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CAVE-DWELLING INVERTEBRATES IN SERBIA

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Abstract — The paper presents geological characteristics and other features of Serbia. Tables give lists of the country's currently known cave-dwelling invertebrates.

Key words: Balkan Peninsula, Serbia, cave invertebrates

GEOLOGICAL DATA

Centrally located on the Balkan Peninsula, Serbia lies at the convergence of three large tectonic units, namely the three main mountain systems. In the middle is the Rhodopian mass, a rocky crystalline core in the form of a meridional barrier that was formed due to uplifting of the oldest, central part of the Balkan Peninsula. In the east are assembled the ranges of the Carpatho–Balkan mountain system. In the west are the mountain ranges of Šumadija and Western Serbia, which belong to the Dinaric mountain system or the Inner Dinarids.

Within the confines of Serbia, the oldest, pre–Paleozoic (Archaic and Algonkian) terrains are fairly extensive and constitute the bulk of its central part, the core of the Rhodopian mass. These are mainly crystalline schists. In the Pannonian Depression they are almost completely covered by younger sediments. To a lesser extent they underlie Paleozoic and other rocks or occur in the form of nappes and thrusts in the Carpatho–Balkan Mountains.

Older Paleozoic. — The existence of Cambrian deposits is demonstrated by fossil finds near the villages of Crnajka, Dubovčanka, and Donja Bela Reka, as well as in the Vlasina region.

On Mt. Kučaj and in the surrounding regions, the Ordovician is represented by phyllites and phyllitoargilloschists, more rarely by sandstones, containing a meager fauna. A meager brachiopod fauna (sericitic, schists and quartzites) was discovered in the vicinity of Bosilegrad.

Silurian sediments have been found in the mountains of Eastern Serbia (in the core of the Suva Planina Mountains and at the foot of Mt. Rtanj). On Mt. Kučaj they extend in the form of a belt about 3 km wide for a length of 13 km, from Bogovinski

Kamen across the river Radovanska Reka to the course of the Klencuša.

Formations of Devonian age occur in Western Serbia, in the watershed of the Ub River, near Družetić, and in the Gledić Mountains. Devonian sediments with plant remains occur in the core of the Belava and Crni Vrh anticline and in the Svrljig Mountains. A Devonian series (sandstones, sandy clays, and conglomerates) was also discovered in the northern foot of Mt. Rtanj and on Mt. Kučaj.

Younger Paleozoic. — The distribution of Carboniferous formations (continental–lagoonal facies in Eastern Serbia and marine facies in the Dinarids, west of the Rhodopian mass) is considerably more widespread. In Eastern Serbia the sediments contain the remains of a Carboniferous flora and layers of hard coal. In the Stara Planina Mountains the series contains conglomerates, argilloschists, and clayey schists with flora remains. Carboniferous sediments are found in a great syncline in the watersheds of the Mlava and Pek Rivers. Sometimes with iron, silver, gold, molybdenum, and tungsten, shales and schists containing remains of a flora of Carboniferous age have been found in the Suva Planina Mountains and in the granite massifs of Eastern Serbia near Gornjak and Neresnica, as well as in the Stara Planina Mountains. Bismuth and uranium ores are encountered in the foothills of the Stara Planina Mountains.

The Carboniferous in Western Serbia is represented by argilloschist–interlayered sandstones with a rich fauna near Krupanj. A rich brachiopod and coral fauna was discovered in the Tamnava Valley and in Pocerina and Banjevac.

The distribution of Permian sediments is the same as that of Carboniferous ones. The Permian in Western Serbia is represented primarily by limestones (Bastavsko Brdo, Bela Crkva, the Tamnava Valley, and the Valjevo Podgorina) with remains of brachiopods, shells, corals, and algae. In Eastern Serbia the Permian is represented by red sandstones (in the Stara Planina Mountains and in a broad belt extending northwards from the Danube across Vukan, Krepoljin, Senjski Rudnik, Bogovina, and Ozren all the way to the Suva Planina Mountains). Copper ores appear in them in connection with andesite intrusions (in the Suva Planina Mountains near Bončarevo, in the Stara Planina Mountains near Topli Dol, and in the Vukan–Sumurovac region).

Mesozoic. — In the region west of the Rhodopian mass, Triassic sediments with Werfenian layers and a diabase–chert formation (cherts, quartziferous sandstones, marls, diabases, melaphyres) have been discovered near Valjevo, around Užice, and in Stara Raška. The Middle Triassic is represented by limestones and dolomites.

Triassic sediments occur in two zones in Eastern Serbia: in the west from the Kučaj to the Suva Planina Mountains; and in the east in the watershed of the Porečka Reka River to the north and in the region of the Stara Planina Mountains to the south. In the eastern zone, the Triassic lies directly over red sandstones.

Effusion of diabases, melaphyres, and porphyrites occurred in Western Serbia (Krupanj, Zajača, Kostajnik, Tisovik, Medvednik, etc.) during the Lower and Middle Triassic. At the close of the Triassic, water receded from a large portion of the territory of Serbia, so that the Rhodopian mass was joined by a great part of Western Serbia with Šumadija.

The Jurassic (the Upper Jurassic), is marked by a transgression that encompassed the above–mentioned regions. The Lower Jurassic (Liassic) is well developed in Eastern Serbia: in the carbonic layers of Vrška Čuka, around Dobra and Miroč, at the foot of the Deli Jovan and Stara Planina Mountains, and in the Suva Planina and Ruj Mountains (with economically significant layers of hard coal). The Dogger is represented by limestones near Gornji Milanovac, around Crnajka, on Vrška Čuka, and in the Stara Planina and Ruj Mountains. Sandstones with conglomerates and sandy limestones containing a fauna are represented in the base of the Dogger on the mountains of Kučaj and Beljanica. A great transgression that involved even the Rhodopian mass took place at the close of the Jurassic.

The presence of the Malm zoogenic reef facies can be seen in dolomites and limestones (Tithon — Wallendian limestones), that build the karsts and conspicuous ridges of the mountains of Eastern Serbia (Mt. Kučaj, the Suva Planina and Ruj Mountains, Mts. Miroč and Starica, the mountains Veliki and Mali Krš, Mt. Sto, the mountains Rgotski Kamen and Vrška Čuka, and the Stara Planina Mountains). In the anticlinorium of the Suva Planina Mountains, zoogenic reef formations attain a thickness of more than 600 m.

The distribution of Cretaceous sediments is greater than that of Jurassic ones. The depression of a deep sea with bathyal sediments formed in the Lower Cretaceous still exists in Eastern Serbia, extending from Mt. Greben toward the Stara Planina Mountains. Zoogenic reef limestones are formed in other regions of Eastern Serbia as well, their lower parts being constructed of Tithonian limestones. A Hauterivian bathyal facies is represented by marls and marly limestones (Mt. Greben). A Hauterivian neritic facies is developed at the foot of the Svrljiške Planine Mountains and in the eastern foothills of the Stara Planina Mountains, as well as on Mts. Ozren and Devica, and in the Stara Planina Mountains. Around Belgrade, in Šumadija, and in the belt of the Inner Dinarids, the Lower Cretaceous is represented by all of its divisions. Urgonic limestones are developed in Čukarica, on Banovo Brdo, in Košutnjak and Rakovica, on Mt. Rudnik, and in the Gledićke Planine Mountains.

As for the Upper Cretaceous, it is widespread on the territory of Serbia. In Eastern Serbia it is represented by sandstones and shales of a neritic facies with carbonic layers (Mts. Rtanj, Dobra Sreća, Tresibaba, etc.). Zoogenic sandbar formations are well developed. Inoceramic marls are extensively developed in Eastern Serbia, primarily in a Senonian trench. Andesites and their tufas are interstratified in these layers. Occurrences of Upper Cretaceous ores are significant.

Cenozoic. — There are no Paleocene formations in Serbia.

The presence of Eocene flysch sediments has been recorded in the valley of the Pčinja. Strong effusions of andesitic lavas in a tectonic trench continued to take place in Eastern Serbia.

Development of Oligocene marine deposits is limited because the territory of

Serbia in that epoch was dry land with freshwater lacustrine basins. Marine deposits (coralimestones) are developed in the Gnjilane Basin. The coal of the Bogovina Basin in Eastern Serbia is found in Oligocene lacustrine deposits.

Serbia has widespread Miocene sediments, which are present in the Pannonian and Dacian Basins, as well as in some partiular lacustrine basins. Neogene series of the freshwater lacustrine phase (the Vrdnik series on the mountain of Fruška Gora) are the oldest in the Pannonian Basin. Other series include a saline one, the freshwater series in the Velika Morava Bay, ones in the vicinity of Topola and Arandjelovac, and the Posavo–Tamnava series. Tortonian marine deposits are developed in the Velika Morava Bay (Despotovac, Misača, etc.), around Belgrade, and in Northwest Serbia (Jadar, Posavo–Tamnava). The Tašmajdan limestones represent sandbar limestones of the *Lithothamnium* algae, corals, etc.). The Tortonian is coal–bearing near Despotovac.

Occurring in a facies of gastropod, shell, and serpulid limestones, ceritic sands, and piscine schists and clays, the Sarmatian is widely disseminated in Serbia.

It should be noted that Pannonian or Lower Congerian deposits (Vojvodina, the neighborhood of Belgrade, the land along the Danube, northern Šumadija, the Mionica–Valjevo Basin, Posavo–Tamnava) were formed in the freshened waters of the Pannonian Basin following breaking of the connection between it and the Dacian Basin.

For its part, the Dacian Basin encompassed the Timočka Krajina region. Older lacustrine phase of Miocene deposits have been found in the vicinity of Zaječar. The Tortonians developed near Veliki Izvor. Clays occur from Brza Palanka to Štubik. Buglovian layers constitute transition to the Sarmatian, which is represented by clays and sands, conglomerates, and shelly grus. The Meotian floor is well developed and contains shells. Miocene deposits have also been found in the Iron Gate region (Dobra, Donji Milanovac).

Separate lacustrine basins have terrestricolimnic deposits in the guise of marls, sandstones, sands, and clays (the Čačak–Kraljevo, Ibar, Vranje, Jelašnica, Aleksinac, Senj–Resava, Levač, Gruža, Kosjerić, Kremna, and Rakova Bara deposits). They are coal–bearing for the most part and contain rich veins of brown coal. The occurrence of layers of hard coal in the Ibar Basin is attributable to the action of thermal metamorphosis.

Oil-bearing Miocene deposits are present in the Banat region (Jermenovci, Boka, Elemir, Kikinda). Also of significance are deposits of magnesite in the Ibar Basin (Bela Stena), lead–zinc deposits in the Kopaonik–Golija region, cement marls, quartziferous sand, etc.

Widespread Pliocene deposits occur around the southern rim of the Pannonian Basin (Vojvodina, Pocerina, the Kolubara Basin, the neighborhood of Belgrade, land along the Danube near Smederevo, the Kostolac region); around the western rim of the Dacian Basin (the Danube Bend, the neighborhood of Negotin); and in the Kosovo and other basins (terrestricolimnic Pliocene).

The presence of Pontian deposits is evident in the Pannonian Basin, where they emerge on the surface near the insular mountains of Fruška Gora and Vršačka Kula. South of the Sava and Danube Rivers, they are developed in a shallow–water facies of congerian sands, clays, and sands. A layer of lignite 12–14 m thick occurs in Pontian deposits in the Kolubara Basin. The Danube type of Pontian deposits (the Beli Potok Trench, Grocka, Smederevo, Ralja) contain coal, especially those deposits tending toward Smederevo. Paludal layers are developed in the Srem, Bačka, and Banat regions. They are covered by Quaternary deposits (only on the Fruška Gora mountain are they found on the surface).

In the Dacian Basin of Eastern Serbia, Pontian sediments are developed in the region of the Danube Bend (Kladovo) and in the wider vicinity of Negotin (clays with congerias and paradacnas).

Basins of the type having predominantly Pliocene deposits are represented by the Kosovo and the Metohija — Drenica Basins. Thick series of Pliocene sands and clays with deposits of lignite 100 m thick are present in the Kosovo Basin.

There are oil and gas occurrences in Pliocene deposits of the Banat region. Deposits of cement marls (Beočin) and diatomic clays (Baroševac) are significant.

Serbia also has significant Quaternary deposits. Loess deposits in the form of loess plateaus (the Banat, Titel, Tamiš, Srem, and Bačka Plateaus) are present in the Pannonian Basin. They contain remains of mammoth, wooly rhinoceros, etc. Terrace sediments have been preserved in the valleys. Quaternary deposits of clay with cave bear bones have been found in caves (the cave Prekonoška Pećina, the Zlotska Pećina Cave, the cave of Risovača in Arandjelovac, etc.).

TECTONICS

Serbia is characterized by highly complex tectonic relations. The Rhodopian mass was consolidated from former pregeosynclinal space in the central part of Serbia. Already in the Paleozoic it took on the appearance of a meridionally oriented mega-anticlinorium sinking in the north and rising in the south. The anticlinorium is bordered on the east and west by deep dislocation lines with injected basic and acidic magmas. Following tectonic dislocation, the unstable zones migrated from this central zone to the east and west. Those newly formed geosynclinal areas acquired great facial evolutionary differences in the Devonian and especially in the Carboniferous and Permian: thus, lagoonal continental and swamp formations (occurrences of coal and desert red sandstones) developed on the eastern side of the Rhodopian barrier, but predominantly marine deposits on the western side.

In the course of Alpine Orogeny (the Austrian phase), the territory of Serbia underwent strong movements radiating in two opposite directions from the Rhodopian mass. In that period, many nappes were created in Eastern Serbia and the Dinarids. Underwater eruptions of andesite occurred in Eastern Serbia during the Upper Cretaceous.

The Laramian and Pyrenean phases where marked by movement of the upper Cretaceous layers — also in two opposite directions from the Rhodopian mass — with thrusting, shearing, and uplifting of extensive areas and almost total regression of Paleogene waters. The tangential movements of the Pyrenean phase were accompanied by intensive magmatism. At the end of the Pyrenean phase and in the Sava and Styrian phases (and later), radial breakup of the terrains of Serbia took place —in the Rhodopian mass as well as in both lateral regions — with casting of magma. At the margin of the Rhodopian mass, nappe formation continued in the region of the Senje–Resava mines and the Morava nappe. As it moved away from the ancient core, this process crowded onto the earlier consolidated massifs of Mt. Kučaj, the Homolje Mountains, etc. A whole series of deep longitudinal and transverse dislocation lines were formed in Šumadija and Western Serbia. These lines were accompanied by tectonic depressions in which were later formed the basins of Neogene lakes. Casting of dacitic lavas occurred on Mt. Rudnik and across Mts. Kotlenik and Kopaonik all the way to Kosovo Polje (Zvečan) in the south. Radial breakup of terrains with partially younger volcanism continued through the Attic, Rhodanian, and Wallachian phases.

An intermontane depression on a crystalline base, the Pannonian Basin is broken up into a series of blocks. It started to sink already in the Eocene and is filled with Neogenic and Quaternary sediments. The depression is bordered by faults, along which the bottom sank and magmatic masses of sublacustrine origin achieved penetration.

Tectonic movements continuing in the Neogene caused breakup in all regions of Western Serbia. This resulted in the creation of longitudinal and transverse faults with tectonic depressions penetrated by Neogenic waters. Such phenomena include the Kraljevo–Čačak, Valjevo–Mionica, Kosjerić, Požega, Kremna, Podujevo, and Kosovo Basins, etc. On the north are the Mladenovac Basin with its Vlaško Polje and Jasenica parts; and the Kragujevac Basin with its Sabanta and Levač parts. The Drina, Posavo–Tamnava, and Kolubara Basins as well as others are oriented toward the Sava depression. Along the deep Western Morava and Arandjelovac–Lazarevac faults, there are a number of hot and cold mineral water springs (the spa of Ribarska Banja, Trebotina and Čitluk springs, and Vrnjačka Banja spa). Mineral water springs are found on the latter fault (the Bukovička Banja spa in Arandjelovac below Mt. Bukulja and springs on the mountain and around the village of Darosava).

FOSSIL RELIEF

Jovan Cvijić was the first to study the fossil abrasional relief of Serbia. On the basis of morphogenetic and geological investigations on the southern rim of the Pannonian Basin, Cvijić (1902, 1966) formulated his well–known theory as to the abrasional origin of the relief of not just Serbia, but all of the former Yugoslavia. When the relief of Šumadija is observed from one of its mountains, the impression is created that it represents a completely homogeneous and very extensive plateau cut by young river valleys. Rising above this plateau are the mountains of Avala, Kosmaj, Bukulja, Venčac, and Rudnik. However, detailed examination of the plateau reveals that it is not simple, but rather represents several plateaus that underlie each other in stages and withdraw along the present day river valleys. They are separated from each other by scarps that cut across the direction of the young river valleys. These scarps are of erosive rather than tectonic origin. However, neither scarps nor plateaus were created by any one geomorphological process active in the relief today. That erosive process was brought about by the waves of a former lake that stretched far to the south in Šumadija and extended toward the Dinaric watershed.

Recession of lakes in the Pannonian Basin took place rhythmically, from south to north. In the process, lakes stayed longer at certain levels and through the mechanical action of their waves carved abrasional plateaus arranged one below the other.

According to Cvijić (1902, 1966), the upper boundary of abrasional relief in Eastern Serbia lies at the elevation of the Miroč Plateau: 500–560 m. Thus, a Pliocene lake in the Soko Banja Basin attained an elevation of 940 m and was in communication with one in the Crnorečka Kotlina Basin. In so doing, Cvijić equated the elevation of the Pliocene transgression in Eastern Serbia with that of the transgression on the southern rim of the Pannonian Basin. It follows that the entire relief of Eastern Serbia below 940 m is of abrasional origin.

ANCIENT VOLCANIC RELIEF

Serbia today lacks both active volcanism and forms of volcanic relief (volcanoes). However, volcanic activity was intensive and encompassed large areas of Serbia in the geological past. This is indicated by extensive terrains built of volcanic rocks (andesites, dacites, trachytes, rhyolites). Volcanic activity accompanied the entire geological history of Serbia and was completed at the end of the Tertiary (about a million years ago). It passed over into the Pleistocene (the Ice Age) only in places.

Occurrence of volcanic rocks is widespread in Šumadija. It was concluded that Tertiary volcanism occurred in several phases from the Eocene to the Diluvium. On Mt. Rudnik dacitic–andesitic rocks were cast in the Paleogene and Neogene, and volcanic material was also ejected in the younger Pliocene. Basalt casting occurred in the Upper Pliocene to the Diluvium. Volcanism in the Šumadija region is linked with the older and middle Miocene and lasted clear to the Pliocene, when casting of andesite–dacites and rhyolites occurred on the mountains Avala, Kosmaj, Rudnik, and Kopaonik. The youngest volcanism in the vicinity of Kotlenik lasted until the Quaternary and possibly continued into the Quaternary. Casting of andesite–basaltic lavas lasted throughout the entire Pliocene and partly continued into the Quaternary.

Located between the Kučaj, Rtanj, Tupižnica, and Homoljske Planine Mountains, the great andesite massif of Eastern Serbia was built by eruption of lava from the Upper Cretaceous to the Pliocene. Volcanic eruptions were completed “before the Tortonian, and possibly before the Upper Oligocene.”

Evidence of young volcanic eruptions can be found north of Vlasotinci on the right bank of the Southern Morava River. Volcanic activity here began and ended during the Pliocene. The eruptions were very powerful and occurred along the dislocation lines that predisposed the Leskovac Basin. Volcanic material is represented by tuff and breccia. Firm volcanic rocks occur sporadically in the form of lava flows and effusive veins. Volcanic activity was completed in the Upper Pliocene.

From the above discussion it is possible to conclude that Tertiary volcanism left behind enormous masses of eruptive rocks and loose volcanic material. However, the volcanic relief that was built then has today been almost completely destroyed by later erosion, denudation, and breakup of rocks. The typical forms of volcanic relief — volcanic cones with gaping craters — have not been morphologically preserved in the present–day relief. If they exist, they have been in great measure morphologically modified and deformed, so that today it is difficult to reconstruct them with certainty as primary forms of the previously existing volcanic relief. For this reason, it can be asked with justice whether the present–day relief has partially preserved at least fragments of the former primary volcanic relief, or whether such forms occurring in the present–day relief are only pseudovolcanic, created by the work of later erosive processes in volcanic rocks.

HYDROLOGY

UNDERGROUND WATERS

Groundwater on the alluvial plains alongside the indicated and other smaller rivers lies at depths of 2–5 m (at depths of 7–11 m near the banks of rivers when water levels in them are low). The quality of underground water is poor: near settlements it is bacteriologically contaminated, in addition to being hard. The groundwater on river terraces is somewhat deeper (10–20 m), and the water is of better quality than on the alluvial plains. On loess terraces groundwater is scarce in places, and it is of poor quality due to the presence of iron and great hardness. The groundwater on loess plateaus lies at a depth of 18–20 m, except in the valleys of the Krivaja and Čik as well as several depressions, where it is shallower. Underground water in regions of sands lies at great depths, almost everywhere at least 30 m below the topographic surface. Despite the fact that it is very hard and contains much iron, the water in such regions is withdrawn with great difficulty and used for various purposes on account of its scarcity there.

Groundwater is scarce on the insular mountains of the Pannonian Depression. It is therefore of only local significance. The water is of good quality, with little hardness and temperatures of 10–14°C.

REGIME OF UNDERGROUND WATER

The regime of underground water consists of rising or falling of the upper surface of groundwater throughout the month, year, or longer sequence of years. In our country, rising of the upper level of groundwater occurs under the influence of climatic factors (primarily precipitation and air and ground temperature). In valleys with alluvial plains, it also occurs due to changes of the water level in rivers. Falling of the level of groundwater results from its exhaustion after long droughts or from lowering of the water level in rivers. Changes in the level of underground water in Serbia are monitored by 285 groundwater level gages (tubes or boreholes whose lower end is in groundwater and upper end aboveground). The first such gages in Yugoslavia were set up after the Second World War. Since 1 April 1948, they have been used to observe and record height of the groundwater level every 10th, 20th, and last day of the month in Mačva, along the Kolubara River, in the Pančevo Marshes, along the Mlava and Morava Rivers, and in Kosovo and Metohija.

Spring is the season with the highest level of underground water, which usually occurs in April, but sometimes in March or May. Since the precipitation minimum on the territory of Serbia occurs in March, it is clear that the high levels of groundwater in that month are a consequence of melting of the snow cover, i.e., they occur under the influence of snow water. High levels of underground water in April and May are typical of places near rivers, whose high water levels influence the level of underground water through straining of river water through soil of the river's banks.

RIVERS —MARINE WATERSHED SIZE

Serbia has an area of 88,361 km², which amounts to 34.6% of former Yugoslavia. It is drained into three seas.

With an area of 21,506 km² the Vojvodina Province is entirely drained by the Danube into the Black Sea, as is 97.83% (or 54,753 km²) of Serbia in the narrow sense (without its provinces). Only 2.17% (or 1,215 km²) of the territory of Serbia in the narrow sense is drained by the Pčinja and Dragovištica Rivers into the Aegean Sea. In keeping with its geographical position and characteristics of its relief, Kosovo Province is drained into all three seas: 50.74% (or 5,524.61 km²) into the Black Sea; 42.85% (or 4,665 km²) into the Adriatic Sea; and 6.41% (or 697.4 km²) into the Aegean Sea. A hydrographic hub in which all three marine watersheds converge is found on the territory of Kosovo. This hub is the peak Drmanska Glava (1363 m) in the Crnoljeva Mountains above the Kosovo Basin. It represents a unique geomorphological and hydrological phenomenon not only in Yugoslavia, but throughout Southern Europe.

PALEOGEOGRAPHY AND EVOLUTION OF MARINE WATERSHEDS

We see the first clear traces of a marine transgression coming from the direction of Macedonia, i.e., the Aegean Sea, in the southern part of the Gnjilane Basin and Kosovo. This means that greater areas of Serbia then gravitated in that direction than was later the case. Whether or not plateaus at elevations of 2000–2400 m in the Šar Planina, Prokletije, Kopaonik, and Stara Planina Mountains represent the only evidence of this stage can only be guessed.

In the Lower Miocene, a transgression occurred that encompassed extensive areas from Fruška Gora to Metohija. The situation in regard to gravitation of the river network toward the Paratethys or the Aegeis at this time is indefinite. Such inclarity is also evident in the matter of dating high plateaus at elevations of 1600–1800 and 1400–1500 m. The only thing certain is that the lower of these plateaus in the Suva Planina Mountains and south of them was inclined to the south, i.e., toward the Aegean Sea. It would appear that a line drawn from the Suva Planina Mountains to Mt. Kopaonik was the divide between this watershed and the one oriented toward the Paratethys.

In the course of the Tortonian and Sarmatian transgressions from the Paratethys at the time of the plateau at 1000–1200 m, this divide shifted southward to an area whose parallels cross one part of the Grdelica Gorge.

There is a complication at the time of Attic Orogeny in the Middle and Upper Sarmatian, when the connection between the Pannonian and Wallachian–Pontian Basins was broken due to uplifting of the Carpatho–Balkan Arc. As the water level rose during the Pannonian, overflows from the Pannonian Basin apparently occurred from time to time across the Carpathian barriers and along river arms in the region of the Iron Gate to form a delta on the rim of the other basin. However, it would seem that the more lasting orientation of these waters was toward the Aegeis in that period, when a sedimentary connection was established across terrains west of the Grdelica Gorge between the Morava Basin on the one hand and the Vranje–Preševo complex and Skoplje Basin on the other.

A connection was once more established between the Pannonian and Wallachian–Pontian Basins during the Pannonian. The Grdelica Gorge–Prepolac line then took on a more clearly expressed role as the divide between the Black Sea and Aegean–Adriatic watersheds. To be specific, the southern part of the Ibar, the Lab, and the portion of the Southern Morava in the Grdelica Gorge south of Bojišina were then oriented southward.

The given divide between the Black Sea watershed on the one hand and the Aegean–Adriatic watershed on the other was especially pronounced in the post–Pontian period. Meanwhile, differentiation of the Aegean and Adriatic watersheds occurred south of it. The region of Kosovo, i.e., the watershed of the Lepenac River (together with the Ibar, Drenica, Lab, and Sitnica), was part and parcel of the Aegeis watershed, whereas the Dacian–Levantian Lake of Metohija drained into the Adriatic Sea.

As for the Adriatic watershed, it boundaries remained unchanged following the Levantian lacustrine state, which was gradually replaced by the river network of the Beli Drim. However, during the Wallachian and Pasadena Orogenies (somewhat earlier in the valley of the Southern Morava), perturbations occurred on the divide between the Black Sea and Aegean watersheds. The watersheds of the Ibar and Southern Morava Rivers finally acquired their present–day contours. As a result, the Aegean watershed dropped from second to third place with respect to the number of rivers in it.

The indicated orogenic phases also affected the arrangement of the river network within the Black Sea watershed itself. We need only mention the piracy of rivers in the Stara Planina Mountains and the Blatašnica to demonstrate how the Danube as an erosive base influenced this type of watercourse movement.

Climatic changes during the Quaternary also enhanced decapitation in certain parts of the Black Sea watershed.

All things considered, we are able to conclude generally that paleogeography as a reflection of tectonic processes exerted decisive influence on the arrangement of rocks with different lithological natures and thereby on the disposal of erosive expansions and constrictions on the one hand, and shifting of the boundaries between marine watersheds and the orientation of valley systems on the other. All of that occurred in combination with the corresponding climatic changes, which indisputably affected the intensity of geomorphological processes in the river watersheds of Serbia.

KARST

Serbia is characterized by the presence of five morphostructural and geotectonic units: the Dinaric Mountains, the Carpatho–Balkan Mountains, the Serbo–Macedonian Belt of horsts and rift–valleys, and the Pannonian and Pontian Basins. In the present–day relief, carbonate rocks are more or less widespread only in the two mountain systems mentioned. In the zone of the Serbo–Macedonian Belt and in the Pannonian Basin, they occur sporadically or are found under a thick covering of Tertiary sediments (Fig. 1).

Up to the present time, the oldest carbonate rocks have been recorded in the Serbo–Macedonian Belt and at the foot of the Carpatho–Balkan Mountains. They occur for the most part in the form of intercalations (up to 20 m thick) and large lenses of marble and metamorphized limestones inserted in gneisses and chlorite schists. Apart from calcite and dolomite, they often contain quartz and other minerals. On the basis of paleontological investigations, they were preliminarily concluded to be of Proterozoic age. The largest complex of older Proterozoic marbles (11 km^2) was discovered near the town of Prokuplje in Southern Serbia. These marbles arose from shallow–water marine limestones and are now collectors of underground water, that is to say the karst process is expressed in them.

For the most part consisting of marbles and orthomarbles, carbonate rocks of the Cambrian, Ordovician, and Silurian have been discovered at the base of the Carpatho-Balkan Mountains, in the Serbo–Macedonian Belt, and at several localities in the Inner Dinarids. They occur in the form of smaller lenses and intercalations in schists and are fairly impure, without karst phenomena. Dolomites and limestones of Devonian age have been discovered northwest of the West Serbian city of Valjevo, but they still are not distinct from the Carboniferous. Little is known about this carbonate formation because it is mostly covered by younger sediments.

It can therefore be asserted that carbonate rocks of Precambrian and older

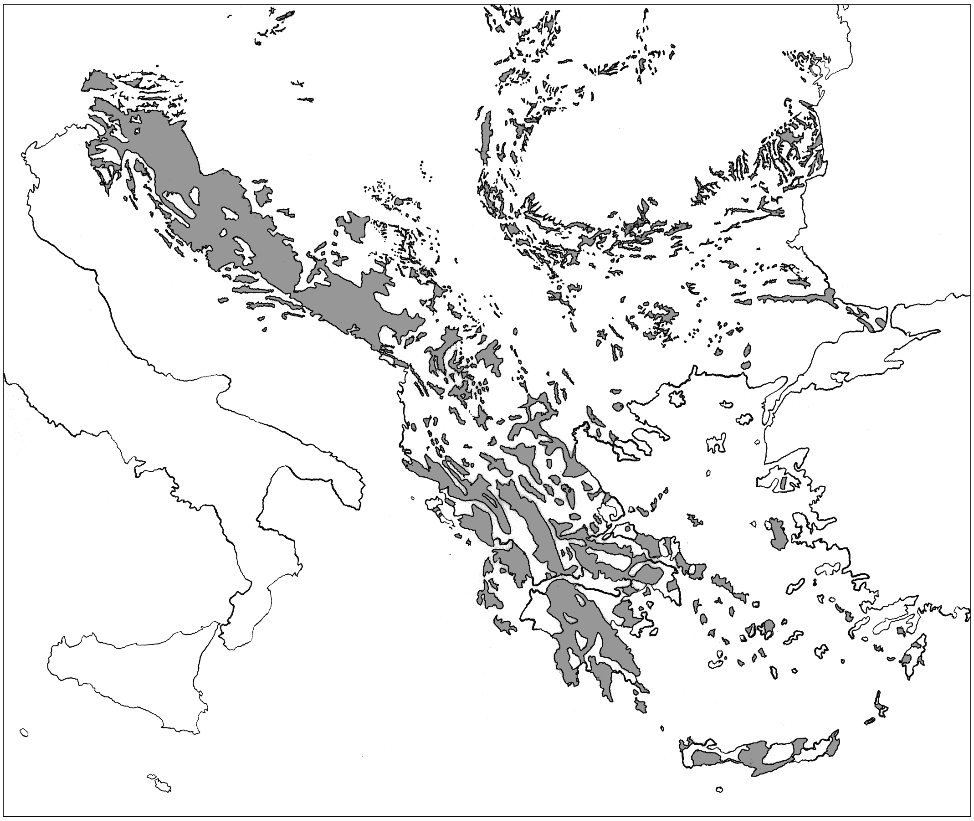

Fig. 1. Karst areas of the Balkan Peninsula (modified after Jakšić, 2006).

Paleozoic age represent a local phenomenon. They are of little thickness, impure, enclosed in impermeable rocks, and karstified in exceptionally rare cases.

In the case of the Dinarids, the carbonate complex rests on an older Paleozoic base. There, the Carboniferous series is primarily constructed of clayey schists, sandstones, and conglomerates, with larger and smaller insertions of limestones and dolomites, in which karst phenomena are encountered. Permian deposits are likewise in large measure composed of clastites, and west of Valjevo are represented by bituminous limestones.

Mainly of a dolomitic character, Triassic limestones are very widespread in the Inner and Central Dinarids. The Triassic carbonate series is discordantly deposited over the Paleozoic and is fairly heterogeneous. In the Central Dinarids, it is covered by extensive layers of Jurassic diabase–cherts, serpentinites, and amphibolites, whose thickness ranges from several tens to hundreds of meters. In most cases, Cretaceous limestones are deposited over serpentinites. In view of the position of serpentine covers within the Mesozoic carbonate series, it is certain that they played a very significant role in development of the karst process, both in upper and lower parts of the limestone. In the Inner and Central Dinarids, the Mesozoic carbonate

Fig. 2. Spreading of Upper Pliocene non-marine aquatorium according to different Russian and other sources. Legend: gray – basins spreading, strippled – supposed ancient connections, not yet sufficiently known (after Krstić et al., 2005).

series is covered by Senonian flysch.

The whole area was dry land during the Paleogene. In other words, the possibility existed for development of the karst process. By action of the Laramian, Pyrenean, and Savic Orogenies, the Mesozoic sediment series was lifted and vaulted in the form of extensive monoclines, anticlines, and anticlinoria, in which horsts and grabens occur as lower structural units. Due to strong lateral thrusts, nappes were formed in several places. The formation of deep grabens where basins later arose and the covering of limestones and dolomites by impermeable rocks exerted great influence on the morphological and hydrological evolution of karst. The higher a mountain range was lifted, the deeper the karst process penetrated the carbonate mass, so that karst was successively developed already from the Upper Cretaceous or more than 70 million years ago.

Development of karst in the Carpatho–Balkan Mountains occurred in Mesozoic carbonate rocks, primarily Cretaceous and Jurassic limestones and dolomites. The Mesozoic carbonate series lies over Paleozoic schists and sandstones. Lower parts of the series most often consist of Jurassic dolomites, which pass over first into bedded, then into massive limestones. The Mesozoic phase of sedimentation was completed at the end of the Cretaceous with the deposition of Senonian flysch. This was followed by the Paleogenic dry land phase, which was characterized by intensive tectonic movements, volcanism, and erosion.

Karst occurs in smaller isolated areas of carbonate rocks, between which are found basins, river valleys, and terrains composed of impermeable rocks. Although thickness of the carbonate series is most often 100–300 m, there are places where it is more than 700 m thick. Besides being broken up in the horizontal direction, it is

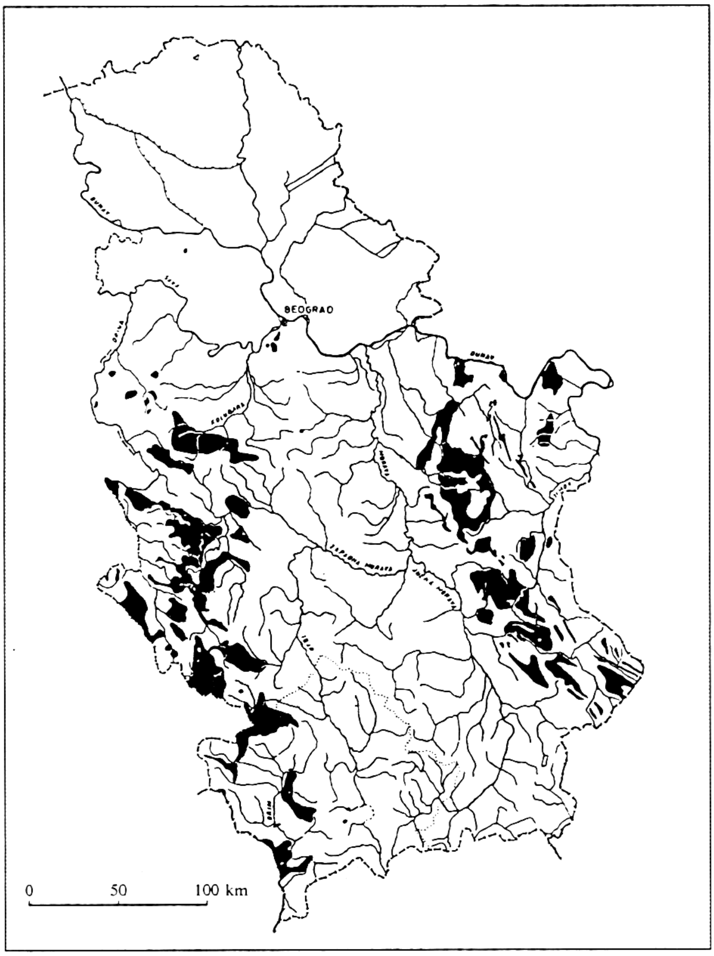

Fig. 3. Karst regions in Serbia (after Gavrilović, 1976).

not uniform in the vertical direction either. Intercalations of marls and sandstones occur between pure limestones and dolomites. Veins of magmatic rocks very often penetrate limestones. On the other hand, the phenomenon of nappe formation is expressed along virtually the entire western rim of the Carpatho–Balkan Mountains. Nappes of Triassic and Jurassic limestones of the "western belt" were formed over Permian–Triassic red sandstones, and then together with them over Miocene lacustrine sediments and Cretaceous limestones in the east. Thus, a broad zone of impermeable rocks is wedged between the western and eastern limestone belts. All of this has caused terrains of carbonate rocks in the Carpatho–Balkan Mountains to take on the characteristics of fluviokarst (Fig. 2).

The beginning of the Miocene was marked by major marine–lacustrine transgressions from the Pannonian and Pontian Basins. Following tectonic depressions, they extended far to the south, flooding lower parts of the relief in the Carpatho–

Balkan Mountains and the Inner and Outer Dinarids. In the course of the Miocene and Lower Pliocene, marine–lacustrine transgressions occurred again several times, leaving thick layers of sediments behind them. Thickness of the Neogene sedimentation series constitutes 100–400 m on the bottom of certain basins, while it achieves a value of 800–900 m in the Morava Depression. Considerable areas of karst were also covered by Neogene sediments. Lakes disappeared at the end of the Levantian in the Pannonian and Metohija Basins and already during the Pontian in other regions. Weakly expressed karst relief is also occasionally encountered in Miocene marls and clayey limestones, which are most widespread south of Belgrade.

We know that conditions favorable for karst development were created already in the Proterozoic, but there is no evidence indicating the existence of karst phenomena older than Carboniferous. If they were expressed at all, Precarboniferous karst phenomena became difficult to recognize due to subsequent mineralogical changes in carbonate rocks.

Exploratory boreholes have indicated that Paleogenic karst relief occurs along the western rim of Beljanica and Kučaj Mountains in the Carpatho–Balkan system. The paleorelief is developed in Cretaceous limestones and is covered by coal–bearing lacustrine sediments, whose thickness is in places greater than 400 m. Dolines, uvalas, and karstified valleys occur in the paleorelief. Two uvalas near the Resavica Mine are about 1 km wide and 100 m deep. Similar karst landforms of Paleogenic age were discovered during mining operations in the Jasenovac–Bliznak coal–bearing zone, on the western side of the Krepoljin–Krupaja Basin.

Among the most unusual karst landforms in Serbia is the extensive cave system discovered in the Stari Trg Mine on the southern slopes of Kopaonik Mountain. In exploration for lead and zinc ores, galleries of the cave system have been surveyed from 730 to 135 m a.s.l. They were formed through the action of thermomineral waters in orthomarbles near their contact with schists. In addition to vertical channels, this system also contains horizontal galleries and halls measuring several tens of meters in diameter. Prior to mining operations, all galleries lying below the bottom of the Ibar River Valley were constantly filled with water. Inasmuch as the potassium–argon method established a Middle Eocene age for Kopaonik granites, it can be asserted with a fair degree of certainty that the indicated cave system arose in the younger Paleogene.

The age of karst relief is a very complicated question because such relief was created parallel with the evolution of fluvial relief, which has still been inadequately studied. In determining the age of fluvial landforms, it is usual to proceed from the position and age of Neogene sediments in the relief, which are most often dated on the basis of paleontological finds. Just as geologists change their minds about the age of sediments and duration of the Miocene and Pliocene, so geomorphologists change theirs about the age of landforms in the relief. Already from the time of Cvijić (1966), it was believed that valleys in Serbia were for the most part downcut and that river terraces reflect brief interruptions in the deepening of valleys, that is to say only the superposition method was used in dating surfaces and river terraces.

For all of these reasons, the age of karst relief can be determined only approximately, often with an error of several millions of years.

There can be no question but that study of the age and evolution of karst relief is a very complex task involving many difficulties. At the same time, however, such study opens up new possibilities for visualizing the essence of the karst phenomenon as a whole. It is likely that future investigations will significantly alter existing ideas about the genesis and age of landforms in the karst relief of Serbia.

PEDOLOGY

The pedological cover in Serbia is highly complex and topologically diverse. This is above all a consequence of the country's geographic position and very specific geological, hydrological, morphological, and bioclimatic characteristics. The possibilities of numberless combinations of all these characteristics, which are sometimes linked causally, converge and are manifested in the form of a very complicated set of pedogenetic factors. Broadly viewed, it is evident that some of the great pedological provinces of Europe extend to the territory of Serbia. They not only reach Serbia, but their influences intermingle within it. The most clearly expressed intermingling is between the Steppe and Forest–Steppe Province of Eastern Europe and the Atlantic Mountain Province of Western Europe, both of which then intermingle with the Mediterranean Province of Southern Europe. The pedological component of relations between the Pannonian, Carpatho–Balkan–Rhodopian, and Dinaric Regions (including Metohija) must be viewed in this light. Herein lies the essence of relations between chernozems, acidic brown soils, and red soils, for example. The intensive dynamics of pedogenetic processes and great diversity of the factors determining them represent another aspect of the extremely complex natural conditions under which soil formation occurred. Without analyzing individual pedogenetic factors other than by stressing their great complexity, it can be asserted that some of these factors had more decisive influence than others on soil formation in Serbia. For example, climate was decisive in some places, human influence in others. However, it is inadmissible to construct any division of the soils of Serbia based on consideration of just one pedogenetic factor. This is true even where it is clear from the pedological viewpoint that certain climatic types of soil can be isolated. The influence of relief, the geological substrate, hydrological relations, and plant and animal life in the Pannonian Region of Serbia is so great that classification by climatic types must be abandoned where the subject of pedological analysis is Fruška Gora, Vršački Breg, or the extensive alluvial plains, depressions, and marshes encountered in the region. For these reasons, discussion of the soils of Serbia in the broader sense must be conducted outside the divisions existing in physical geography. This means that climatic, hydrological, biogeographic, geological, and geomorphological factors must all be taken into account in treating a certain type of soil. Conceived of in this way, every soil type represents the synthetic expression of a special combination of all pedogenetic factors in a given region.

PLANT LIFE

The most important thing to remember about the phytogeographical position of former Yugoslavia is that its territory belongs to two essentially different vegetation — floristic subdivisions of the Holarctic region: Mediterranean and Euro–Siberian–North American. In addition to this, in the high mountains above the upper forest border, a high mountain Alpine–High Nordic region can be found. The Mediterranean region is not represented in Serbia, but Mediterranean influences are more or less felt. In Serbia the Euro–Siberian–North American region is dominant, whereas in the high mountains the Alpine–High Nordic region is also dominant. The Euro–Siberian region in former Yugoslavia is divided into three provinces: Illyrian, Moesian, and Central European. The Illyrian province takes in only the western and southwestern parts of Serbia, the area south of the Jadar River, the regions of Valjevo and Čačak, the area west of the Ibar, and the massifs of Golija and Prokletije. The largest part of Serbia (without Vojvodina) is comprised of the Moesian province. The northern part of Serbia (the largest part of Vojvodina, except for southern Srem, southeastern Banat, and the Vršac mountains) belongs to the Central European region, with a very specific flora and vegetation (a forest and steppe region).

THE HYPOGEAN AND SUBTERRANEAN FAUNA

The Balkan Peninsula forms an irregular, inverted triangle of land which extends from Central Europe in the north to the Eastern Mediterranean to the south, and is bounded on both sides by the Adriatic, Ionian, Aegean, and Black Seas. The northern boundaries are not clearly demarcated by mountain chains, so are not clearly defined (Fig. 1; Stillman, 1966).

From the aspects of genesis of different geological phenomena, it is evident that the historical development of cave-dwelling forms lasted a very long time (Vandel, 1964). If we accept the understanding (Vandel, 1964) that the evolution of cave forms already begins outside of caves, then a possibility that suggests itself is that cave habitats significantly affect the definite adjustment of such animals to the underground way of life. However, the «troglobitic» state is not realized in the course of a single development stage. A «troglophilic» phase of development intrudes between the epigean and strictly cave-dwelling stages. This stage is characterized by great instability of morphological attributes, especially pigmentary and eye structures, as was already considered from the genetic viewpoint by Kosswig (1960a, 1960b).

Terrestrial cave-dwellers in Serbia are usually the descendants of a tropical epigean fauna living in Europe and North America at the end of Cretaceous and at the beginning of the Tertiary period. The tropical fauna subsequently disappeared from these regions; the species changed, were destroyed, or migrated towards the modern tropics. Only in caves have some species survived, since simultaneous karstification provided a wide variety of niches underground, which resulted in a huge new

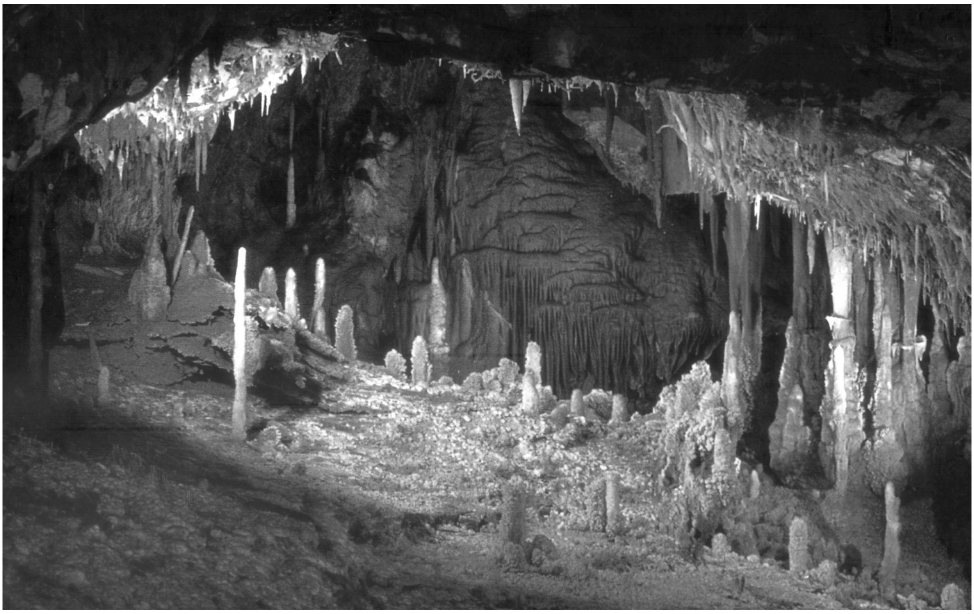

Fig. 4. Bogovinska Pećina Cave in Eastern Serbia.

refugial zone for originally epigean species (Camacho, 1992; Deeleman-Reinhold, 1978; Ćurčić, 1975, 1988a).

Biogeographically, some genera and species of Serbian terrestrial and aquatic troglobites are characterized by a discjuntive distribution. This type of partition can be attributed to successive paleogeographical and climatic changes, since the distributions of these troglobitic animals and their closest epigean relatives correspond to the distribution of the old Mediterranean dry land which existed at the very beginning of the Tertiary period; despite the fragmentation of this land mass since the Eocene, long continuity of the continental phase in the areas inhabited both by the epigean ancestors and their hypogean descendants has been preserved up to the present time. Consequently, the present localities of these genera are probably remnants of their primordial distribution areas (Ćurčić et al., 1997; Dimitrijević, 1988, 1996). The composition of the old thermophilous fauna was not uniform, and regional differences no doubt existed (Juberthie and Decu, 1994). With the Ice Age, its distribution changed. Many species that disappeared in Central and Northern Europe, Siberia, and North America for the most part were pushed south, into refugial zones where climatic and other changes were less unfavorable (Gueorguiev, 1977; Stanković, 1960; Vitali di Castri, 1973).

However, the large and rapid climatic subversion (Ćurčić, 1978a) that brought aridity to the Mediterranean area rendered it uninhabitable by humidity-dependant species, and Serbia, where sufficient moisture was preserved, offered shelter for the retreating and hygrophilic fauna. Among the main causes which have affected the history of cave invertebrates in Serbia, one should emphasize the effects of the

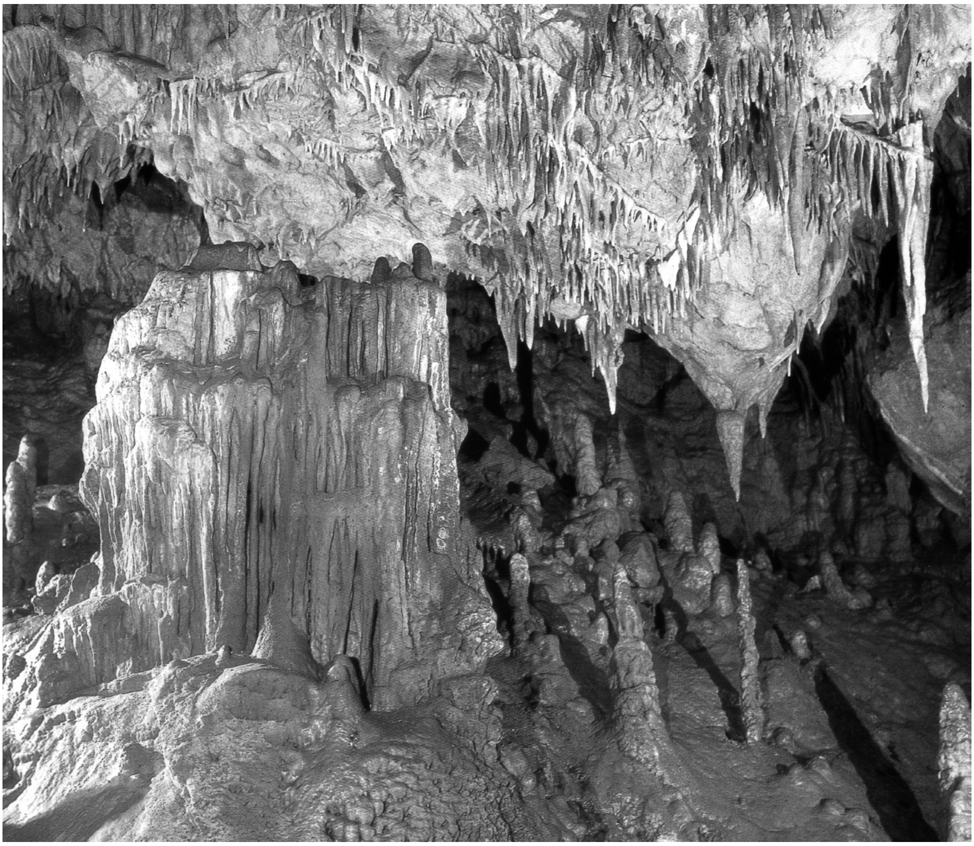

Fig. 5. Potpećka Pećina Cave in Western Serbia.

karstification process (Gavrilović, 1976, 1979; Krešić, 1988). This process is very little known as yet, and its interpretation must therefore be more or less hypothetical. It is evident that the Serbian karst was not developed all at one time; hence its colonization had to have occurred progressively throughout its existence (Hadži, 1941; Ćurčić and Makarov, 1998).

Certain habitats are especially suitable for «preparation» of some animal species for permanent residence in caves. For this reason, it is a basic task of all biospeleologists to investigate surface biotopes carefully before investigating cave biotopes. Thus, the main zones in which differentiation of species as candidates for the cave way of life occurs are as follows: the soil, the edge of long-lasting snow covers, mosses, humus, and interstitial habitats (which represent an environment transitional between external biotopes and the underground world (Ćurčić and Radović, 1998).

*

Protozoa. A number of ciliates have been found on some cave specimens of *Stenasellus* sp. in several caves in Eastern Serbia; however, these taxa have not been

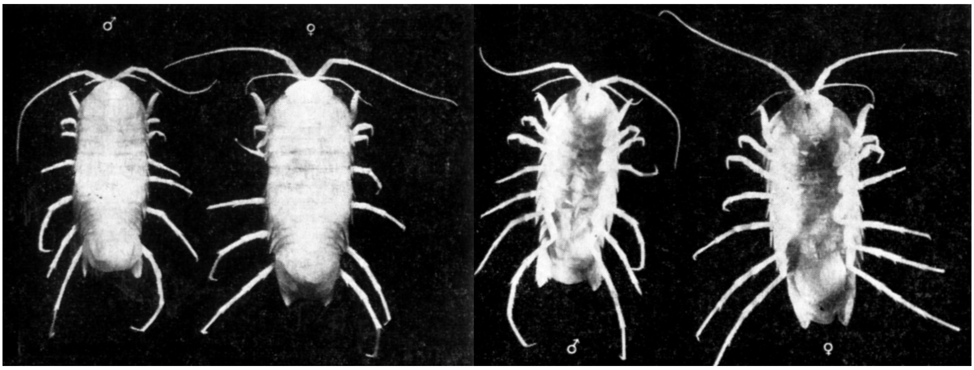

Fig. 6. The cave isopod *Sphaeromides serbica* Pljakić from Southeast Serbia.

described. Furthermore, free living protozoans have not investigated to date.

Turbellaria. Some epizoic and ectoparazitic species of temnocephalids have been noted on certain *Gammarus* and *Niphargus* specimens. The tricladids are far from being fully investigated.

Cnidaria. Pale specimens of *Hydra* sp. were found in the Zlotska Pećina Cave and in the Bogovinska Pećina Cave, respectively; however, these forms are also undescribed.

Gastropoda. Gastropoda are represented by a great number of spring and cave forms, some of them being endemic to the underground waters in Serbia (Table 1).

Oligochaeta. Oligochaeta are represented in caves by a number of (collected) specimens, the scientific analysis of which is the subject of another paper.

Hirudinea. Hirudineans include some predatory depigmented forms, which have not been studied in detail.

Cladocera, Copepoda, and **Ostracoda.** Cladocera, Copepoda, and Ostracoda

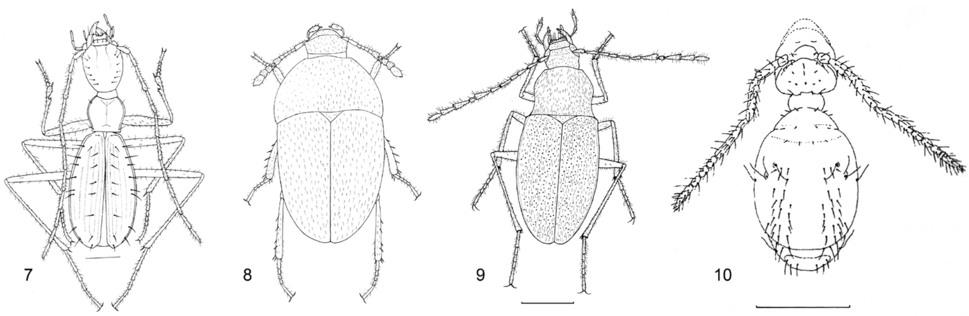

Fig. 7. The cave arthropods *Phegomisetes ninae* S. Ćurčić from Southwest Serbia (7); *Magdelainella zivojindjordjevici* S. Ćurčić, Brajković, B. Ćurčić & Schönmann from Southwest Serbia (8); *Pholeunopsis zlatiborensis* S. Ćurčić, Brajković, B. Ćurčić & N. Ćurčić (9); and *Arrhopalites zloti* B. Ćurčić & Lučić (10).

Table 1. List of cave hydrobiid snails inhabiting Serbia. Abbreviations: S – Southern, E – Eastern, W – Western, BG – Bulgaria, BH – Bosnia and Herzegovina.

Taxa	Distribution
ORIENTALIDAE	
ORIENTALINAE	
Grossuana serbica serbica Radoman	W
Grossuana serbica codreanui Radoman	E/BG
Grossuana serbica remesiana Radoman	E
Terranigra kosovica Radoman	S
BELGRANDIELLINAE	
Sarajana apfelbecki driniana (Radoman)	W/BH
BYTHINELLIDAE	
BYTHINELLINAE	
Bythinella serborientalis Radoman	E
Bythinella drimica alba Radoman	S

Table 2. List of cave trichoniscids inhabiting Serbia. Abbreviations: S – Southern, SE – Southeastern, E – Eastern, W – Western, C – Central, S/Mo – Serbian and Montenegro.

Taxa	Distribution
TRICHONISCIDAE	
TRICHONISCINAE	
Hyloniscus kopaonicensis Buturović	C
Hyloniscus kossovensis Pljakić	S/Mo
Macedoniscus metohicus Pljakić	S
Microtithanetes licodrensis Pljakić	W
Trichoniscus bogovinae Pljakić	E
Trichoniscus serbicus Pljakić	W
Trichoniscus buturovici Pljakić	E
Trichoniscus naissensis Pljakić	SE
Trichoniscus serboorientalis Pljakić	SE
Trichoniscus timocensis Pljakić	E
Trichoniscus sotirovi Pljakić	E
Trichoniscus pancici Pljakić	E
Trichoniscus licodrensis Pljakić	W

Table 3. List of cave pseudoscorpions inhabiting Serbia. Abbreviations: S – Southern, E – Eastern, W – Western, C - Central.

Taxa	Distribution
CHTHONIIDAE	
Chthonius (Chthonius) bogovinae Ćurčić	E
Chthonius (Chthonius) iugoslavicus Ćurčić	E
Chthonius (Chthonius) latidentatus Ćurčić	C
Chthonius (Chthonius) lesnik Ćurčić	E
Chthonius (Chthonius) stevanovici Ćurčić,	E
Chthonius (Ephippiochthonius) bidentatus Beier	W
Chthonius (Ephippiochthonius) kemza Ćurčić, Lee & Makarov	E
Chthonius (Globochthonius) pancici Ćurčić	W
Chthonius (Globochthonius) purgo Ćurčić, Lee & Makarov	E
Tyrannochthonius psoglavi Ćurčić	E
NEOBISIIDAE	
Acanthocreagris ludiviri Ćurčić	E
Neobisium babusnicae Ćurčić	E
Neobisium meridieserbicum Hadži	S
Neobisium rajkodimitrijevici Ćurčić	E
Neobisium remyi Beier	S
Neobisium stankovici Ćurčić	E
Neobisium stitkovense Ćurčić & Dimitrijević	W
Roncus bauk Ćurčić	E
Roncus pantici Ćurčić & Dimitrijević	W
Roncus pljakici Ćurčić	E
Roncus remesianensis Ćurčić	E
Roncus sotirovi Ćurčić	E
Roncus svanteviti Ćurčić	E
Roncus svarozici Ćurčić	E
Roncus svetavodae Ćurčić & Dimitrijević	W
Roncus talason Ćurčić, Lee & Makarov	E
Roncus timacensis Ćurčić	E
Roncus virovensis Ćurčić & Dimitrijević	W
Roncus vitalei Ćurčić & Dimitrijević	W

Table 4. List of cave diplopods inhabiting Serbia. Abbreviations: S – Southern, SW – Southwest, E – Eastern.

Taxa	Distribution
ANTHROLEUCOSOMATIDAE	
Serbosoma beljanicae (Ćurčić & Makarov)	E
Serbosoma crucis (Strasser)	E
Serbosoma kucajensis (Ćurčić & Makarov)	E
Serbosoma lazarevensis (Ceuca)	E
Serbosoma zagubicae (Ćurčić & Makarov)	E
Svarogosoma bozidarcurcici Makarov	E
JULIDAE	
Lamellotyphlus sotirovi Makarov, Mitić, & Ćurčić	E
Serboiulus lucifugus Strasser	E
Serboiulus deelemani Strasser	E
Typhloiulus (Typhloiulus) albanicus Attems	E
Typhloiulus (Typhloiulus) nevoi Makarov, Mitić, & Ćurčić	E
Typhloiulus (Typhloiulus) serborum Ćurčić& Makarov	E
Typhloiulus (Typhloiulus) strictus (Latzel)	E
POLYDESMIDAE	
Brachydesmus (Absurdodesmus) jalzici Mršić	S
Brachydesmus (Brachydesmus) herzegowinensis Verhoeff	SW
Brachydesmus (Brachydesmus) subterraneus Heller	SW
Brachydesmus (Brachydesmus) troglobius Daday	E
Brachydesmus (Stylobrachydesmus) pancici Makarov & Ćurčić	S
Polydesmus (Nomarchus) undeviginti Strasser	S

are common in underground streams and lakes, but have received very little attention so far.

Isopoda. Terrestrial forms of the trichoniscid familiy are represented by a number of endemic species, and the genera *Macedoniscus* and *Microtithanetes* are endemic to the area studied (Table 2). Aquatic isopods are represented by troglobitic species of *Asellus* and *Proasellus,* as well as by *Sphaeromides serbica.*

Amphipoda. Amphipoda include many endemic *Niphargus* species adapted to different niches, as well as a number of relict interstitial forms.

Aranea. In spite of the great number of spiders collected in Serbian caves, only *Centromerus serbicus* is a typical troglobite with no eyes developed.

Pseudoscorpiones. This is a varied group, with many cave endemics and relicts;

Table 5. List of cave collembolans inhabiting Serbia. Abbreviations: SW – Southwest, E – Eastern, W – Western.

Taxa	Distribution
HYPOGASTRURIDAE	
Hypogastrura cavicola Börner	W
NEANURIDAE	
Trojanura mirocensis Lučić & Stanković	E
ONYCHIURIDAE	
Hymenaphorura uzicensis B.Ćurčić, Lučić, S. Ćurčić & N. Ćurčić	W
Onychiurus pancici Ćurčić & Lučić	E
Onychiurus ravanicae Ćurčić & Lučić	E
Onychiurus trojan Ćurčić & Lučić	E
Onychiurus zloti Ćurčić & Lučić	E
Protaphorura zlatiborensis Ćurčić & Lučić	W
ENTOMOBRYIDAE	
Entomobrya pazaristei Denis	W
Heteromurus uzicenzis Lučić & Ćurčić	W
Pogonognathus plumbeus (Templeton)	W
Pseudosinella ivanjicae Ćurčić & Lučić	W
Pseudosinella problematica Gisin & Da Gama	E
Sira platani flava (Apren) Handschin	W
SMINTHURIDAE	
Arrhopalites zloti Ćurčić & Lučić	E
Megalothorax remyi Denis	W
Serbiella curcici Lučić	SW

more than 50 cavernicolous species are known, while a great number of samples collected to the date still await description. Interesting finds include those of the genera *Tyrannochthonius* and *Acanthocreagris* (Table 3).

Palpigradi. This group is represented by a number of new species of *Eukoenenia* and *Pauropus* inhabiting caves and potholes in Serbia.

Opiliones. A new travuniid genus and species (“*Ala*” *serbica)* has been recently discovered and described from Southeast Serbia.

Chilopoda. Chilopoda include some weakly or highly specialized species which have not been described as yet.

Diplopoda. Diplopoda include many cavernicolous anthroleucosomatid, julid, and polydesmid forms, most of them without eyes (Table 4).

Collembola. Many endemic forms of this group live underground; these are

Table 6. List of cave carabids inhabiting Serbia. Abbreviations: S – Southern, SW – Southwest, E – Eastern, W – Western.

Taxa	Distribution
CARABIDAE	
TRECHINI	
Biharotrechus reufi (Pavićević & Popović)	SW
Curcicia bolei (Pretner)	E
Javorella javorensis S. B. Ćurčić, Brajković & B. P. M. Ćurčić	SW
Javorella suvoborensis (Pavićević & Popović)	W
Duvalius (*Paraduvalius*) *stankovitchi devojensis* (Jeannel)	E
Duvalius (*Paraduvalius*) *stankovitchi georgevitchi* (Jeannel)	E
Duvalius (*Paraduvalius*) *stankovitchi stankovitchi* (Jeannel)	E
Duvalius (*Paraduvalius*) *winkleri* (Jeannel)	E
Pheggomisetes ninae S.Ćurčić, Schönmann, Brajković, B. Ćurčić & Tomić	E
Rascioduvalius stopicensis (Jeannel)	W
Rascioduvalius zlatiborensis S. B. Ćurčić, Brajković & B. P. M. Ćurčić	W
Serboduvalius dragacevensis S. B. Ćurčić, Pavićević & B. P. M. Ćurčić	SW
Serboduvalius starivlahi (Guéorguiev, S. B. Ćurčić & B. P. M. Ćurčić)	SW
LEIODIDAE	
LEPTODIRINI	
Anthroherpon taxi boschi (Zariquiey)	S
Magdelainella bozidarcurcici S. B. Ćurčić & Brajković	SW
Magdelainella hussoni Jeannel	SW
Magdelainella milojebrajkovici S. B. Ćurčić & B. P. M. Ćurčić	SW
Magdelainella serbica (Müller)	W
Magdelainella zivojindjordjevici S. B. Ćurčić, Brajković, B. P. M. Ćurčić & Schönmann	SW
Pholeuonopsis (*Pholeuonopsis*) *cvijici* S. B. Ćurčić & Brajković	W
Pholeuonopsis (*Pholeuonopsis*) *magdelainei* Jeannel	W
Pholeuonopsis (*Pholeuonopsis*) *zlatiborensis* S. B. Ćurčić, Brajković, B. P. M. Ćurčić & N. B. Ćurčić	W
Proleonhardella hirtella Jeannel	SW
Remyella scaphoides droveniki Giachino & Etonti	SW
Remyella scaphoides borensis (Winkler)	SW
Remyella scaphoides hussoni (Jeannel)	SW
Remyella scaphoides propiformis (Winkler)	SW
Remyella scaphoides scaphoides Jeannel	SW
Serboleonhardella remyi (Jeannel)	SW

extremely well adapted to life underground (Table 5).

Diplura. Only two campodeids, *Plusiocampa affinis* and *P. denisi,* are known from caves so far.

Coleoptera. Coleoptera represent one of the most important terrestrial groups inhabiting caves. Table 6 summarizes our present knowledge of this old and geographicaly limited fauna, mostly including representatives of both carabids and leiodids.

*

In conclusion, the Serbian karst is inhabited by a great number of endemic and relict cave animals belonging to the Paleo-Mediterranean, Laurasian, Paleo-Aegean, and South- or North-Aegean (or Proto-Balkan) phyletic series (Furon, 1950, 1959; Radoman, 1988, Pljakić, 1978; Ćurčić, 1988).

The major causes of the extraordinary variety of the troglobitic fauna of this region include: i) the varied epigean fauna populating the Proto-Balkans in the remote past; ii) continuity of continental phases in different areas of the Balkans; iii) the presence of mighty limestone beds and subsequent evolution of underground karst relief; iv) succession of suitable climatic conditions favoring the colonization of subterranean habitats; and v) divergent differentiation of different lower and higher taxa in numerous isolated niches underground.

Study of cave inhabitants of the Serbian karst has offered further proofs of their great ages and different origins. These species and genera represent the last vestiges of an old fauna that found shelter in the underground domain of the area studied and its adjoining regions.

Apart from this, it is apparent that specific aspects of geomorphological and climatic events in the Balkans, together with peculiarities of historical development of the fauna there, have caused Serbia to become the main center of dispersion and colonization of species and groups of species, i.e., the main source for the revitalization and genesis of biodiversity not just in the Mediterranean region, but throughout all of Southeast Europe.

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