

## THE DEVELOPMENT OF GEOLOGY IN SERBIA

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**Abstract.** Geology in Serbia began to develop in the first half of the 19th century mainly for two reasons: the endeavours of Prince Miloš to expand the national economy (including mining) and the interest shown by European scientists for an unknown country. When in 1880 Jovan Žujović became the professor of geology and mineralogy at the High School in Belgrade, as the first Serbian geologist who studied in Belgrade and Paris, the development of geology in Serbia was strongly increased. Žujović's successors: Sava Urošević (mineralogy, petrology), Svetolik Radovanović (palaeontology), Petar Pavlović (palaeontology), Vladimir Petković (regional geology), Jelenko Mihailović (seismology) and others continued geological investigations in Serbia.

### PROLOGUE

Although it is held that geology in Serbia was founded as late as 1880, its beginnings can actually be traced much further back. In high schools in Vojvodina, mineralogy was taught since the late 18th century, while the first geological collection was created in Sremski Karlovci in the last decade of the 18th century. The Serbs of Vojvodina also wrote the first natural science books, in which geology and mineralogy were treated to a greater or smaller degree - Z. Orfelin, 1783; A. Stojković, 1801-1803; J. Vujić, 1808; P. Kendjelac, 1811 (Jović 2002). In most cases, these books were revised and translated works by foreign authors, but are important because of their educational role and the beginning of geological terminology in Serbian, that is, Serbo-Slavic. Mineralogy and geology were taught at the Belgrade Lyceum since the mid-19th century.

In the early 19th century, Serbia was a rather unexplored and unknown country in a geological sense. It was known that it had various ores in the antique and medieval times, which enabled the flourishing of the Serbian medieval state, but the Turkish occupation contributed to the destruction of mining and mining tradition. The struggle for national liberation from the Turks imposed the need for metals, especially lead, copper, iron, gold and silver.

In the early 19th century there was no organized mining in Serbia. To some extent, the population living around the one-time Podrinje mines extracted lead ore, processed it and sold either lead or its ore to the dahias. It is probable that lead ore

was also mined in the village of Tornik, at the foothill of Mt Bobija, in western Serbia. Lead was carried on horseback and sold in Užice, Sarajevo and on the Adriatic coast. Certain mining work was also carried out on Mt Avala and in Kučajna.

In 1806, it was decided "... to bring 35 Saxon miners and one engineer to Serbia" (Simić 1951). This decision was carried out and foreign miners came to Serbia that same year already. Some went to Mt Rudnik and some to Mt Avala. Two years later, iron and copper were already mined on Mt Rudnik (for casting and "forging military equipment" – Simić, 1951). It is probable that lead and silver were also mined, the latter being used for coin minting. Vuk Karadžić also wrote about lead mining in 1808 (Jović 2002).

Karadjordje and the insurgent government relied very much on Serbia's mineral wealth, which could not be extracted and processed without foreign experts. In 1809, Karadjordje wrote a letter to Napoleon in which he pointed out that: "Serbia has great wealth in its bosom, such as gold, copper and other ores... There is probably no need for anything else, but for a few masters being familiar with the science of mineralogy and some money to cover the expenses." He also negotiated with the chief commander of the Russian Army in Wallachia "... to send to Serbia two mining officers, who will teach the Serbs about mining" (Simić 1951). Correspondence was also carried on with the French Foreign Minister "... to send to Serbia a skillful mineralogist to ascertain the mineral wealth in Serbia and two foundrymen ..., *pour seconder nos ouvriers*" (Simić 1951).

The diplomatic efforts at organizing mining in Serbia and the initial results achieved in the extraction and processing of various ores were thwarted by the collapse of the First Serbian Uprising. From 1815 to 1835 there was no organized mining, with the exception of the Podrinje mines, which have been run almost continuously since the medieval times.

## 1. THE FIRST GEOLOGICAL EXPLORATIONS

The history of Serbian geology began in 1835 when Baron Sigmund August Wolfgang Herder came to Serbia to explore its mineral wealth (Fig. 1). A Serbian ruler took the initiative once again to start up the economy. Namely, as early as 1834, Prince Miloš appealed to Herder, through an unknown intermediary, to propose a certain number of miners who would help opening certain mines in Serbia. Herder answered Miloš's call and, in October 1834, sent him his proposal "On the Employment of Mining Experts and Workers in Serbian Mining". Prince Miloš was satisfied with the seriousness of this proposal and invited Herder to come to Serbia and assure himself of the potential mineral wealth awaiting experts and a certain amount of capital. Apart from the former mine remains, Herder also had to explore the occurrence of coal deposits and thermal springs and ascertain whether there were some ore deposits at the sites pointing to such a possibility by their toponyms (Železnica, Zlatovo, Slatina, etc.). Prince Miloš was especially interested in salt and coal deposits, since he had already rented several salt quarries in Wallachia and had almost a complete monopoly on salt in Serbia (together with some other enterprising people).

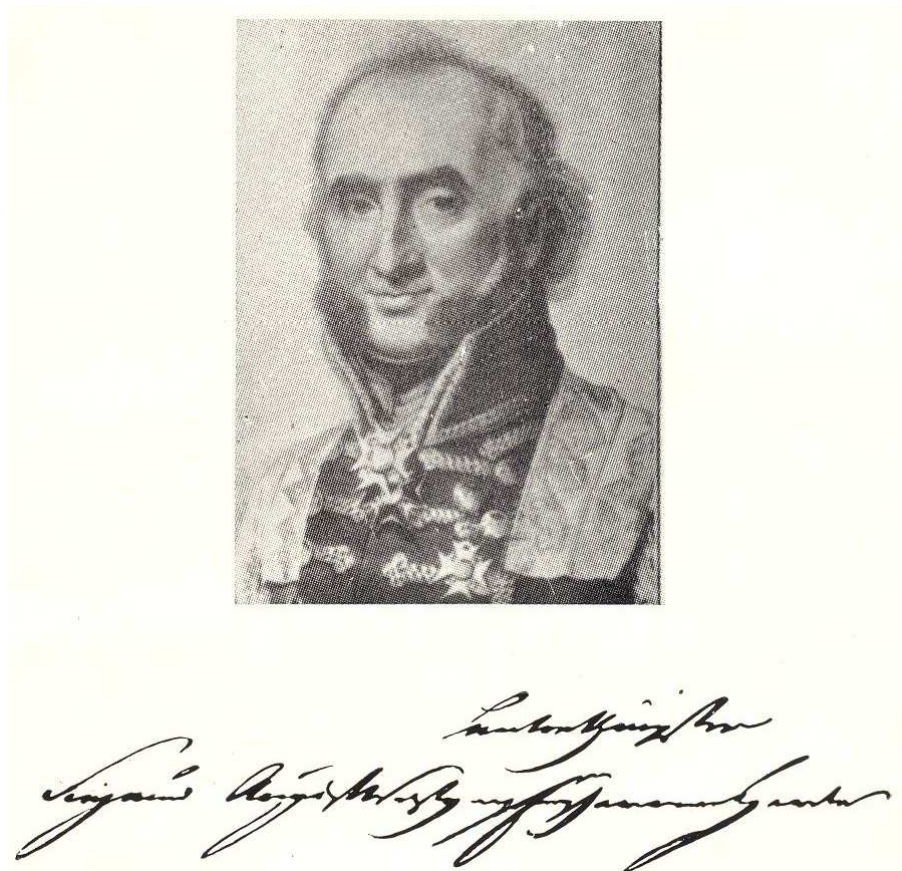


Figure 1: S. A. W. Herder.

Baron Herder was the son of the famous German philosopher and poet, Johann Gottfried Herder, who "introduced our folk poetry in world literature" at the end of the 18th century. The love of young Herder for mineralogy and geology was inspired by his godfather Goethe, who used to take him on a hike through the German mountains.

Herder came to Serbia in 1835 and travelled through it from 24 August to 2 November (10 weeks). During that period, he wrote down his geological and mining observations and, after returning to Kragujevac, edited the manuscript and gave it to Jevrem Obrenović. When his manuscript was translated into Serbian (1845), there began the creation of geological and mining terminology, which was primarily based on colloquial terms, but if the name of something was not known, the German name was adopted and phonetically transcribed (e.g. glimersifer).

Herder arrived in Serbia via Erdely and Banat wishing to form a certain picture of Serbian geology, since he held that there should be some similarities between them.



Figure 2: Ami Boué.

During his travel through Serbia, Herder explored geological relations and visited the sites of special interest due to their ore deposits. He ascertained the abundance of mica schists, slate, gneiss, graywacke, sandstone, limestone, syenite, syenite-porphry, serpentinite, gabbro, etc. As for stratified rocks and ore veins, he measured the thickness, strike and the angle of dip. He also explored thermal springs, measured their temperatures and made some preliminary chemical analyses of mineral waters. Near Rudnjak, on Mt Željin, he discovered a new mineral which he named "miloschine" after Prince Miloš. However, for such a short time he could not see everything so as to be able to form a reliable picture of the geology of Serbia.

Herder's geological observations were published in Serbian, albeit in an abbreviated form, as late as 1845 (*Пударскиј нѣм но Сербѣ*). Next year, the complete work was published in Pest, in German (*Bergmännische Reise in Serbien*). It must also be noted that after his return to Freiberg in 1835, Herder had to write a comprehensive study on Serbia's mineral wealth, but he got sick and died in 1838.

## 2. GEOLOGICAL EXPLORATIONS OF AMI BOUÉ

Ami Boué, a physician by vocation and a geologist by inclination, came to Serbia in 1836 in order to explore not only then Serbia, but also the entire Balkans. Therefore, many regard him as the founder of geology in the Balkans (Fig. 2).

During his studies of medicine already, Boué took an interest in geology and, after completing his studies, attended the courses in mineralogy and crystallography in Paris and Berlin. In contrast to Herder, who came to Serbia without any greater preparations, Boué first travelled through a larger part of Europe, including some countries surrounding Serbia. As early as 1828, he published his first work on the geology of some of our regions, based on what was known at that time and smaller geological collections kept in various European museums. Ami Boué prepared himself thoroughly for geological explorations, so that he even learned Serbian. This is also one reason why his geological explorations were significantly better than those of Herder, who almost "ran through" Serbia. In 1835, on the eve of his travel to the Balkans, he moved with his family from France to the vicinity of Vienna (Fesslau) so as to make it easier. Credit for Boué's coming to Serbia must certainly be given to Vuk Karadžić.

Boué did not travel alone through the Balkans. He was accompanied by the French geologists A. Viquesnel and F. Montalembert, as well as two Czechs: botanist Friedrihstal and zoologist Schwab. They travelled at their own expense, but Prince Miloš not only received them well, but also arranged that they were well received by the county and district authorities in then Serbia.

Boué came to Belgrade in the spring of 1836 and began his geological and other explorations from this city. He ascertained that the sediment rocks in the vicinity of Belgrade were similar to those from the Vienna and Pannonian basins, which he had already studied. He left Belgrade for Kragujevac and, on his way, explored Mts Avala and Kosmaj, that is, the occurrence of Cretaceous sediments and magmatic rocks. From Kragujevac he went to Mt Rudnik, which was already known for lead, silver and iron mining. He also visited Mt Kopaonik, Novi Pazar, Peć and Priština and then went to explore Macedonia, northern Greece and western Bulgaria. From Bulgaria, via Pirot and Bela Palanka, he went to Sokobanja where Prince Miloš was staying. He explored Mt Rtanj and then went to Kragujevac, via Paraćin and Jagodina. Thereafter, he went to Belgrade and then returned to Vienna.

Next year (1837), Boué came again to Serbia, to Belgrade, wishing to explore other parts of the Balkans. He went first to Majdanpek and Golubac, returned to Požarevac and then went to Niš and Leskovac. Thereafter, he travelled through Bulgaria and Turkey, returned to Serbia and, via Vranje, Priština and Prizren, went to Albania. After conducting the planned explorations, he returned to Priština, passed through Metohija, Sandžak and northern Montenegro, and went to Sarajevo. From Bosnia he returned to Belgrade and then left for Vienna. On his way back, he stopped to explore Mt Fruška Gora.

Next year (1838), Boué came to Belgrade and then travelled to Krupanj, Valjevo and Kragujevac. Thereafter, he went to Albania, via Novi Pazar and Plav. After exploring some parts of Albania, he travelled through Greece and Macedonia. He returned to Serbia and then went to Bosnia, via Prizren, Peć and Prijepolje. Thereafter, he went to Vukovar and returned to Vienna by steamer.

Boué spent the following two years in sorting out his impressions and notes, and in preparing his book on the Balkans (then European Turkey) for publishing. This comprehensive work entitled *La Turquie d'Europe* I-IV (European Turkey) has four

volumes (2247 pages) and contains his "Observations about Geography, Geology, Natural Sciences, Statistics, Ethnology, Customs, Archaeology, Trade, Different Governments, Clergy and Political History of this Empire" (the subtitle of his work). With this work Boué became the founder of Balkan geology and many hold that the best part of his book is the one devoted to his geological explorations.

That same year (1840), Boué published separately the part of his book devoted to geological explorations under the title *Esquisse géologique de la Turquie d'Europe*.

The extent to which Boué's work was well received in the Serbian learned circles is also evidenced by the fact that he was elected as a corresponding member of the Serbian Learned Society. At the end of the 19th century, this work was translated into German and published in two volumes under the title *Die europäische Türkei* (1890, Vienna). This shows that the work was still relevant and that many of its parts were unsurpassable for understanding the Balkans, although 50 years elapsed since its publishing in French. And while it took 10 years to publish Herder's work in Serbian, the part of Boué's book devoted to the geology of Serbia waited even 50 years. As late as 1891, the Žujović brothers (Milenko and Jovan) and Jovan Cvijić published its Serbian translation on 157 pages as a supplement to *Geološki anali Balkanskog poluostrva* (*The Geological Annals of the Balkan Peninsula*), Vol. III, Belgrade.

Boué classified stratigraphic formations by age (from the oldest to the latest) and dealt specifically with magmatic rocks, ore deposits and mineral waters. At the end, he compared the terrains of European Turkey to those of the neighbouring countries.

Boué visited almost all ore deposits described by Herder and also revealed other ones, such as those in the vicinity of Golubac, Ripanj, Štavna, Vranje, etc. He devoted special attention to the registration of mineral and thermal waters in Serbia. He also described numerous spas (Brestovačka, Gamzigradska, Niška, Vranjska, Ribarska, Lukovska, Jošanička, Sokobanja). As for mineral springs, he mentioned Palanački kiseljak, Bukovička banja, Višnjička banja and Koviljača.

Boué travelled with one more geologist – A. Viquesnel, who also wrote down his geological observations, based on the routes of their travel. In 1842, Viquesnel published his geological diary, giving more details and more precise descriptions of rocks. He also made the first geological map of our territory. On this map he specifically singled out alluvium, Tertiary, Cretaceous, gneiss terrain, as well as magmatic rocks (syenite, diorite, serpentinite, porphyry, trachyte). Viquesnel was the first geologist who presented the geological relations of certain rocks in Serbia by using cross-sections. The works of Ami Boué and Viquesnel played an exceptional role in the further development of geology in Serbia.

### **3. GEOLOGICAL COLLECTIONS IN SERBIA IN THE LATE 18<sup>th</sup> CENTURY AND THE FIRST HALF OF THE 19<sup>th</sup> CENTURY**

The oldest geological collection was created in Vojvodina, in the Sremski Karlovci High School, in the last decade of the 18th century (Jović 2002). The collection was founded by Andreas Wolny, its principal and professor of natural sciences. Wolny (1759, Šemnic, Slovakia – 1827) first studied medicine in Pressburg and then natural sciences. He came to Sremski Karlovci to teach at its High School, at the invitation

of Metropolitan Stefan Stratimirović. He was a passionate naturalist, especially a botanist, who made the well-known herbarium (*Florae Syrmiensis seu plantarum in Syrmio sponte nascentum. Anno 1797-1801. Centuria I-III*). The extent to which Wolny was a serious naturalist is also evidenced by the fact that he wrote the book entitled *Historiae naturalis Elementa, conscripta per Andream Wolny, Eruditarum Societatum Mineralogiae Jenensis et Botanicae Ratisbonensis membrum. Budae 1805 in 8*.

At the very beginning, the geological collection in Sremski Karlovci had about 800 specimens and was intended for teaching mineralogy in the High School. As early as the mid-19th century, the collection had over 2000 specimens. After Wolny, however, it was neglected. It must also be noted that he discovered a new mineral and named it *Minera Volniya*, but it is not known what it was and whether it really was a new mineral. The extent to which he was familiar with mineralogy is also evidenced by the fact that he was elected as an honorary member of the Mineralogical Society in Jena in 1800.

In the mid-19th century (before 1855), the geological collection was also founded in the Serbian Orthodox Great High School in Novi Sad. It had about 400 mineral, rock and ore specimens, which were acquired in Heidelberg.

In the early 19th century, the museums of Bassano, Vienna, Paris, Freiberg and Berlin housed mineral, rock and ore specimens from Serbia. They were most likely brought by unknown travellers through our regions in the 18th century. During the Austro-Turkish wars (1718-1739), mining was intensified in the entire territory of then Serbia, because the Austrians needed many metals: lead, copper, silver and gold. It is probable that at that time some mineral and ore specimens were taken out of Serbia and found themselves in foreign museums. These specimens were studied by Ami Boué before 1828, when he published his first work on the geology of Serbia.

It is well known that Otto Pirch (1829) and Bois le Comte (1834) travelled through Serbia in the first decades of the 19th century and that they also collected minerals and ores, which they took along.

In 1836, at the invitation of Prince Miloš, the well-known German mining expert, Baron Herder, came to Serbia to explore its mineral wealth. He brought from Freiburg a collection of about 500 mineral and rock specimens from various parts of the world and donated it to Prince Miloš who resided in Kragujevac at that time. During his travel through then Serbia, Herder collected a considerable number of mineral, rock and ore specimens, thus increasing Prince Miloš's geological collection.

Herder's travel through Serbia contributed in large measure to the increased interest of our people in ores. During the preparations for his travel, the Ruling Council instructed all *ispravničestva* (district courts) in Serbia to collect the information from the people about the sites having ore deposits. Thus, during Herder's travel through certain parts of Serbia, the people was bringing to him various ore specimens from their surroundings. This "ore fever" spread to all parts of Serbia visited by Herder. The civilian and military authorities were also collecting ore specimens and sending them to Prince Miloš.

Jovan Žujović writes that Prince Miloš was the founder of the first natural science collection in Serbia: "In his mansion in Kragujevac one could see the bones of pre-

historic animals and other valuable natural objects until he ordered their movement to the military hospital for further care and expansion". While Prince Miloš was residing in Kragujevac, he was taking care of his collection, but after his movement to Belgrade, the collection remained in Kragujevac and was not adequately cared for. Until 1841, the Prince's collection was a part of the Kragujevac Museum and the property of the Ministry of Finance. In mid-1841, the Ministry took renewed interest in the collection, since the work on organized mining was revived. Since the collection could not be immediately moved to Belgrade, the district authorities in Kragujevac were ordered to take special care of it."

Next year (1842), the Ministry of Finance asked the Kragujevac district authorities to send the collection to Belgrade. It was moved to Belgrade at the request of this Ministry and Sigmund Reckendorf, who was in charge of mining in Serbia. Reckendorf sorted out the collection and exhibited it in glazed showcases.

The then Minister of Education, Jovan Sterija Popović, received the collection, which was called the "Mineral Cabinet" at that time, and handed it over to Vuk Marinković, professor of physics, for further care. Since 1845, the Mineralogical Cabinet (as it was called since that year) was supplemented and expanded by the specimens collected, first of all, by graduate students in mining from Šemnic (Dj. Branković, V. Božić, S. Pavlović) during their travel through Serbia, as well as by other experts. At the end of the 19th century, one part of this collection was kept at the Geological Survey, while the Mineralogical-Petrographic Collection of Belgrade's Faculty of Mining and Geology now probably has 100-150 specimens.

#### 4. GEOLOGICAL EXPLORATIONS IN THE MID-19<sup>th</sup> CENTURY

In the mid-19th century, special attention was devoted to coal deposits, primarily for commercial reasons. Coal was explored at several sites in Serbia: near Dobra on the Danube (1846), in the vicinity of Belgrade (1850), in Senj near uprija (1853), etc. After the opening of the Majdanpek mine in 1848, there began more thorough explorations of the minerals at that site (ten or so of specimens were sent to the Geological Survey in Vienna for study). Apart from foreign experts, the first domestic experts, who had been educated abroad, also participated in the geological and mining explorations of ore deposits at Majdanpek. The first chemical laboratory for ore testing was also established there. About the same time, lead and silver were explored at Kučajna (1849). These explorations were led by mining engineer Stevan Djuričić, who had studied abroad. He prepared the report on this exploratory work and made a geological sketch map of Kučajna.

At the beginning of 1854, geological explorations of ore deposits on Mts Kosmaj and Avala were carried out by our mining experts. They discovered former mine remains and some ore fragments around them, thus evidencing ore mining in the past. However, at the end of that period it was concluded that ore mining would not be profitable, so that the explorations were discontinued.

In the mid-19th century, apart from metal ores, quartz sand and clay were also explored: the former in the vicinity of Smederevo (it was used as casting sand in casting ammunition at Majdanpek) and the latter near Slatina (in the vicinity of Valjevo).



## 5. GEOLOGICAL EXPLORATIONS IN RESTORED SERBIA (1854-1904)

The second half of the 19th century was marked by the geological explorations of two great Serbian scientists – Josif Pančić and Jovan Žujović. Their importance for the development of geology in Serbia is also evidenced by the names given to its two phases by their followers: "Pančić's time" (1853-1880) and "Žujović's time" (1880-1914).

Before Pančić, natural sciences were taught by Vuk Marinković, who was interested primarily in physics and the least in – geology. He also wrote the first textbook *Jestastvena povestnica za mladež srbsku History of Natural Sciences for Serbian Youth*, 1851), in which one section was devoted to geology. In 1853, Mihailo Rašković was appointed the professor of chemistry and technology at the Belgrade Lyceum although, apart from natural sciences, he also studied mining. He founded the chemical laboratory at the Lyceum in which geological specimens (ores, minerals, rocks and water) were also analyzed.

## 6. "PANČIĆ'S TIME"

There is no doubt that the most important event in the history of natural sciences in Serbia was Pančić's appointment as the professor of natural sciences at the Belgrade Lyceum in 1853 (Fig. 3). Parallel to other natural sciences, Pančić taught "mineralogy with geognosis". Having no predecessor in this field, he was forced to painstakingly create the basic conditions for the development of geology in Serbia, such as a geological and mineralogical collection, professional library, education of younger experts, etc. As early as 1854, Pančić created a collection of fossils from Torlak hill above Rakovica and sent it to Vienna for paleontological analysis. After studying this material, the renowned paleontologist, M. Hoernes, included the finds from Rakovica in his monograph on fossil mollusks from the Tertiary Vienna basin. As early as 1867, Pančić wrote the first mineralogy and geology textbook, which was used by many generations. He was also the first to study meteorites, the first to emphasize the influence of the geological base on the occurrence and abundance of plants, the first to create a specialized paleontological collection, etc.

## 7. PANČIĆ'S STUDY OF METEORITES

The falling of meteorites to the Earth's surface is not a frequent phenomenon. In the Balkans twenty, or so such phenomena were recorded. Before the Sokobanja meteorite, Pančić already observed two such phenomena in Serbia: the first in Rača Kragujevačka, on 14 October 1849, and the second in Ramaća, on 2 May 1852. When on 1 October 1877 one meteorite fell in the vicinity of Sokobanja (between Šarbanovac and Sokobanja, in Blendija and Dugo Polje), Pančić, as an inquisitive naturalist, rushed there to collect the material (he found eight pieces weighing over 48 kg). He brought them to his office at the Advanced School, studied them and published the results in 1880.

The beginning of Pančić's work on this meteorite is interesting:

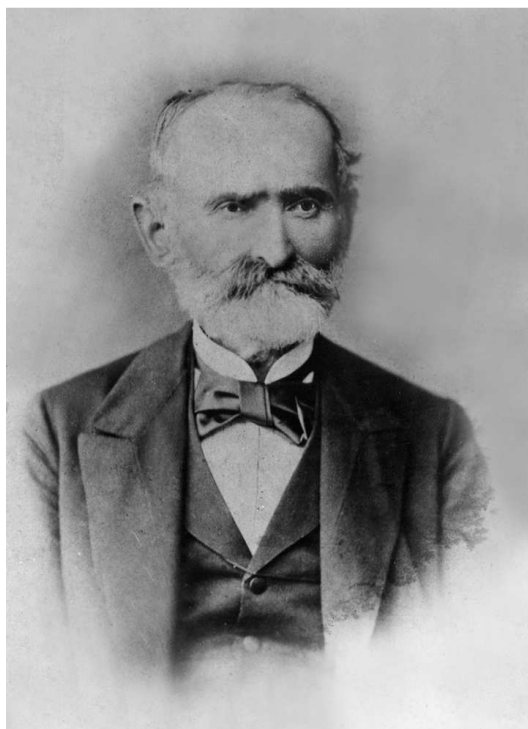


Figure 3: Josif Pančić (1814 – 1888).

”Early in October 1877, there were rumours in Belgrade that something unusual happened near Aleksinačka Banja, that heavy shooting was heard. Given the situation in our country – which was between two wars – it was thought of various possibilities not only in Belgrade but, as we heard later, in Banja as well. Some thought that the Turks crossed the border to attack Banja, while others held that this was a volcanic eruption and many of them immediately recalled the stories of hot rocks which, at times, would fall from the sky. The official reports, which arrived in Belgrade a little later, confirmed the latter opinion. Four pieces of those rocks, sent to our department for keeping by the Minister of the Interior, proved at first glance that they were meteorites and that it would be worthwhile to explore the place where they fell more thoroughly...” (p. 241).

Pančić described each piece, the place where it had fallen, in what direction it had been moving, under what angle and how deep it had penetrated the surface. Then he gave the definition of the meteor, explained how and where meteors occur, what types of meteors exist, how much scientists know about them and what the people think about them. He illustrated all this with various beliefs of the Serbian and other peoples. He also listed the physicists and chemists who studied the physical and chemical composition of meteorites, as well as the scientists who tried to explain their origins.

Finally, he gave the list of meteorites in the collection of the Natural Science Department of the Advanced School in Belgrade, including the year and the place where each meteorite had fallen, the number of pieces and the weight of each of them. The news about the fall of a meteorite in Sokobanja was published in many European countries.

Pančić's letter to Trautshold, geology professor in Moscow, is actually a treatise about the Sokobanja meteorite; he provides the data on its composition and other properties, and negotiates the exchange of meteorites. His letters to K.I. Renar (Moscow), T. Libisch (Berlin), F. Wöhler (Göttingen), Kesselmeyer (Frankfurt), Čermak (Brno), Gregory (London) and Brezina (Vienna) concerning the exchange of meteorites have also been preserved. Pančić also used the collected meteoric material for exchange with various European institutions, thus obtaining other specimens. Thus, he created an exceptional collection of meteorites from other parts of the world (95 world meteorites) but, unfortunately, most of them disappeared during the First World War.

## 8. FOREIGN GEOLOGISTS IN SERBIA

In the period 1850-1880, Serbia was visited by foreign geological and mining experts. In 1856, at the invitation of the Serbian government, Majdanpek was visited by the renowned mineralogist from Freiberg, A. Breithaupt. He acquainted himself thoroughly with its ore deposits and also visited other parts of eastern Serbia. In Gamzigrad, a Late Antiquity site, he discovered a new type of volcanic rocks, which he named "timacite" (after the Latin name of the river Timok – Timacum), as well as a new mineral from the group of amphiboles, which he named "gamzigradite". In 1863, the well-known professor of geology from Freiberg, B. Cotta, travelled in north-eastern Serbia and explored some ore deposits (Kučajna, Majdanpek, Golubac). In 1869, F. Hochstetter carried out geological explorations in the eastern part of European Turkey, including the south-eastern part of Serbia (Vlasina, Vranje, Niš). He ascertained the occurrence of crystalline schists, volcanic and plutonic rocks, as well as alluvial sediments. The following year, eastern Serbia was visited by the Viennese geologist, E. Tietze, who later published several notes and one larger volume devoted to his geological explorations. A little later (1874-1877), J. Szabo, professor of mineralogy and geology from Pest, also visited Serbia. He was accompanied by A.V. Popović, who wrote the report on this travel and published it in 1875 ("Geološke crtice o Srbiji" / "Geological Notes about Serbia" /). Szabo was especially interested in volcanic rocks ("trachytes"), which he also later explored under a microscope. His student L. Erös systematized the collection of rocks collected by Szabo in Serbia and published his work as late as 1892. At that time, another Austrian geologist, F. Toula, also explored south-eastern Serbia. He made two geological maps, one covering the district of Pirot and the other – the region between the Nišava and Vlasina. His stratigraphic and paleontological studies of Serbia's territory provided a sound basis for further research for a long time. From 1867 to 1904, Hungarian geologist A. Koch explored thoroughly Mt Fruška gora (its volcanic rocks, serpentinites, sedimentary rocks, fossil fishes from cement marls, etc.). He also prepared a general geological map.

## 9. "ŽUJOVIĆ'S TIME"

In 1880, Pančić left teaching in mineralogy and geology to his student Jovan Žujović who, after completing the Advanced School in Belgrade, spent three years in Paris studying with the most renowned geologists (A. Michel-Lévy, F. Fouquet). As the first educated Serbian geologist, Žujović invested his modern knowledge and strong will in the formation of the Serbian school of geology (Fig. 4). In only twenty years (1880-1900), he succeeded, together with his students and associates, in achieving something for which other countries needed the whole century. Since he brought a polarizing microscope from Paris, he was the first naturalist in Serbia who used it in his research. Apart from his political engagement and obligations in the Serbian Royal Academy, Žujović found time to study minerals, rocks, ores, fossils, meteorites, coal, stratigraphic and regional geological relations, seismic phenomena and mineral waters, as well as to enrich geological terminology in the Serbian language. Within a relatively short time, he prepared the geological map of Serbia, wrote the basic textbooks, contributed to foreign and domestic journals, founded the Geological Survey of the Advanced School (1889), launched the first geological journal *Geološki anali Balkanskog poluostrva* (*Geological Annals of the Balkan Peninsula*) in 1889 and founded the Serbian Geological Society (1891). It must also be noted that everything that was initiated by Žujović has been preserved to the present day.



Figure 4: Jovan Žujović (1856 – 1936).

Toward the end of the 19th century, Žujović published his life's work, *Geologija Srbije I-II* (*The Geology of Serbia I-II*, 1893, 1900), which encompassed everything that was needed for a country to be regarded, in essence, as geologically explored. Thus, Serbia joined a small number of European countries which were geologically explored in the 19th century.

## 10. ABOUT METEORITES

In Žujović's time, "sky iron and rocks" were falling on Serbia: in 1877 near Sokobanja, in 1889 on Mt Jelica, in 1891 near Guča and in 1919 near Čačak. Those "sky guests" were received by Žujović with the curiosity of a mineralogist, petrographer and naturalist. The Sokobanja meteorite was described and studied by J. Pančić, S. Lozanić and some foreign scientists, while Žujović presented its microstructure in 1891. When meteorites fell on Mt Jelica, he organized the gathering of the specimens and the testimonies of eye witnesses, and then described the specimens, their structure and microscopic composition (1891). He also presented the meteorite from Guča to the Serbian Geological Society in 1891.

The result of Žujović's interest in meteorites was the relevant monograph, as the third volume of his *Petrography* (1895), which is of great significance, since it presented their chemical and mineralogical components, structure, form, various classifications and types. The Serbian meteorites were presented to the extent to which they were studied by foreign and domestic scientists up to then. Thereafter, no other monograph devoted to the meteorites in Serbia came out, although "sky rocks" continued to fall.

One of Žujović's extremely important contributions to the science of geology was the development of the first geologists. Many of his first students were later to become reputed geologists and scientists, such as: Sava Urošević, Svetolik Radovanović, Petar Pavlović, Jovan Cvijić and Vladimir Petković. Žujović selected his best students for his associates. All of them spent some time abroad for advanced study; some of them also received their doctorates in geology and then returned to Belgrade with modern knowledge, ideas and methods. This is also why Serbian geology was keeping pace with European geology until the First World War and in the inter-war period. Together with Žujović, they worked intensively on solving various geological problems: Radovanović was concerned with paleontology and stratigraphy, Urošević with mineralogy and petrography, Pavlović with the Tertiary and Quaternary paleontology and stratigraphy, Cvijić with karst, geomorphology and tectonics, and Petković with the geology of eastern Serbia. Everything that has been initiated or indicated by Žujović was studied by them in greater detail, thus enabling the increase and dissemination of the geological knowledge of Serbia. Parallel to their scientific work, many of them were successfully engaged in the popularization of geology, which gave it a significant place in the cultural circles, at the Advanced School, that is, the University and secondary schools.

In the period 1880-1914, the development of geology in Serbia was linked mostly to the Faculty of Philosophy, the Geological Survey and the Mineralogy and Petrography Department of the Advanced School (that is, the University since 1905), as well as the Serbian Geological Society, whose activity was much more intensive and more

significant than it can be inferred from the preserved records. The end of the 19th century was also marked with the founding of the Serbian Land Museum (today's Natural Science Museum), where P. Pavlović developed exceptional scientific and museum-related activities. To a lesser degree, geological explorations were also carried out within the Mining Department of the Ministry of the People's Economy, which also had the "state geologist" (S. Radovanović was the first).

## 11. GEOLOGY FROM 1914 TO THE PRESENT DAY

During the First World War, from 1916 to 1918, the so-called war geologists – German, Austrian and Hungarian geologists – worked in Serbia. They studied mostly mineral raw materials, but also devoted attention to geological material. The quality of their work was not identical, because they often neglected something that had already been thoroughly explored by the Serbian geologists, so that their conclusions were occasionally wrong and unfounded. It can be said that only the works of F. Kossmat, O. Ampferer and W. Hammer contributed to the geological knowledge of Serbia to some degree.

After the First World War, it was necessary to restore and sort out the collections, libraries and everything else that was destroyed during the war, so that a slowdown in the development of geology in Serbia lasted another few years. It must also be noted that the number of geologists in Serbia was insufficient for its fast recovery. Moreover, within ten or so years, Serbia lost its most significant and most experienced representatives – J. Cvijić, S. Radovanović, S. Urošević, V. Petković, J. Žujović and P. Pavlović died in the period 1927-1938. And while petrography was dominant in the late 19th century thanks to Žujović and Urošević, regional geology and paleontology took the lead after 1918 (V. Petković, V. Laskarev, M. Protić, M. Pavlović, B. Petronijević, V. Simić, B. Milovanović, K. Petković and others). During the 1930s, mineralogy and petrography were given a new impetus (J. Tomić, B. Dimitrijević, M. Ilić, S. Pavlović, etc.). Two geologists especially distinguished themselves in this interwar period: Vladimir Petković and Vladimir D. Laskarev.

After the First World War, geology was introduced in the Faculty of Agriculture and Forestry (agogeology) and the Faculty of Technical Sciences (engineering geology). Engineering geology was introduced and especially dealt with by M. Luković (who taught this subject from 1922 to 1941 and after the Second World War). He also engaged in the hydrogeological study of Serbia. In 1931, after the decades-long efforts, the Geological Institute of the Kingdom of Yugoslavia was established. Its main tasks included the preparation of a general geological map at a scale of 1:100,000 and the conduct of a comprehensive geological study of then Yugoslavia. Until the beginning of the Second World War a number of Serbia's geological map sheets was prepared. The geologists from the Belgrade University were very active associates of the Geological Institute and certainly had a significant role in the geological mapping and study of Serbia.

After the Second World War, the ideological changes in Yugoslavia brought about changes in the conception of the development of geology in Serbia. In 1947, the Geological Institute of the Serbian Academy of Sciences was established with a view

to carrying out geological-paleontological, mineralogical-petrographic and pedological research, as well as the geological mapping of Serbia's territory. Thereafter, the Institute became autonomous and later merged with the Geological Survey of Serbia.

At the University of Belgrade the study of geology was continued at the Faculty of Philosophy (until 1947) and then (since 1947) at the Faculty of Natural Science and Mathematics (Geology/Paleontology and Mineralogy/Petrography Programmes), but the Geology Department was also established within the Faculty of Technical Sciences (1948). The latter evolved into the Faculty of Geology (1949) and later merged with the Faculty of Mining, thus creating the Faculty of Mining and Geology (Geology and Geophysics Programmes). In 1963, the geology programmes within the Faculty of Natural Science and Mathematics were merged with the Faculty of Mining and Geology, thus creating the single Geology Department.

A gradual neglect of the fundamental geological disciplines, while at the same time overemphasizing applied geology, resulted in a slowdown in the development of geology as natural science and its lagging behind European and world geology. It must also be noted that over the past 50 years the curriculum for the study of geology has been changed even more than the science of geology itself.

After the Second World War, the number of geologists of various specialties increased considerably; the geological disciplines were expanded; the number of geological journals and other publications also increased; the geological map of Yugoslavia was drawn up at a scale of 1:100,000; numerous congresses, thematic symposia and conferences were held; a large number of master's theses and doctoral dissertations were defended, etc. On the other hand, teaching in geological disciplines is not conducted at some faculties within the Belgrade University any more and there is also no geology as a teaching subject in high schools.

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The history of geology in Serbia was shaped to a great extent by the socio-historical and political events over the past two centuries. The two Balkan and the two world wars not only suspended the development of geology in Serbia, but also brought about the destruction of geological institutions (Paleontological Survey), libraries and collections (large collections of meteorites and crystals disappeared), as well as the parishing of some geologists (B. Popović, M. Gočanin and others).

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