

PILLOW LAVAS OF THE VAREŠ AREA

Mevlida Operta, Univerzitet u Sarajevu, Prirodno-matematički fakultet, Odsjek za geografiju, Zmaja od Bosne 33-35, Sarajevo, Bosna i Hercegovina
mevlidaoperta@gmail.com

The Triassic deposits in the area of Vareš build the vast majority of the research area. Rocks of the volcanogenic – sediment formation, so called "diabase-chert formation", of the Jurassic age, surround the complex of the Triassic deposits with limestones and spilites. In this area, spilites represent the greatest volcanic mass.

The first researchers have registered these volcanic rocks most often as melaphyres, diabases, and both. Optical tests have confirmed that spilites prevailed, and keratophyres appear subordinate in Borovica on the southern slopes of Kiprovac.

Spilites in the area of Vareš are most commonly found in a "pillow-lava" shape or pillowish lavas that occur in process of submarine volcanism. Ballasting is characteristic of spilites, basalts, diabases, melaphyres and porphyres. Dimensions of spheroids at spilites in the area of Vareš amount from 20 to 40 cm, and rarely to 100 cm.

The outcrops of spilites are submarine-ones as indicated by the "pillow lavas". Cherts point to interruptions of volcanic activities, and tuffs are proof of the existence of explosive eruptions above the water.

During volcanic activities, chunky limestones so called „kremencelkalk“, had been created along with iron ore deposits, as well as heterogeneous breccia with „turbiditic“ characteristics cemented with barite and sulphides, and that was the final phase of volcanic activity.

Key words: Triassic deposits, spilites, pillow lava, ballasting, submarine volcanism.

HISTORICAL REVIEW OF PREVIOUS RESEARCH

Vareš is a very old mining area, known since the time of the Romans. The first geological knowledge and observations about the Vareš area were provided by A. Conrad (1870), R. Halmhacker (1879), then E. Mojsisovic, E. Tietze and A. Bittner (1880).

The significant contribution to knowledge of the Vareš area geological structure has been provided by a famous geologist F. Katzer in the geological map of Sarajevo, ratio 1:200 000, where he marked off the Lower and Middle Triassic around Borovica, and around Vareš melaphyres, amphibolites and other rocks. Especially he marked off ore appearances of iron, manganese, lead and copper.

Intensively geological researches in the Vareš area Triassic sediments zone, where special attention is devoted to complex sulphide ores of lead, zinc and barite, has lasted for decades with less or more interruptions. These researches aimed to define sulphide appearances by position in stratigraphic column, then by mineralogical composition, by genetic characteristics and by chemical composition. Numerous researchers participated in these researches, like Ž. Popović (1929); A. Cisar (1951, 1956, 1957); M. Ramović (1954, 1955, 1956, 1957); D. Veljković (1971, 1973, 1979, 1983); R. Jovanović (1956, 1957, 1961); M. Petković (1962, 1964), S. Karamata (1960) and J. Pamić (1963).

In 1964, in the Vareš area Triassic sediments zone, study geological researches started again with special attention paid to sulphide concentrations. Analyzing individual Triassic

floors in the Borovica area on the base of large paleontological documentation, were done by M. Atanacković, V. Mudrenović and M. Gaković (1968).

The Jurassic, as well as Triassic formation has been detailed processed in papers of: F. Katzer (1904 and 1906); M. Kišpatić (1897); J. Pamić (1963-64); M. D. Dimitrijević and M. N. Dimitrijević (1973); S. Karamata and J. Pamić (1970); J. Pamić and I. Kapeler (1970) and J. Pamić (1971).

Appearances and deposits of chromite from the Duboštica and Tribija (subordinated) areas are linked to the Jurassic formation. There are also appearances of magnesite (Radoševići-Ćuništa) and corundum deposit of Donja Vijaka that are linked to this formation.

Since 1970, amphibolites have been researched in the Vareš municipality area, having in mind that detailed researches were conducted in period 1996 – 2000. The aim of these researches was to determine the possibility of amphibolites' usage as raw material for the architectural-building and technical stone (technical building stone and a raw for the production of mineral wool) – Operta, M. et. all, 1998, 2000, 2004, 2006. Operta, M. (2003, 2004, 2006, 2011, and 2012) conducted mineralogical-petrographic examinations of these metamorphic rocks and geochemical researches of minerals which come into their composition.

The Jurassic-Cretaceous and Cretaceous formation is the least studied. The first data was provided by F. Katzer (1906). He marked off the Upper Cretaceous, in facies of marl limestones and rudist limestones, as well as in flysch facies. R. Jovanović (1957 and 1961) gives paleontological documentation for the Lower and Upper Cretaceous. T. Sliškić (1964), determines the Upper Cretaceous deposits in the vicinity of Budoželj.

With a new geological shooting of the Bosnia and Herzegovina's terrain, which started in 1962 and lasted until 1985, BGM was made in ratio 1: 100.000. A huge progress was made by this, in cognition of geological composition and structure of Bosnian and Herzegovinian space.

Researches of the Middle Triassic volcanic rocks in the area of Vareš, conducted from 1952 until 1983, gave a lot of information on position of spilites and Triassic zone, their mineral and chemical composition, and seclusion of certain varieties inside the zone. Researches of spilites in the area of Vareš have been conducted with the aim of studying the genetic connection between the Vareš vulcanite and iron ore deposits.

In the south wing of the Triassic complex lie significant limestone reserves and spilites effusive mass. This mass rarely appears in several separated bodies, in one of which is „Kota” spilites deposit with „Kota” limestone deposit at its bottom.

In period 1999 – 2001, spilites of the zone's west part were object of the study with aim to determine geological structure, to prove spilites reserves and to define deposits which, according to their qualitative – quantitative characteristics would suit modern market needs (Brđanović et. all, 2000, 2001; Operta, M. 2002, 2004, 2006).

GEOLOGICAL CHARACTERISTICS OF THE VAREŠ AREA

According to determined geological composition and the structure of terrain (BGM of Vareš, ratio 1:100 000), the area of Vareš belongs to the two structural – facial units and they are: central ophiolite zone and transitional zone of Paleozoic cherts and Mesozoic limestones.

During the regional geological researches of colored metals and barite in the area of Vareš (D. Vejković, 1983), separated were Paleozoic deposits in the vicinity of the villages of Daštansko and Brgule. Paleozoic build quartz-mica-chlorite schists, feldspar-quartz clayish schists, lydites and meta-sandstones. These rocks lie beneath sandstones and mica claystones of the Lower Triassic. Most probably they are of Paleozoic age.

The Triassic deposits of northern and southern development type are mutually divided by the Vareš – Nemila fault zone. In the area of Vareš, sediments of the Lower Triassic have the greatest presence, and they are represented by clastites and subordinated carbonates.

In the northern development, among the Lower Triassic sediments prevail quartz sandstones, so called “Sarajevo’s sandstones” (Kittl, 1904) and sandy claystones, while carbonate rocks are not presented. Those sandstones often transform into quartz conglomerates.

Quartz sandstones are in higher parts, and sandy claystones with layered sandstones in deeper. The depth amounts about 200 m.

The southern development type is characterized with fine-grained sandstones with carbonate cement matter, sandy claystones, marls and sandy limestones. At the end of the column are marly dolomites and travertine limestones established in the area of the Daštansko and Pržići (the Borak hill) villages, and they further spread across Droškovac and Smreka all to the Kota locality. The depth of the Verfenic sediments amounts about 400 m.

The Middle Triassic of the Vareš area is presented with crinoid and dolomite limestones, and in the southern development prevail dolomites, limestones, sandstones, siderites and hematites. On the base of content of micro and macro fauna three Anisian zones can be extracted: *Dadocrinus*, *Decurtata* and *Ceratites* zones. According to Pamić and associates, the average depth of these sediments amounts about 200 m (J. Pamić, et. all, 1978).

In the area of Vareš, northern and southern Anisian type can be marked off, and presented are also differences in carbonate composition of the Anisian age.

Dolomite limestones lie over crinoid limestones, and there are also reddish-breccia ones (Han-Bulog type) over which lie massive dolomite limestones of the Zvijezda Mount. Reddish breccia limestones are similar to the Han-Bulog ones, and they probably belong to the *Dadocrinus gracilis* zone, having in mind that dolomite limestones would suit the *Rhynchonella decurtata* zone.

The northern development is presented with coarse-grained sandstones, often conglomerate ones, on which lie crinoid limestones of 60 m thickness. Over these limestones lie massive and gnarled limestones of the Han-Bulog type in which roof we can find massive grey limestones of the Zvijezda Mount. The Anisian is most often presented with massive dolomite limestones. Crinoid limestones are paleontologically proved, and ammonite fauna of the Han-Bulog limestones is often and poorly preserved.

In the southern development, we can find the Anisian age at: dolomites, limestones, sandstones, hematite and siderite.

On transition from the Lower Triassic to the Anisian, one can find marly dolomites or poriferous, dolomite limestones on which lie dolomites, grey gnarled limestones, and then sandy limestones with layered sandstones and, at the end, red Han-Bulog’s limestones with ammonites of the *Ceratites trinodosus* zone. Fe and Mn claystones lie over the Han-Bulog’s limestones.

Transitional deposits from the Anisian to the Ladinian are presented with dolomites and dolomite limestones in the northern, and Fe-Mn claystones with spilites, tuffs, cherts

and grey limestones in the southern Triassic development type of the Vareš wider surroundings. Fe-Mn formations present so called “Vareš productive series” that contain significant concentration of iron ores (hematite and siderite) as well as lead and zinc sulphides with barite. The origin of these sediments is linked to igneous activity, only that its nascence is linked to sedimentation basin to where no volcanic spout can reach. These formations were established around the Borovica village, then around Vareš (Droškovac and Smreka), as well as around the Pržići village (Veovača, Orti and Selište) and less around the Ponikva cave.

In the northern development type presented are limestones, dolomite limestones and limestones, and the southern development is characterized with spilites, tuffs, claystones, cherts and limestones. In both of the types, the Ladinian is paleontologically proved (*Daonelle*, *Posidonia Wengensis* etc.). The northern development is presented with dolomites and dolomite limestones with rare gnarls or lens-like chert inserts. Limestones are usually massive and cannot be different from the Anisian ones.

In the southern development type, the Ladinian is presented with volcanogenic – sediment formation. Of sediment rocks, the greatest distribution belongs to claystones, cherts and plate limestones. Those sediments often alternately change, and they can be layered in places, by tuffs, tuffitic sandstones and spilites.

Spilites represent the greatest volcanic mass in the area of Vareš. In the researched Kota area they represent roof for limestones of the *Ceratites trinodosus* zone and limestones of the *Rhynchonella decurtata* zone, which are presented close to contact with spilites, figure 1.



Fig. 1. Contact between plate and silicified limestones with spilites in the road's cut near the Gašina stijena, Vareš.

The first researchers registered these volcanic rocks most often as melaphyre, diabases, and both. Researches, conducted by M. Petković (1964), Pamić (1963) and Trubelja (1966) have shown that it was about spilites and keratophyres with tuffs and claystones. It has been established by optical tests that spilites prevail, and keratophyres are determined only in Borovica in the south slopes of Kiprovac.

Spilites in the area of Vareš are most commonly found in the „pillow-lava“ shape or pillowish lavas that occur in process of submarine volcanism. Ballasting is characteristic of spilites, basalts, diabases, melaphyres and porphyres. It appears due to unequal cooling of igneous mass and crystallization around irregularly placed centers. Dimensions of spheroids at spilites in the area of Vareš amount from 20 to 40 cm, and rarely to 100 cm (figure 2 and 3.). Going towards east, tectonic damage of spilite is greater and primary textures are not noticeable. On the western slopes of the Mačak hill, schistosity is noticed in places. Fresh spilites are grey-green color and very firm, and under the weathering influence they become hollow and warrn rocks. The decomposition of these rocks increases with tectonic damage intensity.

On the base of optical tests it has been found that spilites often have ophitic, holo to hypocrystal porphyry structure, and rarely fluid texture. Primary mineral components in spilite composition are: albite and chlorite, rarely augite. Accessory components are: magnetite, hematite, ilmenite, apatite, pirite, calcite, epidote, coisite, prenite, sericite, calcedone and caolin isomorph substance. Albit appears in the shape of phenocrystals. They are rarely fresh, most often they are cloudy due to creating a blend of caolin, epidote, coisite and prenite.



Fig. 2. Spilite ballasting in the area of Vareš.

According to Karamata (1953) plagioclase's phenocrysts were probably more bases before, and subsequently they were albitized. Augite appears in massy phenocrysts, and then it is decomposed, chloritized and uralitized, and if they are smaller, then they are usually fresh. Amygdales are most often filled with calcite together with calcedone, and rarely independent crystals can be found (figure 4).



Fig. 3. Spilite pillow lavas occurred by sudden cooling of molten lava in touch with sea water, Vareš.

Within Vareš structure, the Upper Triassic deposits were not proved, so the Jurassic rocks lie discordantly on the Middle Triassic ones.

At the both development types, it is not always possible to extract the Anisian and Ladinian in limestones, therefore those limestones are sometimes shown as undivided Middle Triassic. Most often they are massive or thick banked. These rocks have the greatest distribution in the Zvijezda mountain area. Their thickness amounts about 400 m.

Formations of the Middle and Upper Triassic are distributed in the northwest of Vareš, in the area of tectonic contact between ultramafic and sediments of the Jurassic volcanogenic – sediment formation. Those are usually massive limestones and limestone-dolomite rocks, of total thickness about 300 m. As they are masses of lithologically identical sediments that somewhere contain also Middle Triassic and Upper Triassic microfauna, and mainly they do not contain fossils, they are ranked in the Middle and Upper Triassic formations.

During the previous researches in the area of Vareš, the Upper Triassic age formations have not been established. The Ladinian highest parts made of limestones with cherts may come also into the Upper Triassic.

Volcanogenic-sediment formation, so called "diabase-chert formation" of the Jurassic age is presented with rock complex, thickness about 1000 m. Rocks of these formation surround the complex of the Triassic deposits with limestones and spilites, detailed

researched as useful mineral raw materials. Among the sediment rocks, clastic ones dominates, while cherts and limestones appear subordinated. They are distributed in the north and northwest from the Vareš-Nemila fault zone.



Fig. 4. Spilite sample with amygdales. Vareš.

The part of that formation, F. Katzer (1906) marked off as the Lias deposits (J_1), but R. Jovanović (1957) and J. Pamić (1970) ranked in the Titon-Berriasian (J_3 , K_1). J. Tišljar (1973) made detail mineralogical-petrographic researches on a profile of the Boroviči potok near Vareš and he gave his concluding opinion about the Lower Jurassic deposits, determined as the Liassic ones by F. Katzer (1906), and as the Titon-Berriasian by a R. Jovanović (1957) and J. Pamić (1970), saying that they are flysch serie.

CONCLUSION

The Triassic sediments in the area of Vareš are product of unique sedimentation space in which various occurrence conditions existed. Most likely that sedimentation space is originated at the beginning of the Lower Triassic. By its end, conditions were made for coral development as well as other organisms important for development of carbonate sediments in the Anisian stage.

From the Middle Triassic starts differentiating of sedimentation space that affected also sediments. In the basin's northern part sandstones and conglomerates are deposited, probably due to water reduction and coast nearness. In its southern part, stratified sandstones and claystones with limestones are deposited. As sediments are fine-grained, that refers to deepening of the midst or to selective sedimentation.

Northern and northeast from today's spilites position limestones can be found, and southern and southwest from them, dolomites, dolomite limestones, siderites and ankerites. In the basin's northern part, the sea was clean and warm what brought to genesis of massive limestones. In the basin's south and southwest part, the heterogeneity of carbonate rocks points out jagged basin's bottom and reduction conditions. Therefore, dolomites, dolomite limestones, ankerites and siderites originated in this part of the basin.

Northern from the spilite zone, there are carbonate spilite rock masses with stronger power from the carbonates of development south type.

The outcrops of spilites are submarine-ones as indicated by the "pillow lavas". Cherts point to interruptions of volcanic activities, and tuffs are proof of the existence of explosive eruptions above the water.

During volcanic activities, chunky limestones so called „kremencilkalk“, had been created along with iron ore deposits, as well as heterogeneous breccia with „turbiditic“ characteristics cemented with barite and sulphides, and that was the final phase of volcanic activity.

After cessation of volcanic activity, conditions in sedimentation basin are equalled and mainly cherts deposited with claystones and tuffitic sandstones originated by over-depositing of volcanic material. Increased number of silicium component is in link with volcanism and conditions made for radiolarian development. At the end of the Ladinian, greater carbonate component occurs in sedimentation space, therefore mainly stratified limestones with cherts appear. Those formations are not presented in northern sedimentation space due to rising of that part of the basin's bottom above sedimentation level. Participation of carbonate sediments points out to rising of the sedimentation basin's bottom and creation of conditions for development of organisms which build carbonate sediments.

Literature

- Atanacković, M. Mudrenović, V., Gaković, M. (1968): Stratigrafija i tektonika područja Borovice kod Vareša, Geološki glasnik 12, Sarajevo.
- Brđanović, M., Operta, M. (2000): Elaborat o klasifikaciji i kategorizaciji rezervi tehničkog kamena amfibolita na ležištu Stupčić II kod Vareša.
- Brđanović, M., Operta, M., Kulenović, E. (2001): Elaborat o klasifikaciji kategorizaciji i proračunu rezervi spilita na ležištu "Kota" kod Vareša.
- Brđanović, M., Operta, M., Kulenović, E. (2001): Elaborat o klasifikaciji, kategorizaciji i proračunu rezervi krečnjaka na ležištu "Kota" kod Vareša.
- Jovanović, R. (1957): Razvoj mezozoika u Bosni i Hercegovini. II Kongres geologa Jugoslavije, Sarajevo.
- Karamata, S. (1953): Opšte karakteristike melafira okoline Vareša, Spomenica M. Kišpatića, Zagreb.
- Katzer, F. (1906): Istorijsko razvijanje i današnje stanje geoloških proučavanja Bosne i Hercegovine, Glas. Zem. Muzeja B i H 18, 37 – 68.ž
- Katzer, F. (1919): Das Serpentin und Gabbro-Vorkommen von Kostajnica bei Doboj in Bosnien.-Glas. Hrv. Priir. Društva, 31, 96-97, Zagreb.
- Kišpatić, M. (1897): Kristalinsko kamenje serpentinske zone u Bosni. Rad Jugosl. Akad. znan Umj., 133, 95 – 231.
- Kišpatić, M. (1900): Die krystallinischen Gesteine der bosnischen Serpentinzone.-Wissenschaft. Mitt. Aus Bosnien und Herzegovina, VII, 377-484, Wien.
- Kulenović, E. (1968): Prilog poznavanju zone sa obojenim metalima u povlati željeznih rudišta Vareš, Geološki glasnik 12, Sarajevo.
- Operta, M., Zahirović, H. (1998): Amfiboliti područja Vijake (ležište Stupčić i Pobilje) i njihova primjenjivost, I Međunarodni naučno-stručni skup Zbornik radova, str. 31-42.

- Operta, M. (2000): Exploration, new results and usability of Vareš carbonate, II Međunarodni naučno-stručni skup "Nemetalni anorganski materijali" Zbornik radova, str. 93-103, Zenica.
- Operta, M., Rahić, F., Brđanović, M. (2000): Amphibolites—the source of nonmetallic mineral resources, II Međunarodni naučno-stručni skup "Nemetalni anorganski materijali", str. 283-295, Zbornik radova, Zenica.
- Operta, M., Brđanović, M. (2002): "Kota" deposits of spilites in Vareš, IV Međunarodni naučno-stručni skup "Nemetalni anorganski materijali", Zbornik radova, str. 69-79, Zenica.
- Operta, M., Pamić, J., Balen, D. & Tropper, P. (2003): Corundum-bearing amphibolites from the metamorphic basement of the Krivaja-Konjuh ultramafic massif (Dinaride Ophiolite zone, Bosnia). Mineralogy and petrology, Springer-Verlag. 77, 287-295.
- Operta, M., Salihović, S. (2003): Rezultati istraživanja amfibola iz amfibolitskih stijena u okolini Vareša, Zbornik radova Rudarsko-geološko-građevinskog fakulteta u Tuzli, broj. XXVI, str. 67-73, Tuzla.
- Operta, H., Operta, M., Brđanović, M. (2004): Geološki građevinski materijali područja Vareša, Evropska konferencija o prirodnim građevinskim materijalima, Knjiga sažetaka, 140, Sarajevo.
- Operta, M., Brđanović, M. (2004): Kontrola kvaliteta u funkciji ocjene podobnosti geoloških građevinskih materijala, Evropska konferencija o prirodnim građevinskim materijalima, Knjiga sažetaka, 191, Sarajevo.
- Operta, M., Brđanović, M. (2004): Iskorištenje mineralnih sirovina na primjeru ležišta spilita i krečnjaka „Kota“, Evropska konferencija o prirodnim građevinskim materijalima, Knjiga sažetaka, 113, Sarajevo.
- Operta, M., Balen, D., Pamić, J. (2004): Hemijska istraživanja granata iz metamorfih stijena južnog oboda krivajsko-konjuškog masiva, I Savjetovanje geologa BiH s međunarodnim sudjelovanjem, Zbornik, 81-82, Kladanj, 2004.
- Operta, M., Balen, D., Pamić, J. (2004): Hloriti u amfibolitskom kompleksu na južnom obodu krivajsko-konjuškog masiva, I Savjetovanje geologa BiH s međunarodnim sudjelovanjem, Zbornik, 83-84, Kladanj, 2004.
- Operta, M. (2006): Olovo, cink i barit u metalogenetskoj zoni Borovica-Vareš, VI Naučno-stručni simpozij sa međunarodnim učešćem, „Metalni i nemetalni anorganski materijali“, Zbornik radova, str. 287-293, Zenica. ISBN 9958-785-02-1. COBISS. BH-ID 14793478.
- Operta, M. (2006): Technical stone spilite deposit „Kota“ near Vareš, PAN-Evropska konferencija „Planiranje mineralnih sirovina i transportne infrastrukture, Proceedings, Second book, p. 341-354, Sarajevo. ISBN 9958-9252-2-3. COBISS. BH-ID 14904070.
- Operta, M., Balen, D., Pamić, J. (2006): Hemijska istraživanja granata iz metamorfih stijena područja Vijake na južnom obodu krivajsko-konjuškog masiva (BiH), I Savjetovanje geologa s međunarodnim sudjelovanjem, Zbornik radova, str. 108-112, Kladanj. ISBN 9958-9193-0-3. COBISS. BH-ID 14619910
- Operta, M., Salihović, S. (2007): Hloriti iz metamorfih stijena južnog oboda krivajsko-konjuškog ultramafitskog masiva, Univerzitet u Tuzli, Zbornik radova Rudarsko-geološko-građevinskog fakulteta u Tuzli, broj. XXXIV, str. 7-16. ISSN 1512-7044.
- Operta, M. (2009): Elaborat o klasifikaciji, kategorizaciji i proračunu rezervi krečnjaka ležišta »Stijene« općina Vareš.
- Operta, M. (2009): Elaborat o klasifikaciji, kategorizaciji i proračunu rezervi amfibolita u ležištu Selište kod Vareša.
- Operta, M. (2009): Elaborat o klasifikaciji, kategorizaciji i proračunu rezervi arhitektonsko-građevinskog kamena amfibolita u ležištu »Stupčić I« kod Vareša.
- Operta, M., Hyseni, S., Balen, D., Salihović, S., Durmishaj, B. (2011): Garnet group minerals from the amphibolite facies metamorphic rocks of Krivaja-Konjuh ultramafic massif in Bosnia and Herzegovina. ARPN Journal of Engineering and Applied Sciences (JEAS), Vol. 6. ISSN 1819-6608.
- Pamić, J. & Trubelja, F. 1962, Osnovne geološko – petrološke karakteristike Ozren u sjeveroistočnoj Bosni. Savez geol. Društva FNRJ, Ref. V. Savjet 2, 117 – 123, Beograd.

- Pamić, J. 1964, Magmatske i tektonske strukture u ultramafitima Bosanske serpentinske zone. Poseb. Izdanje Geol. glas., knj.2, 1 – 108, Sarajevo.
- Pamić, J. 1966, Magmatske formacije Dinarida, Vardarske zone i južnih dijelova Panonskog bazena. Monografija, Nafta, Zagreb, pp. 225.
- Pamić, J. 1970a, Osnovne petrološke karakteristike kromitskog područja Dobošnice u Bosni. Geol. glas. 14, 135-148.
- Pamić, J. & Kapeler, I. 1971, Korundski amfiboliti na južnom obodu krivajsko-konjuškog ultramafitskog masiva. Geol. anal. Balk. Poluostr., 35, 399-408.
- Pamić, J. Ščavničar, S. & Medjimorec, S., 1973, Mineral Assemblages of Amphibolites Associated with Alpine – Type Ultramafics in the Dinaride Associated with Alpine – Type Ultramafics in the Dinaride Ophiolite Zone (Yugoslavia), Journ. Petrology, Vol.14, pp. 133 –157.
- Petković, M. (1961): Doktorska disertacija o vareškim ležištima gvožđa. Fond SO Vareš.
- Ramović, M. (1955): Borovica kod Vareša, sedimentno ležište cinka, olova, barita i pirita, Geološki glasnik 1, Sarajevo.
- Ramović, M. (1962): Studije metalogenetske zone Ozren-Vareš-Borovica tokom 1961. godine. Geološki institut Sarajevo.
- Trubelja, F. (1969): Petrološke karakteristike nekih tipova stijena na području Borovice kod Vareša. Glasnik Zemaljskog muzeja sv.8,55-58, N.S.Sarajevo.
- Veljković, D. (1973): Prilog poznavanju ležišta olovo-cinkamih ruda u zoni trijaskih sedimenata Borovica, Vareš, Čevljanovići. geološki glasnik 17, 269-291, Sarajevo.
- Veljković, D. (1989): Prilog poznavanju genetskih i paragenetskih karakteristika kompleksnih sulfidnih ruda olova, cinka i barita u zoni trijaskih sedimenata područja Vareša, Zbornik referata naučnog skupa "Minerali, stijene i izumrli živi svijet BiH", Sarajevo, 73-85.

Author

Mevlida Operta was born in Tuzla, where she went to school. She graduated in Geology at the Faculty of Mining and Geology and also obtained master and PhD degree at the same university. Today, she is an Associate Professor at the Faculty of Sciences in Sarajevo. At the center of her scientific work are geological and mineralogical-petrographic studies. She has published over 80 scientific papers. Most of them represent original research papers, and some have an international review. She is author of four university textbooks. She has participated in the development of projects and studies in the field of geology.