora Mt.

Mountains of Eastern Croatia (Papuk Mt., Moslavačka gora Mt.) represent the only Carboniferous area in Croatia out of the Dinarides. They are a part of the Europaean Tisia Unit (Fig. 1, 3). Area is presented at Basic Geologic Map, sheets Daruvar L33-95 (JAMIČIĆ, 1989; JAMIČIĆ et al., 1989) and Orahovica L33-96 (JAMIČIĆ & BRKIĆ, 1988; JAMIČIĆ et al., 1987), and described by JAMIČIĆ & CRNKO (2009).

Crystalline to low-grade parametamorphic rocks from the Slavonian Mountains range from Early Palaeozoic all to the Triassic. Within the strongly tectonized low-metamorphic “Radlovac”-unit, interpreted as intertidal deposits (RAMOVŠ at al., 1990), Mississippian (Westfalian) land flora was found in metagreywacke and metasandstone (Fig. 2). Source of the clastic material is the uplifted Papuk Mt. with granite and metamorphic rocks. Quartz grains are the most common (approximately 50 % grains), followed by plagioclase and micas. Scarce ferns and pteridosperms occur within greywacke (Asterophyllites equisetiformis (SCHLOTHEIM) BRONGNIART, Pecopteris sp., Laveineopteris cf. tenuifolia SCHLOTHEIM, Laveineopteris rarinervis (BUNBURY) CLEAL et al. (= Laveineopteris attenuata LINDLEY & HUTTON)), together with palynomorpha: Cordaites principalis GERMAR, Calamospora, Cordaites and Cyrtospora (BRKIĆ, JAMIČIĆ & PANTIĆ, 1974;
Deposition in Early Permian was influenced by uplift processes (JAMIČIĆ, 1989; JAMIČIĆ and CRNKO, 2009).

3. DISCUSSION

During the Devonian and Early Carboniferous territory of Croatia was a part of a deep ocean. Pelagic fossils (radiolarians, conodonts and/or spores were found in Dinarides (Gorski Kotar, Medvednica and Banovina) and Tisia (Slavonian Mts.). Uplift processes enabled the formation of Bashkirian-Moscovian carbonate platforms at the western Palaeotethys shelf (MERINO-TOMÉ et al., 2009), including the area of Velebit Mt. and Lika Region. Intense erosion of Variscides at the end of Moscovian enabled massive siliciclastic input into the marine basin. Deposits at all Croatian Dinaride localities exhibit this environmental change. Nutrients derived to shelf areas together with terrestrial debris caused the increase of biodiversity of marine flora and fauna in Kasimovian and Gzhelian. Uplifted areas, probably islands were colonized by land flora.

Palaeogeographic reconstructions of Carboniferous period presume the position of Dinaride localities along the shelf of Northern Gondwana (DiMICHELLE et al., 2005; VOZAROVA et al., 2009) (Fig. 3).
Diverse megaflora from the Velebit Mt. was found in shale, siltite and thin coal intercalations of Late Kasimovian-Gzhelian age (Fig. 2). It consists of scarce lycopsids and horsetails, and common and well preserved ferns, pteridosperms and cordaitales (Table 1). NĔMEJC (1936) suggested Stephanian age for the described collection, which is in accordance with age of marine fossils. NĔMEJC also pointed out the lack of conifers in the Velebit flora. Such vegetation might be related with island isolation and local precipitation pattern. Prevalence of ferns and pteridosperms over lycopsids and horsetails reflects global climate trends in the area (CLEAL et al., 2011). Plant fossils are well preserved, with no traces of perturbations, due to the sheltered environment and lack of transport (TENCHOV, 2011, pers. comm.). Marine foraminifera, bivalves and gastropods from this area are widely spread along Euramerican shelves (KOCHANSKY-DEVIDÉ, 1955; RUKAVINA, 1973; BALAŽ, 1981), despite of the calcareous algae, which are partly endemic in character.
(KOCHANSKY-DEVIDÉ, 1970). Distribution of marine fauna was controlled by anticlockwise ocean circulation.

Late Palaeozoic deposits in Gorski Kotar are dominantly clastic and appear as scattered, tectonically outlined patches. Deposition by turbidite current took place at shelf slope. Land flora is present only in form of detritus, and Pennsylvanian marine fossils can be compared to those from the Velebit Mt.

Peculiar position of NW Croatian mountains: Medvednica, Samoborska Gora and Marijagorička Brda were discussed by many geologists. These mountains are positioned opposite to the Dinaric strike, but they have some characteristics of Internal Dinarides. PAMIĆ and TOMLJENOVIC (1998) proposed the name Zagorje-Mid-Transdanubian Zone for this belt (Fig. 1). Palaeozoic sedimentary succession of Mt. Medvednica can be interpreted as a low-metamorphic turbidite sequence. Pennsylvanian uplift was followed by colonization of the first shelf biota – crinoids, stromatoporids and bryozoans (KOCHANSKY-DEVIDÉ, 1981) comparable with marine faunas from Euramerican shelf palaeoprovince. Conodont genus *Idiognathoides* (ĐURĐANOVIĆ, 1968, 1973) was also found in North America and Northern Europe.

Going westwards, terrestrial influence is more pronounced, and sporadic findings of land megaflora, *Calamites cf. carinatus* and *Sigillaria*, were reported from Marijagorička Brda Hills and Samoborska Gora Mt. (JENKO, 1944; HERAK, 1956). Dominantly clastic deposits from these two mountains are not metamorphosed and exhibit different characteristics from SE parts of Medvednica Mt. Lack of marine fossils does not allow precise zonation, but *Calamites carinatus* is known from Namurian-Westfalian of Euramerica. SREMAC and her students performed field
work in the area in 2011 in order to find Pennsylvanian megaflora and/or palinomorphs in this area, but did not collect any palaeobotanical fossils. Banovina Region and Trgovska Gora Mt., seemingly prolongation of ore-bearing Sana-Una Unit, are interpreted as Internal Dinarides. In regional
reconstruction (e.g. VOZAROVA et al., 2009), they are situated near the Gondwana shelf edge towards the Palaeotethys deep basin (Fig. 3). Turbidite deposition during the Mississippian probably took place at marginal slope. During the Namurian and Westfalian this area was uplifted. Calcareous alga Dvinella, cosmopolitan genus of the Northern Hemisphere, inhabited shelves surrounding the uplifted islands and produced biogenic bafflestone-type limestone. Emerged areas were colonized by lycopsids (Stigmaria ficoides), horsetails (Calamites suckowi) and pteridosperms
(Alethopteris aquilina, Neurodontopteris auriculata, Taeniopteris cf. haidingeri) (Table 1). The same taxa occur in Pennsylvanian of Northern America and Europe (Czech Republic, France, Hungary) (GULYAS-KIS. CS., 2003; ZODROW et al., 2006). ZODROW et al. suggest the origin of marattialen fern Acitheca in Nort America and Western Europe in middle Pennsylvanian, with later expansion into Eastern Europe, Caucasus, and into Permian of China. Wide stratigraphic range, from middle Pennsylvanian into the Permian, is also reported for Neurodontopteris auriculata (BOYARINA, 2010). Nevertheless, the presence of lycopods and horsetails would suggest probable Middle Pennsylvanian (Stephanian A?) age for this flora. Moslavačka Gora Mt. and Papuk Mt. in Slavonian Mts. belong to entirely different, Tisia Unit (Figs. 1, 2, 3). Uplift in the area took place during the Mississippian, and prominent influence of igneous rocks and metamorphism is typical for the area. Determined plant fossils Asterophyllites equisetiformis, Laveineopteris
rarinervis, L. cf. tenuifolia and Cordaites principalis differ from described Dinaride floras in age (Westfalian) and composition (BRKIĆ et al., 1974).

4. CONCLUSION

Pennsylvanian deposition in Croatia was strongly influenced by terrestrial input in marine (Western Palaeotethys) basin, due to the Variscan orogeny and intense erosion of Hercynian mountains. Some of the uplifted areas existed as islands, and were soon colonized with land flora. Remnants of Pennsylvanian megaflora occur at Croatian localities from different tectonic units: External Dinarides, Internal Dinarides and Tisia.

Pennsylvanian vegetation in Dinarides was fern dominated, with additional cordaite dryland flora in the area of the Velebit Mt. and Lika Region. Precise age is not always clear, due to the lack of index fossils.

Fossil horsetails from Marijagorička Brda Hills are probably the oldest terrestrial plants in the region, belonging to Namurian or Westfalian age.

Pteridosperms and ferns from Trgovska Gora, together with scarce lycopods and horsetails could be compared with Stephanian A vegetation in Euramerica.

Plant fossils from Velebit Mt. and Lika Region are the most diverse and well preserved, with no traces of transport. Lycopods, horsetails, ferns, pteridosperms and cordaitales were found in this area, while primitive conifers are missing. Age of the Velebit flora is estimated to be Stephanian B or C (Kasimovian-Gzhelian).

Plant remnants in Gorski Kotar are in form of debris, due to the transport by turbidite currents.
Tisja Megaunit with Papuk and Moslavačka Gora Mts. was dislocated from Dinaride islands. Westfalian flora from this region is similar to flora of Eastern America and Central Europe.

It is necessary to continue with regional study of Croatian Carboniferous localities in order to understand the palaeogeographic relationship between these areas during the Pennsylvanian age.

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