

## NON-METALLIC MINERAL RESOURCES IN THE VAREŠ REGION

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*In the territory of the Vareš municipality there are unlimited reserves of certain mineral resources which have not been technically-economically valorized in the municipality development plans until the beginning of war activities in Bosnia and Herzegovina, due to earlier global commitment to exploitation of metallic mineral resources.*

*This area is traditionally known on production of metallic mineral resources: ores of iron, chrome, manganese, then lead and zinc with barite. It is also very perspective in a domain of non-metallic mineral resources. Geological structure of the Vareš region is heterogenic and its composition is made of igneous, metamorphic and sedimentary rocks with favorable physical-mechanical and technical-technological characteristics regarding their usage as non-metallic mineral resources.*

*This paper presents distribution areas of potential non-metallic mineral resources (amphibolites, spilites, diabases, gabbros, amphibole gabbros, peridotites, limestones, quartz sandstones and so). With the aim of obtaining possibilities in usage of those resources in the Vareš region, the analyze of the former researches' results on the reserves and qualities was carried out, and on the base of acquired qualitative-quantitative characteristics were stated domains of their possible usage.*

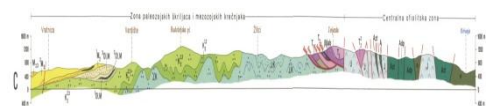
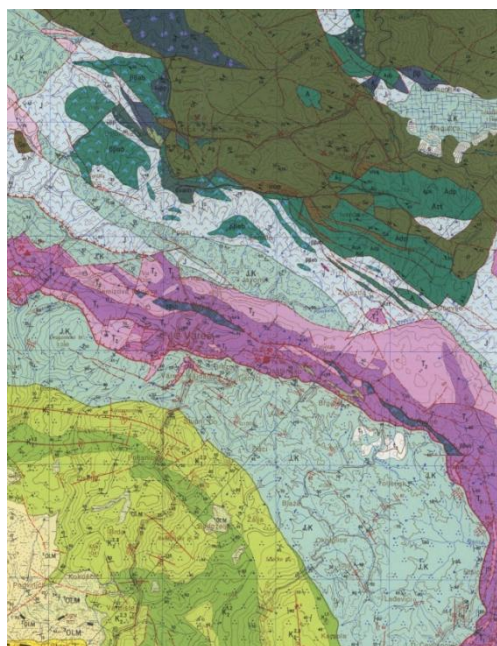
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### INTRODUCTION

The production of non-metallic mineral resources in the Vareš region until the beginning of war activities in Bosnia and Herzegovina has been rooted mainly as following activity of metal production. Numerous smaller or larger limestone quarries and mini pits of quartz sands and sand clays have been opened for the purpose of black metallurgy. For the architecture needs and for building of housing and social objects mainly limestone has been used.

The Vareš region has a very heterogenic geologic structure in which composition all genetic groups of rocks participate: igneous, sedimentary and metamorphic ones. These rocks, depends on the way of genesis, chemical and mineral composition on the structure character, texture, etc., posses certain physical-mechanical and technical-technological characteristics, which determine the degree and domain of their availability as non-metallic mineral resource.

Among non-metallic mineral resources the most detailed researched were spilites, amphibolites and limestone suitable as raw material for the production of technical-building material, architectural-decorative stone and stone wool.



**Fig. 1. General geological map of the area of Vareš and geological profile**

municipality should be the production of decorative stone, technical stone and raw for the building material production.

## ARCHITECTURAL-BUILDING OR DECORATIVE STONE

Very close to Vareš there is great number of basic, ultrabasic and metamorphic rocks, which, according to the physical-mechanical characteristics on decoration, color and durability, can satisfy world rates on the quality of this stone. The top priority for this purpose belongs to amphibolites, then gabbros and amphibole gabbros, gabbro-peridotites, dolerites and amphibole-dolerite rocks, diabases and spilites.

In the Vareš region so far, three deposits of architectural-building stone have been found: Donja Vijaka, Crni potok and Stupčić. By detailed researches, reserves were determined and it was proved that amphibolic rocks can be used for the production of raw blocks, plates and souvenirs.

Completely processed amphibolic plates have a high shine, well edge holding, expressed texture and extremely beautiful green color. It is stated that of the most beautiful examples of this stone one can make tables and benches, in combination with wood and decorative tin, jardinière, ashtrays, vases and other souvenirs.

## PHYSICAL-MECHANICAL CHARACTERISTICS IN THE VAREŠ REGION

On the base of previously conducted regional and detailed engineer-geological researches and dedicated investigations on certain rock types by standard and ungraded methods, data were recapitulated on physical-mechanical characteristics for certain rock types. Valuations of certain physical-mechanical parameters indicate huge differences in numeric values, within the same rock types, for which there are countless reasons. The first important factor which affects qualitative changes of rocks is connected to the way of their genesis and necessary changes that happen inside them, during geological life. It means that silicate minerals in igneous and metamorphic rocks only under the certain thermodynamic conditions can be stable, while changing these conditions results in their disintegration, chemical decay and transformation, and that, as a consequence, has drastically valuation fall on physical-mechanical characteristics.

According to disposal resources, future orientation in development of the Vareš

Plates acquired from green amphibolites decorated numerous office spaces and memorial objects, among which dominant place belongs to:

- The Federal Invest bank in Sarajevo
- The Monument to the Shahids of VII Motorized Brigade in Zenica (fig.2.).



**Fig. 2. Martyrs Monument in Zenica of amphibolite**

Within gabbros mass, one can also notice transforming gabbro amphibole rocks which appear in contact parts with surrounding ultramaphites, which is amphibolites, such as Han Kopaliste mass.

In the Vareš municipality, diabases appear in products of volcanogenic-sedimentary formations and with dolerite rocks between Borovičke arable lands and Duboštica. In comparison to diabases, spilitis are more presented, and the greatest spilit masses are in direct vicinity of Vareš.

The size of Jurassic spilitis varies from several m<sup>2</sup> to massifs, such is the case in the Tribije space or on the west part of Municipality close to Igriste, Borovičke njive (arable lands) and the River Ravnja Rijeka. For the purpose of evaluation of freshness and facility degree for decorative stone, spilitis out of the Vareš Triassic structure should be the subject of the future detailed researches. Spilit reserves are unlimited, and their quality is such that they can be used for all kinds of coatings of horizontal and vertical interiors and exteriors.

Out of sedimentary rocks, as decorative stone one can use massive monolithic blocks of limestones, dolomite limestones, conglobreccias and breccias. Fresh parts of these rocks, which cannot be used as architectural-building stone, one should use as technical stone for all kinds of building objects, because their quality is such that it can satisfies strict quality norms.

## TECHNICAL STONE

Vareš is potential area for exploitation of technical stone, except those parts which were built of Jurassic volcanogenic-sedimentary formations, flysch products of Teton – Lower Cretaceous and clastic-carbonate rocks of Ladinian layer. About 40% of the territory of Vareš municipality represents resource base for the production of quality technical stone. Regarding sedimentary rocks, the advantage should go to: limestones, dolomites, dolomite limestones and fresh quartz sandstones.

Amphibolites are the most researched rocks which represent different kinds of amphibole shales and quite subordinate amphibolites. They take the area of cca 23 km<sup>2</sup> and they are situated on the north and northeast from Vareš. The beginnings of researches on these rocks date from 1971 and more bulky investigations started in 1990, and in a period 1996 – 1999 they achieved impressive intensity. Investigations of basic parameters on quality, chemical and mineral composition as well as physical-mechanical characteristics were done in ZRMK – Ljubljana, the Geo Institute Sarajevo, Traffic Institute at the Faculty of Civil Engineering in Sarajevo and the Mining Institute in Tuzla. By these investigations it was determined that amphibolites from the Vareš region can be used in the production of:

- Stone aggregates for tampon and concretes
- Stone aggregates for lower and upper bituminized bearer layers of all traffic loads
- Stone aggregates for asphalt mixtures of bearer layers 2, 3, 4, and 5 group of traffic loads
- Stone aggregates for gravel



Fig. 3. Amphibolite.

Amphibolites and other basic and ultrabasic rocks represent very quality raw for the production of thermo-isolative material necessary in building practice. Laboratory investigation on amphibolites availability for the production of mineral wool, were performed in 1990 in ZRMK Ljubljana and in 1991 in the Jozef Stefan Institute in Ljubljana. During the 1991, research on amphibolites was done in the DD Termika Novi Marof plants. The results on these testing confirmed the amphibolites availability from the Vijaka territory (localities of Selište, Stupčić, and Šarena kuća) for the production of mineral wool.

During the 1991 investigation on amphibolites were performed in the DD “Termika” Novi Marof plants. The report on the industrial probation of the amphibolites stone close to Vareš, performed in the stated institution, says that the researched stone is usable in the production of mineral (stone) wool. Common conclusion, for all of the conducted analyses reads: “Vareš amphibolites in all criteria are appropriate for the production of mineral fibers.”

To the complex of Middle Triassic products which stretch from the village of Semizova Ponikva on west to the Mačak hill, on outmost southeast of the Vareš region, also belongs the “Kota” spilit deposit, which in period 1999 – 2000 was the subject of detailed researches, with aim of proving spilit reserves and defining of deposit which, according to quantity and quality, would address to today’s market needs. The results on investigation of basic parameters of quality, chemical and mineral composition, as well as physical-mechanical characteristics, indicated on possibilities of spilit application in the sphere of production of technical stone and mineral (stone) wool.

Spilit, from the “Kota” deposit close to Vareš, represents favorable resource for the production of:

- Fractions of stone aggregate for the purpose of designing of asphalt mixtures (AB and BNS);
- Gravel aimed for curtains railway line ;
- Mixture of stone aggregate for production of DNS road constructions of roads – tampons.

Crushed stone aggregates, made of stone – spilite from the "Kota" deposit have found their appliance since the asphalt mixture built in worn layer "Sarajevo West Roundabout" and the same road's bridge was made on the base of these aggregates. The Čekaluša Street in Sarajevo is covered with worn layer, made of spilite fraction aggregates.

Out of sedimentary rocks, as important resource one can use limestone which is broad spread on the area of Vareš with length of 10 km and thickness about 300 m. For the industrial lime production, we can use limestone with over 92% of  $\text{CaCO}_3$  and small content of  $\text{R}_2\text{O}_3$  ( $\text{Fe}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3$ ) and for this purpose we can also use limestone from Triassic Vareš structure as well as limestone from carbonate flysch series of Upper Cretaceous. Limestone from the "Stijene" quarry satisfies the stated criteria, what was confirmed by investigation on limestone chemical composition in the "Geomin" Institute, Germany, in 1999. Limestone from the "Stijene" deposit can be used for the production of two groups of products:

- I products of natural limestone by crushing and grinding (limestone for neutralization, filler of natural limestone for colors, varnishes, adhesive etc).
- II products of lime (hydratized lime, autoclave lime, building lime, hard fired lime etc.)

Among products of grinding natural limestone, the simplest one is limestone for neutralization of agricultural land, very necessary one, concerning the fact that in the area of about 100 km around Vareš over 70% of agricultural land belongs to acid soil.

Regarding the usage of massive bank limestone of the Middle Triassic age, which participates in geological structure of the "Stijene" quarry, laboratory investigations on limestone technical and geo-mechanical characteristics were conducted at the Institute for materials and constructions at the Faculty of Civil Engineering in Sarajevo 1983, and at the Institute for civil engineering, building materials and non-metals in Tuzla 1988.

Acquired results on mineral-petrographic examinations, chemical analyses and examinations on physical-mechanical characteristics of stone and fraction aggregates from the "Stijene" quarry, reveal that the examined material satisfies the standard conditions in appliance and that it can be used as:

- Mineral mixture aimed for building of upper bearer layers, made of bituminized materials (BNS) of road constructions for all kinds of traffic loads;
- Mineral mixture aimed for building of worn layers of road constructions with middle, slightly and very slightly traffic load;
- Concrete mixture for cement concretes of BI class (MB 10, 15, 20, 25, 35, 40) with max grain  $d-16$  mm;
- Concrete mixture for cement concretes of BII class with max  $d-16,0$  mm;
- Mixture of stone aggregate aimed for building of lower bearer layers of roads-tampans road constructions;
- Gravel for curtains railway line;
- Raw in the industrial production of lime and metallurgic raw.

On the base of former researches (geological, laboratory, technological and mining) on amphibolic rocks from the Vijaka region performed several times in periods 1971 – 1974, 1980 – 1981, 1990 – 1991, two deposits of technical stone were sorted out, which also satisfy the quality highest standards.

On the base of physical-mechanical examinations, limestone from the "Kota" deposit, close to Vareš, is favorable resource for the production of:

- Fractions of stone aggregates aimed for designing of asphalt mixtures;
- Fractions of stone aggregates aimed for designing of concrete mixtures;
- Mixtures of stone aggregate for building of DNS road constructions of roads-tampons.



**Fig. 4. Limestone deposit „Kota“**

and breccias from the Upper Cretaceous flysch as well as metamorphic rocks (amphibolites).

## CONCLUSION

The Vareš region, traditionally known on production of metallic mineral resources: ores of iron, chrome, manganese then lead and zinc with barite, is perspective also from the aspect of finding non-metallic mineral resources. In a domain of non-metallic mineral resources, the greatest priority goes to amphibolites, then gabbros and amphibole gabbros, gabbros-peridotites, dolerites and amphibole-dolerite rocks, diabases and spilites. Among non-metallic mineral resources, the most detailed researched spilites, amphibolites and limestones are favorable as raw for the production of technical-building materials, architectural-decorative stone and stone wool.

On the base of former researches' results, three architectural-building stone banks were found: Donja Vijaka, Crni potok and Stupčić. Then the reserves were determined and it was proved that amphibolic rocks can be used for the production of raw blocks, plates and souvenirs.

Plates acquired from amphibolites decorated numerous objects among which dominantly take place: The Federal Invest Bank in Sarajevo and The Monument to the Shahids of VII Motorized Brigade in Zenica.

Vareš is potential area for exploitation of technical stone, except for those parts made of Jurassic-volcanogenic-sediment formation, flysch products of Teton-Lower Cretaceous and Clastic-Carbonate rocks of Ladinian layer.

Amphibolites and amphibolite shales from the Vijaka region are the most researched rocks which represent various kinds of amphibolite shales and quite subordinate amphibolites. On the base of former investigations (geological, laboratory, technological and mining) on amphibolites from the Vijaka region, which have been performed several times, two technical stone deposits were sorted out which satisfy the highest quality standards as well.



Investigation results confirmed that amphibolite rocks represent very qualitative raw for the production of stone aggregates for tampon, concrete, asphalts as well as for the mineral wool production.

Spilite bank "Kota" belongs to the complex of middle Triassic formations which spread from the village of Semizova Ponikva on west, to the Mačak hill on outmost southeast. The investigation results on basic parameters of quality, chemical and mineral composition, as well as physical-mechanical characteristics indicate possibilities of spilite appliance in the sphere of technical stone and mineral (stone) wool production.

Crushed stone aggregates, made of stone – spilite from the "Kota" deposit have found their appliance since the asphalt mixture built in worn layer "Sarajevo West Roundabout" and the same road's bridge was made on the base of these aggregates. The Čekaluša Street in Sarajevo is covered with worn layer, made of spilite fraction aggregates.

Spilite reserves are huge and their quality is such that they can be used for all kinds of coverings of horizontal and vertical interiors and exteriors.

Concerning sedimentary rocks, the followings have the advantage: limestones, dolomites, dolomitic limestones and fresh quartz sandstones. Limestone of Triassic Vareš structure and limestone from Upper Cretaceous carbonate flysch series can be sorted out as significant raw material.

Limestone from the "Stijene" deposit satisfies standard conditions for making aggregates for concrete and for asphalt mixtures (except for worn highway layers, very hard and hard road loads), then as gravel for curtains railway line as well as raw in industrial production of lime and metallurgical raw as well.

On the base of physical-mechanical investigations, limestone from the "Kota" deposit is favorable raw for the production of stone aggregates aimed for designing of asphalt and concrete mixtures, then stone aggregates for making of roads-tampons road constructions.

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