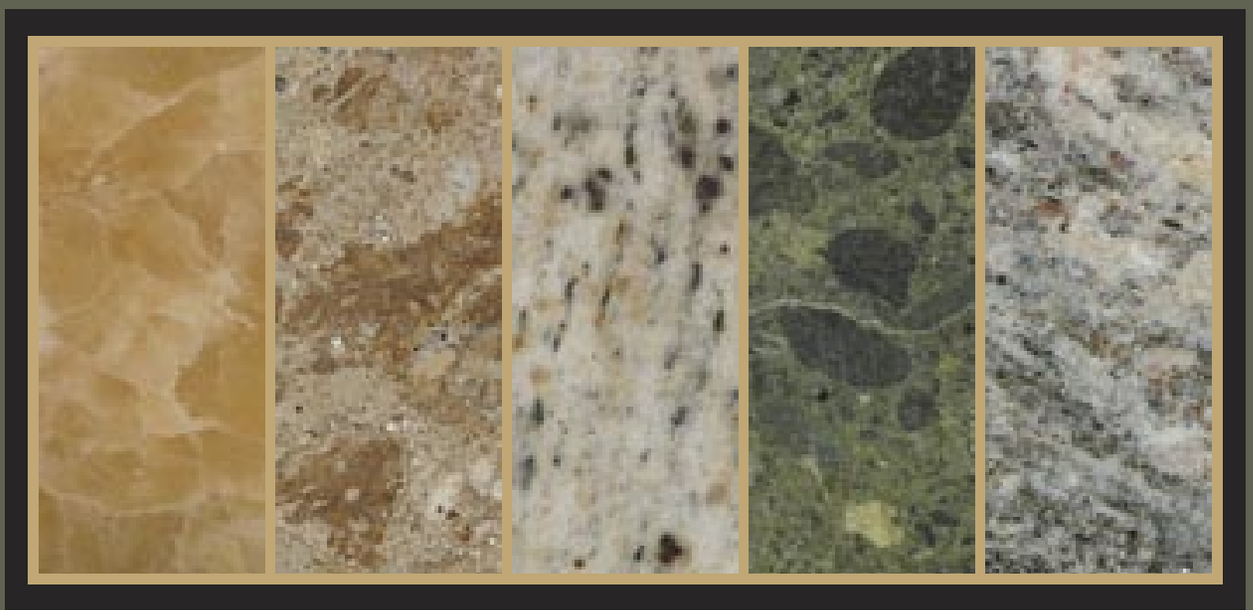
PELAGONIA

MARBLE VALLEY



PREDA

PREDA – Prilep Region Enterprise Development Agency

TRAINING CENTRE

- Organizes trainings according to the needs of SMEs from Pelagonia region.
- Special training programs for accountants and business lawyers.

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- Special support for the marble and stone industry in Pelagonia region.
- Cooperation with Pelagonia municipalities to develop the local economy.

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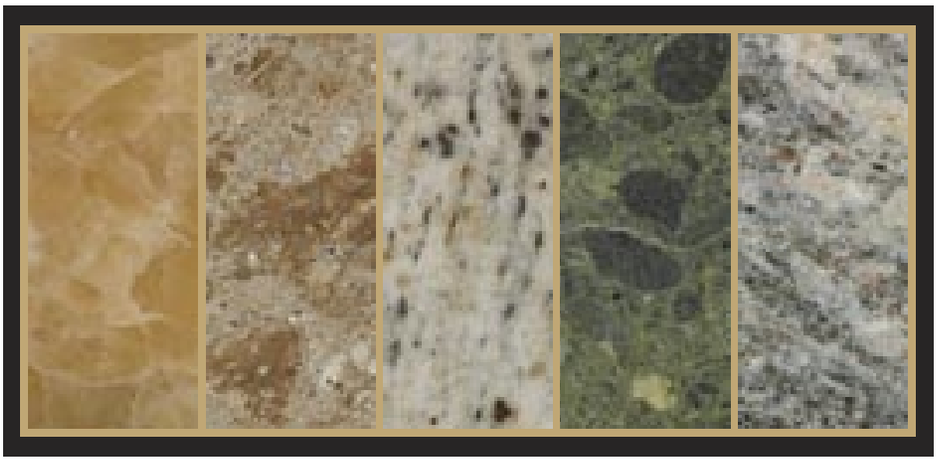
CONTENT



Publication title: Pelagonia Marble Valley

Publisher: PREDA – Prilep Region Enterprise Development Agency
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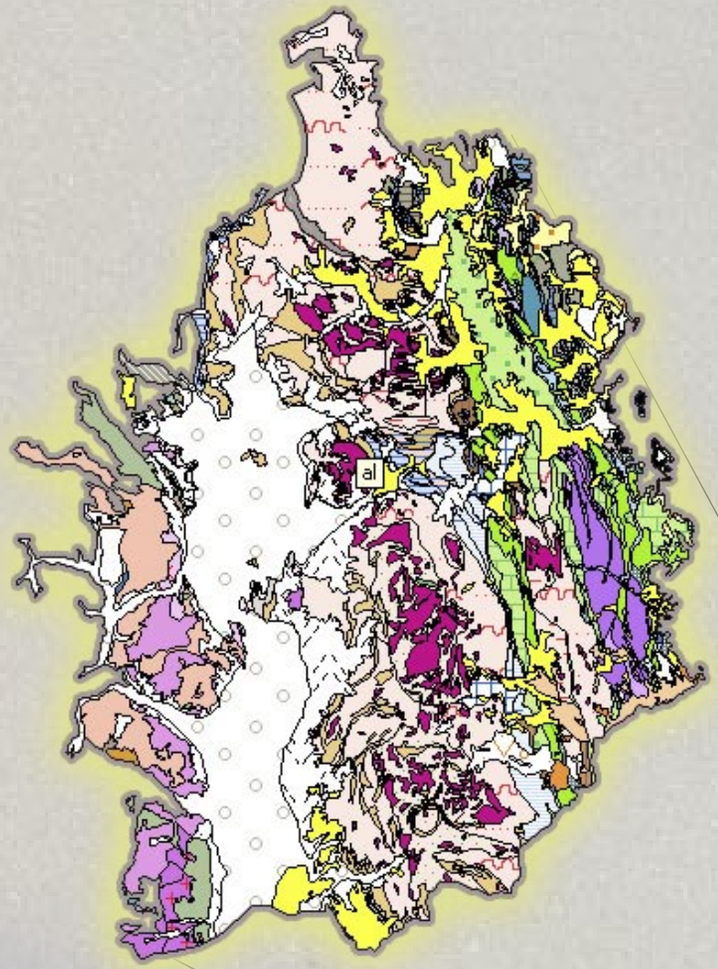
Design: Infodesign, Prilep,
www.infodesign.com.mk

Print: A.D. Kiro Dandaro, Bitola

Press run: 500

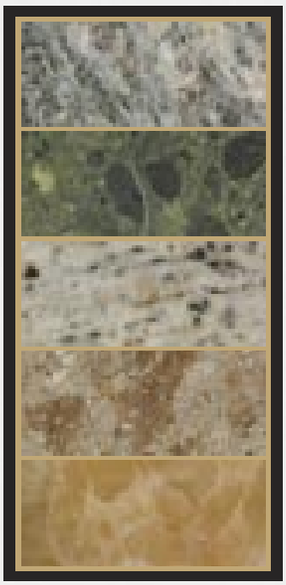
May 2006



Alluvium
Deluvium - proluvium
Granodiorite (from Prilep)
Marly clays
Andesites
Sandstones, slates, marls
Limestones
Diabases
Marbles
Muscovite gneisses
Porphyroblastic gneisses
Amphibole granodiorites
Tuffaceous sandstones (slabs)
Schist and marbles
Metamorphosed rhyolites
Amphibole - pyroxene schists
Basal series
Andesitic tuffs
Slates and platy limestones
Massive limestones

Kumanovo
Kratovo
Tetovo
Skopje
Kočani
Gostivar
Štip
Veles
MACEDONIA
Debar
Kičevo
Brod
Negotino
Strumica
Kavadarci
Prilep
Kruševo
Gevgelija
Struga
Ohrid
Resen
Bitola

PELAGONIA MARBLE VALLEY



Introduction

Macedonia is making tremendous efforts to develop its human and natural resources in order to create income and employment for its people. Conscious of the need for foreign capital the Republic of Macedonia strives to improve the business climate and to decentralize. The decentralization will strengthen municipalities and their capacity to provide adequate infrastructure and services. In addition, a national investment promotion agency (MacInvest) has been created to help investors.

Prilep Region Enterprise Development Agency (PREDA) is a Swiss funded institution to help both small and medium enterprises in their efforts to catch up and municipalities in their newly gained competence for local economic development. The region under geologic scrutiny in this brochure, with the richest deposits of architectural-dimension stone, is covered by the municipalities of Prilep and Dolneni. This brochure is meant as a contribution to their efforts in local economic development.

PREDA also cooperates with KAMEN, an organization of professionals from the local stone industry. The best known activity of this association is the publication of the journal KAMEN & STONE. The best entry point for firms and persons interested in the deposits of architectural-dimension stone in Pelagonia with the most knowledgeable people is certainly KAMEN.

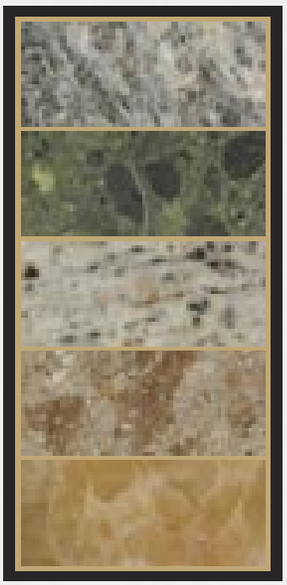
All institutions mentioned, PREDA, KAMEN, MacInvest, the municipalities of Prilep and Dolneni are prepared to assist interested investors. Contact details of all of them are given at the end of the brochure.

The aim of the brochure is to offer a brief account on the potentials of architectural-dimension stone in the region, inform and encourage interested investors.

The brochure gives brief descriptions of the localities that abound in architectural-dimension stone and presents those features of the stone that are important in terms of its usability. It also presents photos of individual types of architectural-dimension stone in order to provide a visual perception of the decorativeness. Furthermore some information is given about factors such as infrastructure, potentials etc.

Willy Parlmeyer
Director

Geological composition of the Republic of Macedonia



The following geotectonic units have been distinguished in the regional geologic pattern of the territory of the Republic of Macedonia: the Western-Macedonian zone, the Pelagonian metamorphic complex, the Vardar zone and the Serbo-Macedonia massif. The Serbo-Macedonian massif (SMM) occupies the eastern parts of the country. In the north it extends further on to Serbia and in the south to Greece. It is composed of Precambrian and Paleozoic metamorphic rocks and divided into upper and lower metamorphic complexes.

The lower metamorphic complex is composed of gneisses, schists and small amphibolite, quartzite and marble bodies. The upper complex is present as volcanogeno-sedimentary formations metamorphosed in a series of green schists. Chlorite schists, amphibole-biotite schists, chlorite-sericite and quartzite schists prevail.

The Vardar zone is a separate unit formed between the Serbo-Macedonian massif in the east and the Pelagonian massif and the Western Macedonian zone in the west. It is a continental rift of which, in the territory of the country, fragments of Precambrian earth's crust have been included, then Paleozoic volcanogenic sedimentary complex as well as acid Mesozoic magmatism. Remains of ocean crust are present as larger gabbro diabase ophiolite complexes.

The Pelagonian massif is of Precambrian age with rock complexes that differ from other tectonic units. It is composed of high metamorphic crystal rocks, gneisses, mica schists, marbles etc. as well as regional metamorphic complexes with large masses of palingenetic granites whose age has been determined as 800 to 1000 million years.

The Western Macedonian zone is present as several formations. The oldest is volcano genesedimentary spilite-keratophyre formation of early Paleozoic age. The upper phylite-marly series is of Paleozoic age (Ordovician, Silurian, Devonian) which includes quartz porphyry.

This geological composition made possible the occurrence of a number of rocks that can be used as dimension decorative stone such as: marbles, granite, gabbro, basalt, syenite, dacites, andesite, various schists, gneisses, travertine's, onyxes etc. The text will present some localities that are of interest with regard to dimension decorative stone.

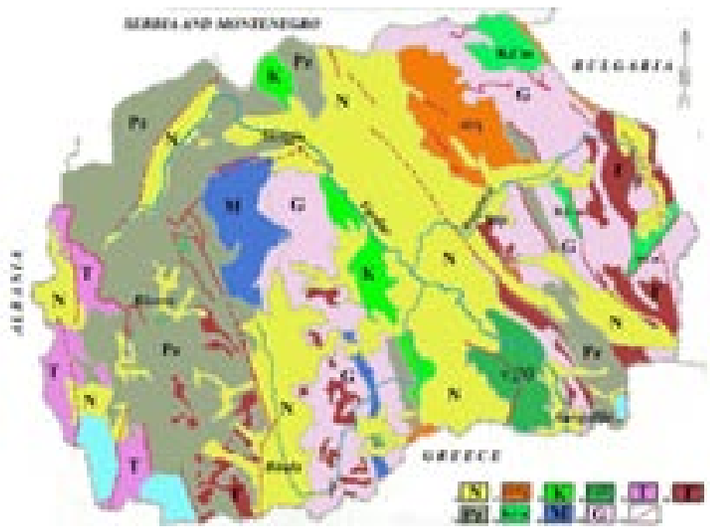
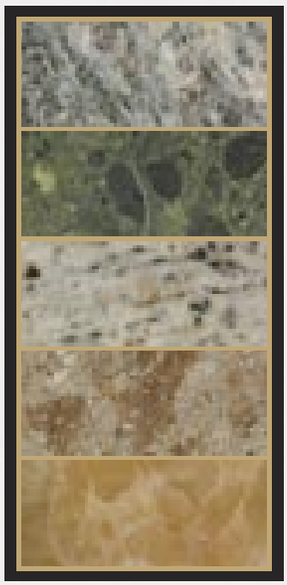


Fig. 1. Simplified geologic map of the Republic of Macedonia.

1.Neogene; 2. Volcanic; 3. Cretaceous; 4. Gabbros and diabases; 5. Triassic; 6. Granites; 7. Paleozoic; 8. Marbles; 9. Riphean-Cambrian; 10. Gneisses; 11. Faults.

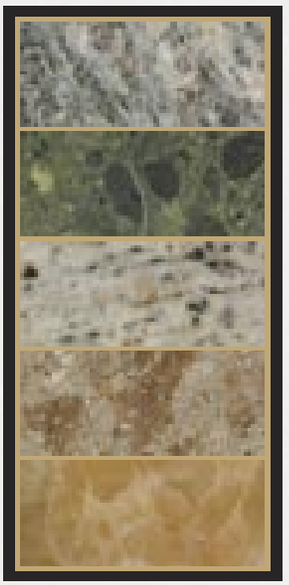


Geographic charcateristics of Pelagonia

Pelagonia (Pelagonia and Mariovo) is a fairly large area of 5 000 km2 occupying the south-western part of the country. The position of the area is almost meridian or about 85 km long and 65 km wide area of NW – SE strike. The region consists of two parts – Pelagonia and Mariovo.

The Pelagonia part consists of two sections: the Prilep and Bitola valleys. The most southern part of the area is the Lerin valley, which extends further south into the territory of the Republic of Greece.
Pelagonia and Mariovo are naturally and clearly confined by Mts. Baba and Pelister in the west, and by the Kozjak massif in the southeast.

Geological characteristics of the Pelagonian methamorphic complex



The major lithostratigraphic features of the Pelagon result from the primary accumulation of petitic-psamitic and carbonate sediments accompanied by poorly expressed initial magmatism. Over the Grenville orogenesis the complexes were affected by metamorphic-magmatic and tectonic processes when they metamorphosed into metamorphic rocks of epidote-amphibolite facies.

Present day understanding of the geological composition of the geological-geotectonic unit makes it possible to divide the complex into two parts: northern and southern.

The northern part is an asymmetric structure whose eastern portion is raised and contains gneiss and micaschist formations, whereas the formations of the so-called mixed series and the series of marbles have been found in the western portions of the segment. Plicative structures are mainly of west and northwest extensions.

The south part of the Pelagon is also asymmetrically built with uplift of the western wing where numerous plicative structures of sub meridian direction that bend to the north and north-west.

The middle parts are built mainly of granidiorite masses so the part of the area is rather raised or deeply eroded. The transition from gneisses to marbles in the eastern margin of the Pelagon is gradual, with absence of micaschists and mixed series, which have been preserved only as relicts. There, the marble series in the eastern rim is present as a band with thickness almost twice smaller than that in the northern part.

The lithostarigraphic position of some formations differs from that of the formations in the northern part of the Pelagon.

Lithostarigraphic characteristics of the northern part of the Pelagon

Upper and lower parts have been distinguished in the northern part of the Pelagon in the Grenville metamorphic complex. The lower part is present as a series of gneisses and micaschists, whereas in the upper part a mixed series and a series of marbles have been determined. Besides, the lower part of the metamorphic complex is connected with granitoid bodies of the Prilep granitoids which in this part of the Pelagon are connected mainly with the terrains of Mt Babuna.

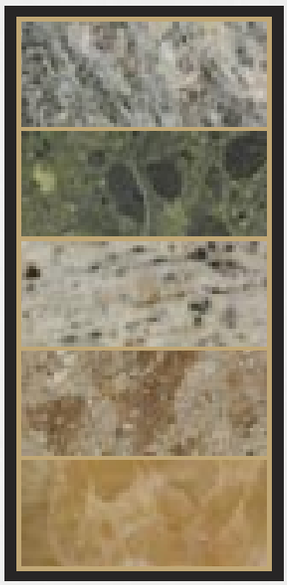
In the series of gneisses which make up the deepest parts of the Grenville metamorphic complex several litho-facial types have been distinguished: augen two-mica amygdaloidal, band like, leucocratic muscovite and epidot-muscocite-biotite gneisses.

Augen two-mica amygdaloidal gneisses are connected with the contact parts of the granitoid intrusions and gradually grade into two-mica biotite-muscovite gneisses.

In the lower parts gneisses are massive and stratified pseudo layered and schistose owing to the presence of mica. On the surface they erode into various irregular, oval shapes or sporadically there are half a meter thick gneiss arenite.

Gneisses are light red so the portions that contain more quartz and feldspar-albite are brighter and those with more mica are grey-greenish.

As a rule, the lower parts of gneisses, present as biotite muscovite gneisses, are characterized by prevalence of microcline, whereas in the upper parts most abundant are albite and microcline.



Poprhyroblastic gneisses are closely related to the contact parts of the granites or the gneiss-granites in the valley of the river Babuna (at Teovo). The thickness of the gneiss series in the northern part of the Pelagon is estimated at 5 000 to 7 000 meters.

The series of micaschists is less widespread than the gneiss series. It was discovered at Plavenski Rid, Osoj and Silegarnik, Begovi Virovi and Kadino Pole, Ubava, north-west of the Kadina Reka basin and Mt Kitka. To the east of Prilep they were distinguished in Mts Prisoj, Viorila and some other places.
As a whole, the series of micaschists is present as micaschists, quartzites and graphite schists, which facially grade one into other both latterly and vertically.

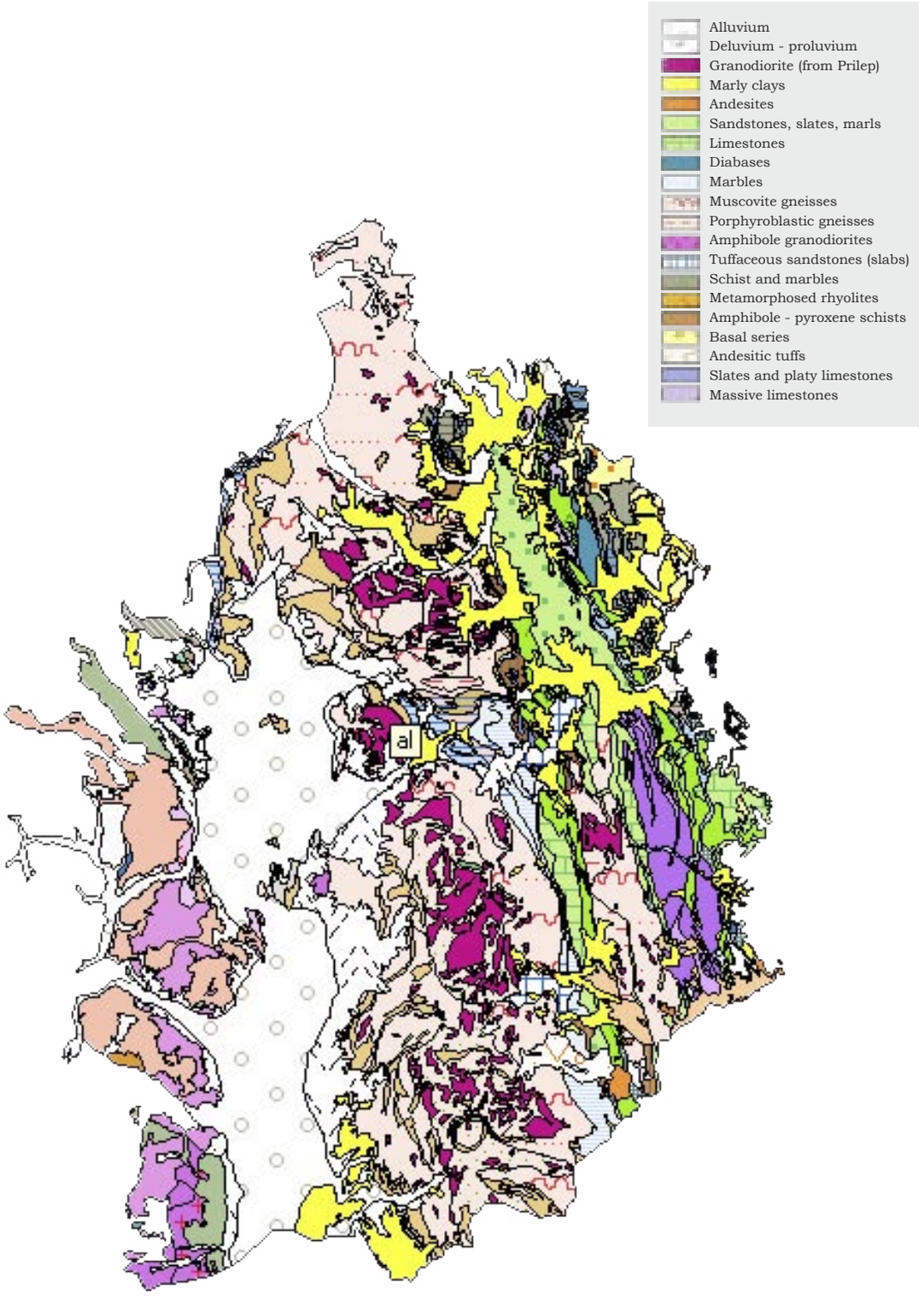
Unlike gneisses, micaschists possess clearly pronounced dark brown to dark schistose texture depending on the graphite material in them. In addition to quartz, micaschists also contain micas (muscovite, biotite, paragonite), chlorite and garnets (of up to 30% in some parts), distene, staurolite, albite, amphibole, tourmaline etc. There are also garnet micaschists rich in garnet with crystals attaining several centimeters in size. They are abundant in Mt Viorila, north of Kozjak. Large distene crystals of 10 cm in size have been found in the micaschists in the area.

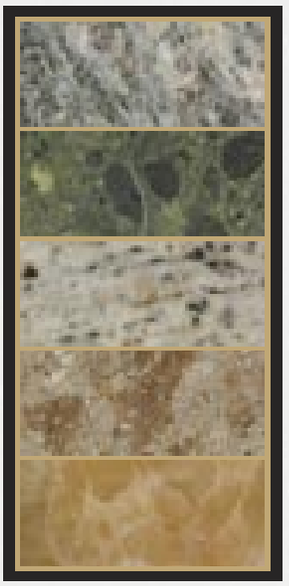
The mixed series in the north part of the Pelagon occupies a sequence of metamorphic rocks of variable petrographic composition: augen schists, feldspatised chlorite schists, cipolines, talc schists and marbles where rocks grade one into other both laterally and vertically. Of all lithological varieties gneisses (mainly albite) prevail (the area of Markova Reka, Kitka, Ruen, the village of Izvor etc). Metarhyolites are also present.

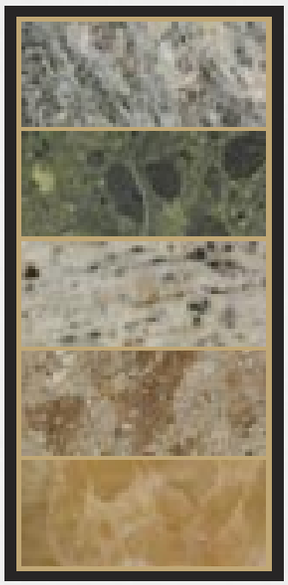
The marble series comprises the top parts of the Precambrian complex in the Pelagon. In the north, the series of marbles comprises the mountain masses of Jakupica, Karadzica and Dautica and the River Treska valley. Some areas north of Prilep (Sivec, Platvar and Kozjak) are also made up of this carbonate formation. Relicts of it are present in the northern slopes of Kitka and in the eastern marginal part of the Pelagon (the village of Izvor, Veles).

The granitoid formation is less present in the north part of the Pelagon. It occurs as smaller granite bodies located in the gneiss and micaschists series. The bodies are 0.5 km2 to several square kilometers in size. Larger granitoid bodies have been found in the north parts of Mt Babuna. Granodiorites prevail in the north, and granites are less present in the formation. A small diorite occurrence has also been found. Pegmatites, aplites and quartz veins occur as lode rocks.

Geological map of The Pelagon







Lithostratigraphic features of the south part of the Pelagon

The Precambrian metamorphic complex in the south part of the Pelagon extends south of the Pelagon to Mt Selečka, Dren, Niđe and Kajmakčalan. The complex is deeply eroded that can be seen from the metamorphic facies characteristic of the deeper parts of the amphibolite facies, then from the position of the micaschist series and the absence of mixed series. The Precambrian metamorphic complex was formed in conditions of regional metamorphism of pelite-psamite sediments, basic and acid volcanic intrusive rocks and carbonate rocks. The rocks are located in three lithostartigraphic levels: gneiss-micaschist series (lower metamorphic complex), mixed series and a series of marbles.

The gneiss-micaschist series (gneisses and micaschists) comprises the lower stratigraphic level of the metamorphic complex and is made up of gneisses, micaschists, metadiabases, quartzites and granodiorites. Different temperature and pressure conditions during metamorphism, different levels and the influence of polyphase of granodiorite magmatism, resulted in zonar structure of the gniess micaschist series. This made it possible to distinguish:

A lower zone present as homogenized mass, made up of muscovite-biotite gneisses, seldom amphibolite bands.

An upper zone, lithologically present as a fairly heterogeneous mass in which various types of gneisses, micaschists, amphibolites and quartzites alternate both vertically and horizontally.

The mixed series is well built and is present as a thick mass of layers in the north part of the Pelagonian massif. In the south the thickness of the massif decreases. Only partially preserved relicts of mixed series occur in the slope of the marble series.

The marble series is well preserved and has been found as a 1 500 to 2 000 meters thick mass in the margin of the south part of the Pelagon, It is transgressively overlain, with an angle discordance, by Riphean Cambrian low metamorphic rocks and Upper Cretaceous sediments that are characteristic of the Vardar Zone. At the Niđe-Labnica-Melnica-Veprčani-Belovodica strike the marble series is present as two superposition horizons. Dolomites and dolomite marble prevail in the lower horizon, whereas quartzite marbles in the upper.

Localities of architectural-dimension stone

Physical-mechanical features

Compressive strength in dry state

Pmax = 145.20 MPa
Pmin = 138.10 MPa
Psr = 140.30 MPa

Compressive strength in water saturated state

Pmax = 138.30 MPa
Pmin = 130.70 MPa
Psr = 134.50 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 125.60 MPa
Pmin = 110.20 MPa
Psr = 114.40 MPa

Water absorption

σ = 0.160%

Volume mass

γ = 2800 kg/m3

Resistance to wear

A = 36.6 cm3/50 cm2

BELOVODICA

Locality

Belovodica is situated in the vicinity of the village of the same name, some 20 km from Prilep. The locality has been uncovered 1 km south of the village in a series of marbles that belong to the Pelagonian metamorphic complex.

The good infrastructure provides good communication with the major Kavadraci – Prilep road. It should be noted that the locality has not yet been supplied with electric power..

The marbles of Belovodica are part of the mass belonging to the south part of Pelagonia. The mass is situated between the marginal part of the Pelagonia metamorphic complex in the west and the Vardar zone in the east. It is a relatively narrow zone present as two types of marble: calcite type in the eastern marginal part and the Vardar zone as well as dolomite in the western part in immediate contact with the gneiss series in the Pelagonian metamorphic complex.

The entire mass of Belovodica is located in the eastern wing of the Dren large anticline, which is a dome-like elongated structure of N – S strike. The Dren anticline is composed of mixed and marbles series.

It is important to mention that in the lower portion homogenization, whitening and dolomitization of the marble mass of Belovodica have taken place. The process is related to the intrusion of granitoid rocks into the Dren anticline. As a result, the lower portions of the rock mass are made up of sugary white to powdered massive dolomite marbles in which, only locally, traces of foliation and microfolding can be seen along with a small occurrence of calcite veins. Further from the contact with the Dren anticline to the east, dolomite marbles grade into band-like and even further into schistose calcite-dolomite marbles.

Rupture tectonics present as faults and fault zones and fracture zones have played and important role in the composition of the marble series. No doubt, some of these structures are older, but the main rupture tectonics is of earlier age and related to the processes of formation of the neotectonic graben of the Pelagonia valley during the Pliocene as well as the processes of younger folding and faults during the Alpine orogeny.

Petrographic -mineralogical features

Microscopic studies carried out on samples taken from the white fine-grained marbles and those from the southwestern parts of the contact with the gneisses yielded that they possess fine-grained granoblastic structure with transitions to mosaic with occasional occurrences of porphiroblastic composition. In fractured zones, cataclastic and occasionally mylonitic structures have been determined.

Dolomite grains are 0.07 to 0.1 mm in size. The grains are partially rounded and possess explicit cleavage. In some places they possess elliptic crosscuts and are poorly elongated to cleavage direction. Dolomite grains are seldom irregular and polygonal in shape. Besides dolomite, calcite and a smaller amount of muscovite also occur. Quartz, fluorite, rutile and flogopite seldom occur.

Potential

The Belovodica locality is an exceptional area in terms of the possibilities for exploitation of white dolomite and grey calcite marbles. The reserves in this locality have been estimated at 100 years of exploitation with 10 to 15 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 164.40 MPa
Pmin = 153.40 MPa
Psr = 162.10 MPa

Compressive strength in water saturated state

Pmax = 169.80 MPa
Pmin = 132.45 MPa
Psr = 146.4 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 156.6 MPa
Pmin = 117.5 MPa
Psr = 139.5 MPa

Water absorption

σ = 0.106%

Volume mass

γ = 2825 kg/m3

Resistance to wear

A = 33.5 cm3/50 cm2

SIVEC

Locality

The locality is situated some 10 km northeast of Prilep at the crosscut between the Babuna massif and Mt Kozjak. The infrastructure is good. The locality is connected with a 8 km asphalt road and 2 km macadam road. The quarry has been in operation for quite some time during which the locality was supplied with electric power.

The Sivec marble mass has been excavated since ancient times. It is 4 km long and 0.8 – 2 km wide extending NW-SE strike with general dip of the series towards SE.

The lower levels of the marbles mass consist of dolomite sugary white marbles that gradually grade to bandy grey white marbles with calcite nests.

The mass in the upper parts has been affected by karstification processes some 5 meters in depth, depending on the part of the marbles mass. The main damages to the marble mass are related to the number of faults and fractures.

Petrographic -mineralogical features

Generally, the lowermost portions of the marble mass in Sivec consist of white dolomite marbles of granoblastic composition and massive texture. Grains are from 0.2 to 0.3, occasionally 0.4 to 0.5 mm in size. Besides dolomite, the marbles also contain variable amounts of calcite, depending on the part of the mass that is being studied. Secondary minerals occurring in small amounts include corundum, rutile, chlorite, ilmenite, quartz, fluorite, muscovite etc.

Potential

The Sivec site is an exceptionally promising area regarding the exploitation of white dolomite and grey calcite marbles. The reserves are estimated at 150 year exploitation with 15 to 20 000 m^3 per year.

Physical-mechanical features

Compressive strength in dry state

Psr = 148.20 MPa

Compressive strength in water saturated state

Psr = 132.10 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Psr = 117.60 MPa

Water absorption

σ = 0.0792%

Volume mass

γ = 2845 kg/m3

Resistance to wear

A = 31.2 cm3/50 cm2

BELA POLA

Locality

Bela Pola is situated in the vicinity of the village of Nebregovo, some 19 km from Prilep. It lies 3 to 4 km southeast of Nebregovo in the series of marbles that are part of the Pelagonian metamorphic complex. The surface mine is situated at the foot of Mt Babuna massif in the north part of the Prilep valley.
The infrastructure in the area is good and the quarry is connected with the town via the local road that leads from Pilep to Nebregovo and the local road from Prilep to the Sivec mine.

The marbles of Bela Pola belong to the marble mass of the Pelagon. The mass is situated between the Prilep anticline in the southwest and the intensely folded mountain mass of Mukos in southeast. To the southwest it buries under the Pliocene sediments in the periphery of the Pelagonian valley and emerges in the localities of Cave and the Kozjak syncline.

The lithostratigraphic and tectonic characteristics of this marble mass point out the polyphase process that took place during the sedimentation, regional metamorphism and later deformation processes.

The whole locality of Bela Pola is situated in a syncline form as an elongated structure that from the north and northeast is in contact, by a fault line, with the Derven anticline and the Kozjak syncline.

The Sivec – Bela Pola syncline is built of rocks of the mixed and marble series. The central parts of the syncline have been found at Crvenica.

It is important to say that in the lower portions homogenization, whitening and dolomitization of marbles took place. The processes are related to the intrusion of granodiorite rocks of the Prilep anticline. Namely, the lower portions of the marble mass are built of sugary white and massive dolomite marbles in which, only locally, traces of foliation and microfoldings can be noticed. Further from the contact with the Prilep anticline to the east, dolomite marbles grade into band-like, and further on to schistose calcite-dolomite marbles.

An important part of the structure of the marble mass is the rupture tectonics present as faults, fault and fracture zones. Some of the structures are of older age, but the major rupture tectonics is young and related to the processes of formation of the neotectonic graben of the Pelagonian valley during the Pliocene.

In the southwest the marble mass is separated by a very important diagonal fault zone, known as Nebregovo neotectonic fault, along which smaller seismic shocks have been registered.

This NW – SE fault structure, with dip to southwest under an angle of 60 to 80o, crosscuts the marble mass of the Sivec – Bela Pola in a diagonal manner.

The second very important periphery fault that delimits the marble mass towards SE is the covered fault that extends SW – SE along the course of River Stara.

Owing to the extensive tectonics along the two faults in the area of the Sivec – Bela Pola mass, fragmenting and smaller or larger fault and fissure systems occur. These fault and fissure systems define the method of excavation of the marble masses in the localities.

Petrographic -mineralogical features

The massive white and fine-grained marbles occur in the southwestern part of the mass, whereas dolomite-calcite marbles build the northeastern higher parts of the marble mass.Microscopic studies carried out on samples taken from the white fine-grained marblesand those from the southwestern parts of the contact with the gneisses yielded that theypossess fine-grained granoblastic structure with transitions to mosaic with occasionaloccurrences of porphyroblastic composition. In fractured zones, cataclastic andoccasionally mylonitic structures have been revealed.

Dolomite grains are from 0.1 to 0.5 mm in size. The grains are partially rounded and possess explicit cleavage. In some places they possess elliptic intersections and arepoorly elongated to cleavage direction.

Dolomite grains are seldom irregular and polygonal in shape. Besides dolomite, calcite and a smaller amount of muscovite also occur. Quartz, fluorite, rutile and flogopite can seldom be found.

Potential

The Bela Pola locality is an exceptional area in terms of the possibilities for exploitation of white dolomite and grey calcite marbles. The reserves in this locality have been estimated at 100 year exploitation with 10 to 15 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Psr = 176.60 MPa

Compressive strength in water saturated state

Psr = 166.95 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Psr = 155.05 MPa

Water absorption

σ = 0.196%

Volume mass

γ = 2785 kg/m3

Resistance to wear

A = 35.80 cm3/50 cm2

MELNICA

Locality

The locality is situated some 40 km southeast of Prilep on the left side of the Prilep – Vitolište regional road near the village of Melnica. The infrastructure is good that makes possible good connection between the town of Prilep and the village via a 35 km asphalt road. The other 5 km road from the village of Melnica to the locality is macadam road. The locality has not yet been supplied with electric power.

The geology of the locality occupies the south parts of the metamorphic complex of the Pelagon. The Pre-Cambrian metamorphic complex in the south parts of the Pelagon is distributed into Mt Selečka, Dren, Niđe and Kajmakčalan. The rocks of the complex are distributed in three basic lithostratigraphic levels: gneiss-micaschist series (lower metamorphic complex), mixed series and a series of marbles.

The gneiss-micaschists series (the series of gneisses and micaschists) comprises the lower stratigraphic level of the metamorphic complex and is built of gneisses, micaschists, metadiabases, quartzites and granodiorites.

The lower zone present as a homogenized mass is built of muscovite-biotite gneisses and seldom amphibolite bands.

The upper zone that is lithologically present as a fairly heterogenous mass in which both vertically and laterally various types of gneisses, micaschists, amphibolites and quartzites alternate.

The mixed series is very well built and widely present as a fairly thick mass of layers in the north portion of the Pelagonian massif. In the south the thickness of the zone is either reduced or is practically absent. It can also be said that here only relics of the mixed series occur. They have been partly preserved at the foot of the marble series.

The series of marbles is well preserved and expressed in the south part of the Pelagon. The series is from 1 500 to 2 000 meters thick. It is transgressively, and with an angle of discordance, overlain by Riphean Cambrian low metamorphic rocks and Upper Cretaceous sediments that are characteristic of the Vardar zone.

In the Nidze – Labnica – Melnica – Veprcani – Belovodica strike the marble series is present as two super position horizons. Dolomites and dolomite marbles prevail in the lower and calcite marbles in the upper horizons.

The Melnica locality is emplaced in a relatively narrow and tectonically rather fractured zone. However, in some parts of the zone greater blocks of the marble mass can be found.

Petrographic -mineralogical features

Microscopic studies have indicated that the Melnica locality contains white dolomite marbles of very fine-grained granobalstic structure with grain sizes from 0.1 to 0.3 mm. Besides dolomite, calcite can seldom be found, except in the eastern part of the zone.

It should be said that in the mass in the south parts of Melnica, small quantity of limonite material occurs that in some places gives the marble yellowish colour.

The admixture disappears in the north. Its occurrence is related to some tectonic structures of north-south strike. Muscovite and chlorite, seldom flogopite as well, occur in the series as accessory minerals.

Potential

The Melnica locality is a promising area in terms of the possibilities for exploitation of white dolomite and grey calcite marbles. Exploitable reserves in the locality are estimated at 100 years of exploitation with 5 - 10 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 118.12 MPa
Pmin = 92.5 MPa
Psr = 105.90 MPa

Compressive strength in water saturated state

Pmax = 125.90 MPa
Pmin = 84.30 MPa
Psr = 102.25 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 111.20 MPa
Pmin = 77.0 MPa
Psr = 102.20 MPa

Water absorption

σ = 0.066%

Volume mass

γ = 2720 kg/m3

Resistance to wear

A = 22.05 cm3/50 cm2

PLETVAR

Locality

The locality is situated 1 km from the Prilep - Gradsko regional road. Its infrastructure makes possible good connection and would not cause any difficulties regarding marble exploitation.

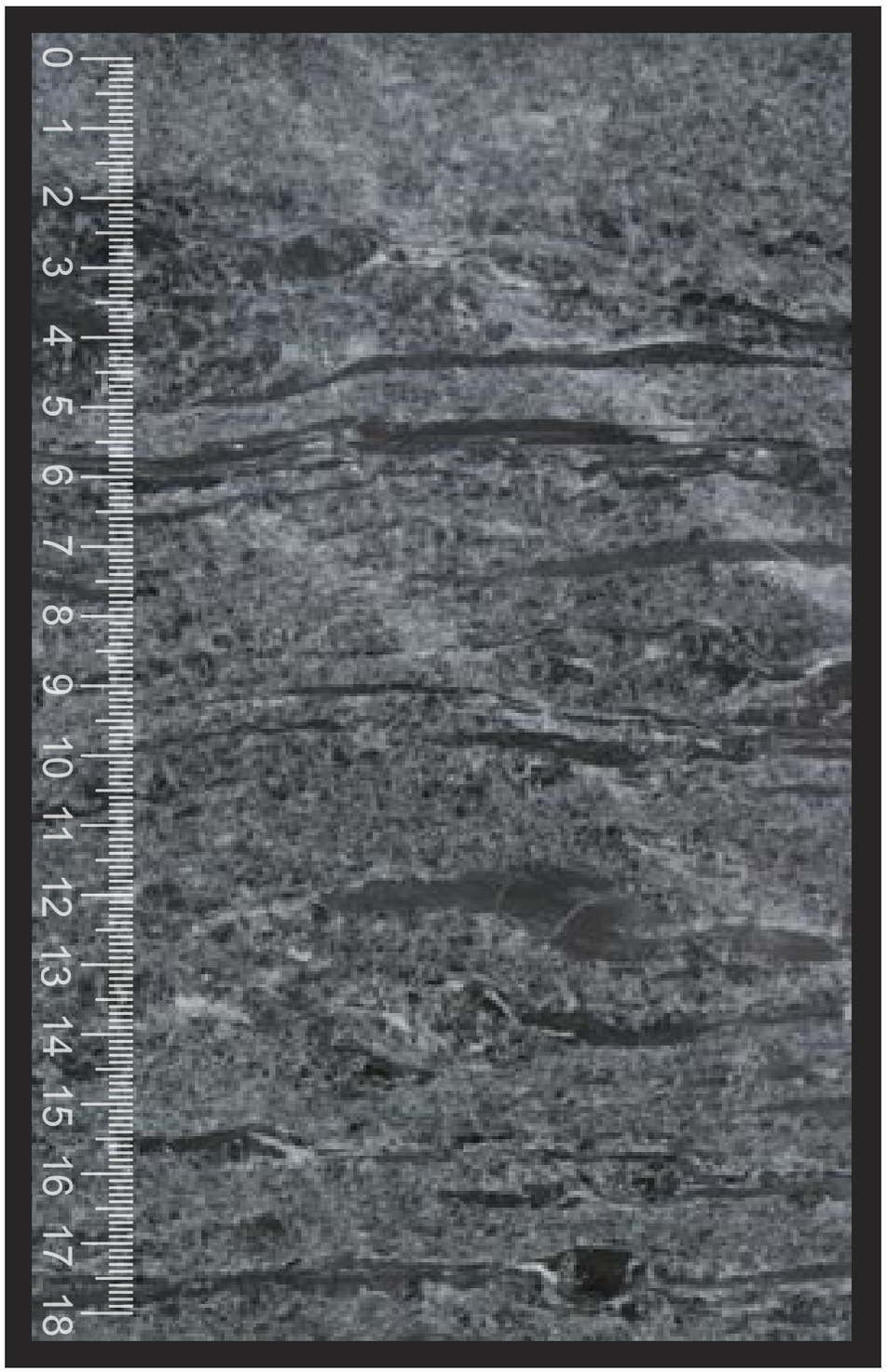
The locality is part of the north portion of the Pelagonian metamorphic complex and is basically built of various kinds of marble. The most common type is grey calcite marble with white dolomite parties as well as reddish and dark varieties in some parts. This geologic structure possesses visible discontinuities that basically separate the marble mass into smaller parts so that during exploitation various categories of blocks are obtained.

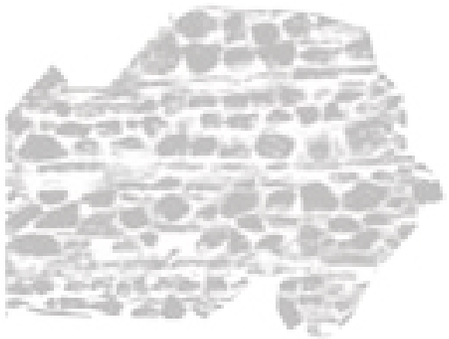
Petrographic -mineralogical features

Regarding the petrographic-mineralogic features it can be said that it is fine-grained grey, calcite marble of explicit granoblastic structure and massive texture. Grain size varies from 0.2 to 0.6 mm, and the grains are mosaically intergrown. Besides calcite, dolomite also occurs including muscovite and chlorite as secondary minerals.

Potential

The Pletvar site is an exceptionally promising area regarding the exploitation of grey calcite marbles. The reserves are estimated at 200 year exploitation with 15 to 20 000 m3 per year.





Physical-mechanical features

Compressive strength in dry state

Pmax = 148.12 MPa
Pmin = 125.5 MPa
Psr = 138.80 MPa

Compressive strength in water saturated state

Pmax = 131.50 MPa
Pmin = 98.20 MPa
Psr = 110.54 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 125.30 MPa
Pmin = 97.20 MPa
Psr = 110.20 MPa

Water absorption

σ = 0.078%

Volume mass

γ = 2750 kg/m3

Resistance to wear

A = 24.30 cm3/50 cm2

DEBREŠTE

Locality

The Debrešte locality is situated near the Prilep – Kičevo regional road, some 2 km from the village of the same name. The infrastructure is good and the locality is connected with other places by roads. In the event a mine is put in operation, the electric power supply will need additional work.

The locality is situated in the north portion of the Pelagonian metamorphic complex in the series of band-like marbles. The locality contains several kinds of marble such as light grey, dark grey to dark with the presence of calcite veins.

It should be noticed that the occurrence of dark marbles is an important feature of the locality that should be made known to others.

Marble occurs as large blocks that make exploitation easier. The marble series contains occasional occurrences of quartz veins and cherts that deserve greater attention in future exploitation.

Petrographic -mineralogical features

These are grey, dark grey to dark quartzite-dolomite marbles of pronounced granoblastic structure and massive texture. Grain size varies, depending on the variety, from 0.3 to 0.7 mm. Besides calcite and dolomite, which occur as dominant minerals, quartz, muscovite and chlorite also occur as accessory minerals.

Potential

The Debrešte locality is promising regarding the exploitation of grey, dark grey to dark marbles. The reserves have been estimated at 100 year exploitation with 5 - 10 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 179.80 MPa
Pmin = 148.50 MPa
Psr = 159.50 MPa

Compressive strength in water saturated state

Pmax = 176.10 MPa
Pmin = 124.20 MPa
Psr = 149.50 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 130.30 MPa
Pmin = 103.40 MPa
Psr = 119.50 MPa

Water absorption

σ = 0.171%

Volume mass

γ = 2700 kg/m3

Resistance to wear

A = 9.70 cm3/50 cm2

KRUŠEVICA

Locality

The Kruševica locality is situated in the central parts of Mariovo near the village of the same name. The locality is connected via a 25 km asphalt road that allows us to say that connections are good. The place is not connected to the power grid.

The locality is situated in the south part of the metamorphic complex of the Pelagon in the series of granite-granodiorite. The tectonics in this part of the complex is characterized by the presence of a number of discontinuities that separate the granite mass into larger blocks that make them easy to excavate. Granite bodies are present as large intrusive dome-like forms with pronounced banked jointing.

Petrographic -mineralogical features

The granites possess grain-like structure and massive texture with pronounced grey color. Under a microscope it can be noticed that the rocks possesses hipidiomorphic grain structure with light and femic minerals occurring as major minerals.

About 75 to 80% of the rock mass is built of salic minerals present as quartz, calcic feldspar (microcline, anorthoclase), acid plagioclases (albite).

About 10 to 15% of the rock mass is femic minerals, present mainly as biotite.

There is a large number of inclusions as poicilitic structures, most often in feldspars, present as apatite, rutile, ilmenite, magnetite, zircon and epidote.

Potential

The Kruševica locality is a promising area regarding the exploitation of grey granites. The reserves are estimated at 100 year exploitation with 5 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 192.80 MPa
Pmin = 164.30 MPa
Psr = 175.60 MPa

Compressive strength in water saturated state

Pmax = 155.80 MPa
Pmin = 139.30 MPa
Psr = 144.10 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 148.80 MPa
Pmin = 131.30 MPa
Psr = 138.10 MPa

Water absorption

σ = 0.189%

Volume mass

γ = 2695 kg/m3

Resistance to wear

A = 10.40 cm3/50 cm2

KALEN

Locality

The Kalen locality is situated some 20 km southeast of Prilep, close to the Prilep – Vitolište regional road. In that regard, the site has good infrastructure.
It should be noted, however, that the electric power grid does not allow operation of powerful mining equipment.

Kalen is situated in the southern part of the metamorphic complex of the Pelagon.
Its geology consists of deluvial-proluvial material; broken material, arenite, sand, gravel, dust and maximum 1.5 m thick clay occurring mostly along the temporal water flow that flows next to the locality.

Biotite granite is also present in the other part of the locality occurring as a larger biotite body of dome-like shape. This makes it possible to have good distribution of fissures of jointing that allow exploiting blocks of large dimensions.

Petrographic -mineralogical features

Petrographic examinations carried out on the biotite granites have determined the following mineral composition:
Over 80% is quartz, potassium feldspars (orthoclase, anorthoclase, microcline), acid plagioclases (albite to andesite);
From 10 to 15% is biotite of clear dark colour;
Up to 5% is idiomorphic inclusions inside the crystal lattices of feldspars such as apatite, rutile, titanite, ilmenite, zircon, epidote.
Of the dominant minerals in the composition of the biotite granite, only biotite is a coloured component part. As a result, 80 to 85% of the granite mass consists of light minerals, and only 10 to 15% of femic minerals.

Potential

Kalen is a promising area regarding the exploitation of grey biotite granites. The reserves are estimated at 100 year exploitation with 5 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 278.20 MPa
Pmin = 220.30 MPa
Psr = 250.40.60 MPa

Water absorption

σ = 0.27%

Volume mass

γ = 2690 kg/m3

Resistance to wear

A = 14.20 cm3/50 cm2

KUKUL

Locality

The locality is situated some 7 km northeast of Prilep. The infrastructure is good, as there is an asphalt road near the mine leading to the Sivec mine.
The close proximity to the Sivec mine makes it possible to supply electric power easily.

In terms of its geology it can be said that this locality is part of a large mass of the Prilep granites (granodiorites) that comprise the vicinity of Prilep. Regarding the structural-geological aspect, it can be said that Kukul is situated in the north part of the metamorphic complex of the Pelagon. Granite rocks occur as a large intrusive dome with pronounced banked jointing that provides favourable conditions for excavation.

Petrographic -mineralogical features

The granite (granodiorite) rocks of Kukul are relatively fresh, of grey to pink color, built of the following minerals: microcline-pertite, plagioclase, anorthoclase, quartz and biotite as major minerals and epidote, zoisite, muscovite, sphen and apatite as secondary minerals.

Microcline occurs as large crystals that are fresh, reddish and include quartz and plagioclase crystals. Quartz occurs as coarse-grained aggregates and biotite as coarse-grained leaves evenly distributed in the rock. Occasional occurrences of muscovite are visible, whereas epidote and zoisite occur either as individual grains or as inclusion in plagioclase.

Potential

The Kukul site is an exceptionally promising area regarding the exploitation of grey biotite granites. The reserves are estimated at 100 year exploitation with 5 000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 134.80 MPa
Pmin = 106.70 MPa
Psr = 121.0 MPa

Compressive strength in water saturated state

Pmax = 117.70 MPa
Pmin = 93.50 MPa
Psr = 104.80 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 116.50 MPa
Pmin = 93.40 MPa
Psr = 103.20 MPa

Water absorption

σ = 0.189%

Volume mass

γ = 2620 kg/m3

Resistance to wear

A = 12.30 cm3/50 cm2

PODMOL

Locality

The locality is situated 35 km south of Prilep. The infrastructure is good and the place is connected by the Prilep – Topolčani regional road and the Topolčani – Erekovci – Kanatlarci – Podmol local road.

The electric power grid in the region is not on the level that would supply large quantities of electric power for normal operation of the mining equipment.

From geological point of view the locality belongs to Mt Selečka which is an outstanding orthographic structure within the Pelagonian metamorphic complex. The locality is located in the Podmol anticline, which is a typical brachy-shape.

The central part of the structure is built of gneiss-granites, whereas the anticline wings are built of gneisses, micaschists and mixed rocks (migmatites). The gneiss-granite body presented in this brochure is of fairly modest dimensions – the width being some 200 meters and the length 1 km.

Petrographic -mineralogical features

The gneiss granites of Podmol are leucocratic types of massive textures and porphyroblastic structure. The rocks are creamy-white with garnet crystals scattered in the rock mass that give them very good ornamental characteristics. On the other hand, the rock minerals such as feldspars are relatively fresh and with no visible changes.

Potential

Podmol is an area of limited potential regarding exploitation. The reserves are estimated at 100 year exploitation with 1500 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 139.60 MPa
Pmin = 130.70 MPa
Psr = 134.0 MPa

Compressive strength in water saturated state

Pmax = 123.20 MPa
Pmin = 100.30 MPa
Psr = 110.40 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 112.50 MPa
Pmin = 88.40 MPa
Psr = 100.00 MPa

Water absorption

σ = 0.28%

Volume mass

γ = 2800 kg/m3

Resistance to wear

A = 12.30 cm3/50 cm2

SKOČIVIR

Locality

The Skočivir locality is situated 30 km southeast of Bitola on the edge of Mt Selečka. The infrastructure is favourable as there is an access asphalt road to the village of Skochivir and 3 km more macadam road along the course of the River Crna.
There is electric power grid but it needs overhaul and restoration.

Regarding the geology the locality is part of Mt Selečka metamorphic complex built of high metamorphic rocks (gneisses, micaschists, gneiss-granites) and large amount of porphyroid granites.
It is these porphyroid granites that are of interest as architectural dimension stone.

Petrographic -mineralogical features

From petrographic point of view it can be said that two granite types are present in Skočivir: poprhyroid granites and two mica granites.The poprhyroid granites are greenish in colour and possess massive texture. They are built of large porphyroid crystals of alkali feldspar, fairly large amount of quartz, some muscovite, augite as well as occurrence of accessory minerals such as zircon, apatite, ilmenite and sphen. Porphyroid granites are relatively fresh rocks except for the surface parts of about 5 m in depth. Fine-grained two mica gneisses are built of quartz, biotite, muscovite, microcline and occurrence of secondary minerals.

Potential

The Skočivir locality is an exceptionally potential area regarding the exploitation of poprhyroid and two mica granites. The reserves are estimated at 100 year exploitation with 3500 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Pmax = 90.0 MPa
Pmin = 70.75 MPa
Psr = 80.45 MPa

Compressive strength in water saturated state

Pmax = 88.75 MPa
Pmin = 69.70 MPa
Psr = 79.50 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 87.50 MPa
Pmin = 73.60 MPa
Psr = 77.80 MPa

Water absorption

σ = 0.064%

Volume mass

γ = 2870 kg/m3

Resistance to wear

A = 9.90 cm3/50 cm2

LOPATICA

Locality

The locality is situated near the village of Lopatica some 35 km from Prilep. There is a regional asphalt road from Prilep to Topolčani that joins the access road from Topolčani to Lopatica. From Lopatica to the quarry there is a 2.5 km macadam road.
As regards electricity supply it can be said that the existing electric power grid cannot satisfy the needs for mine operating equipment.

The geology of the site is part of Mt Selečka as a large orographic unit in the Pelagonian metamorphic complex. The immediate vicinity of the locality is built of high metamorphic rocks present as gneisses, micaschists and gneiss-granites. Lopatica is a lens-like body some 300 meters wide and 2 km long. The body is built of dark-grey to dark amphibole gneisses.

Petrographic -mineralogical features

Microscopic studies of the porphyroblastic gneisses indicated that they possess porphyroblastic and occasionally porphyroclastic structures. They consist of porphyroblasts of alkali feldspar (microcline and orthoclase), occasionally albite, as well. Amphibole is present as a greenish variety. Besides these, biotite, muscovite, zoisite and clinozoisite are also present.

Potential

The Lopatica locality is a limited area regarding exploitation. The reserves are estimated at 50 year exploitation with 3000 m3 annually.

Physical-mechanical features

Compressive strength in dry state

Pmax = 107.30 MPa
Pmin = 70.75 MPa
Psr = 87.25 MPa

Compressive strength in water saturated state

Pmax = 99.10 MPa
Pmin = 72.70 MPa
Psr = 83.10 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Pmax = 85.10 MPa
Pmin = 61.60 MPa
Psr = 69.80 MPa

Water absorption

σ = 0.350%

Volume mass

γ = 2610 kg/m3

Resistance to wear

A = 11.50 cm3/50 cm2

MRAMORANI

Locality

The locality is situated some 6 km north of Prilep in close proximity to the village of Mažučiste. The infrastructure is very good. There is a good asphalt road to the site that is part of the local Prilep – Nebregovo road.
There is no good electric power grid that would supply electricity for normal mining activity. The construction of a small water reservoir will be necessary.

This deposit of architectural-dimension stone is entirely located in a series of gneiss granites as part of the regional geological pattern of the Pelagonian metamorphic complex. Gneiss-granites occur as large bodies that are crosscut, occasionally, by smaller pegmatite veins of quartz and biotite. Secondary occurrences of clay minerals can also be found here and there.

Gneiss-granites are built mainly of quartz, potassium feldspar (microcline), with occasional occurrences of albite as well as large amounts of muscovite and biotite. Zircon, apatite and a small amount of ilmenite occur as accessory minerals.

The pattern structure of the deposit has been defined by numerous fissures of variable orientation. However, it can generally be said that they are of northeast extension with angle of dip of some 40°.

Petrographic -mineralogical features

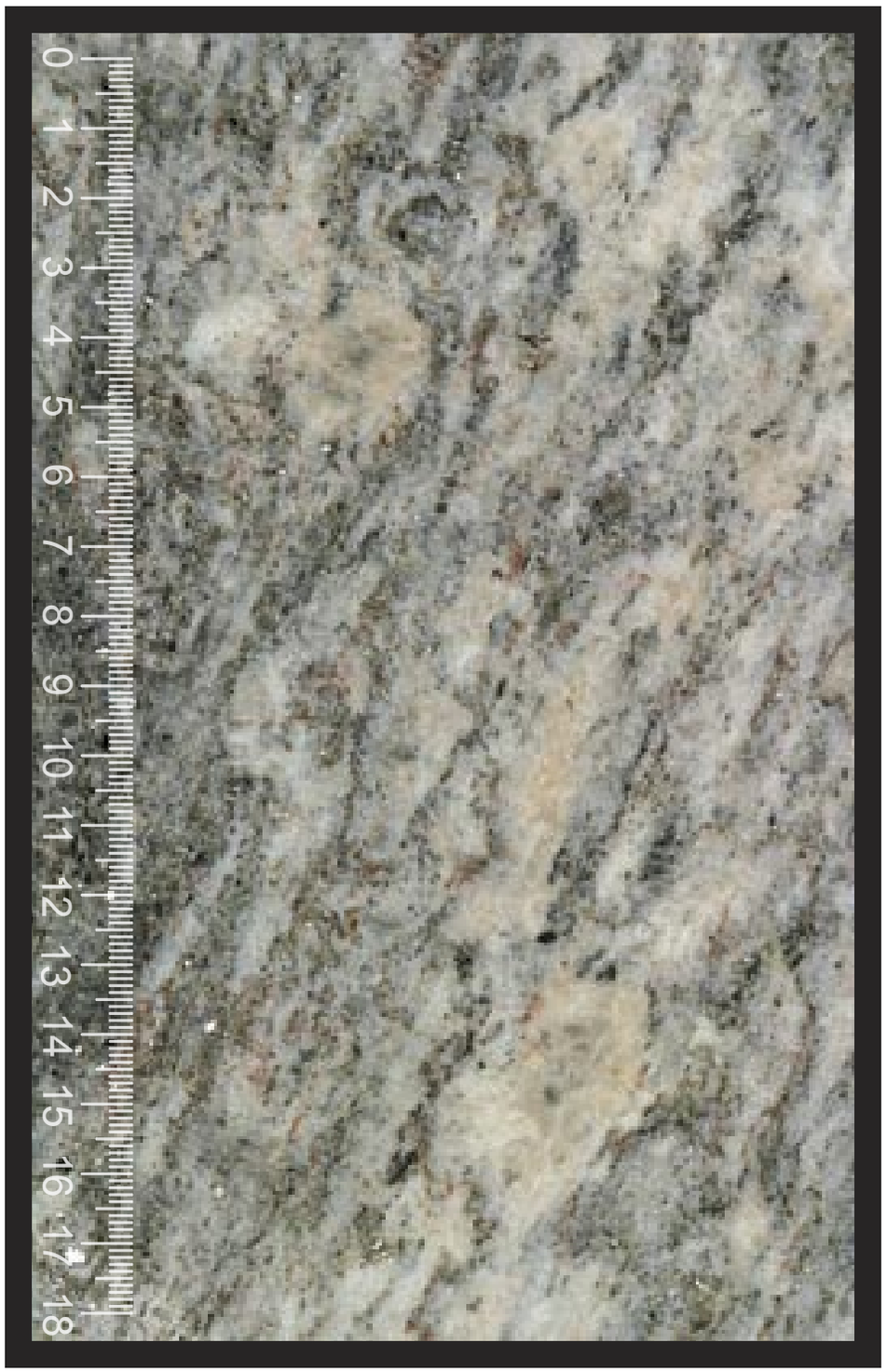
Macroscopically this gneiss-granite possesses ornamental look, white-creamy-greenish colour that comes from the light white to greenish muscovite.
Over 90% of the rock mass consists of light minerals. Femic minerals attain 10 to 15%, present only as light coloured mica-muscovite and biotite with occasional occurrence of epidote.

The mineralogy of the rocks consists of quartz, potassium feldspars (orthoclase, anorthoclase, microcline), acid plagioclases (albite to andesine), muscovite, biotite, apatite, rutile, titanite, ilmenite, zircon and epidote.

The microstructure is granoblastic, in some places lepidoblastic to porphyroblastic. Feldspars and quartz (with over 85%), muscovite, biotite, epidote (10 – 15%), predominate as regards the amount, whereas other minerals occur only as idiomorphic inclusions inside feldspar crystal lattices.

Potential

The Mramorani locality is potential regarding the exploitation of gneiss-granites. The reserves are estimated at 100 year exploitation with 3000 m3 per year.



Physical-mechanical features

Compressive strength in dry state

Pmax = 105 MPa
Pmin = 95.70 MPa
Psr = 101.20 MPa

Compressive strength in water saturated state

Pmax = 116.80 MPa
Pmin = 81.70 MPa
Psr = 91.40 MPa

Compressive strength after freezing and unfreezing of 25 cycles (method of saturated solution Na2SO4)

Pmax = 108.50 MPa
Pmin = 82.05 MPa
Psr = 90.65 MPa

Water absorption

σ = 0.220%

Volume mass

γ = 2650 kg/m3

Resistance to wear

A = 10.0 cm3/50 cm2

SURUN

Locality

Surun is situated north of Prilep, some 10 km from the village of Dupjačani. The infrastructure is good. There is the Prilep - Nebregovo local asphalt road. There is electric power grid that supplies electricity that can be used for exploitation and other mining activities.

In terms of the geology it can be said that the locality is part of the north portion of the Pelagonian metamorphic complex. The immediate vicinity of the locality is built of various types of gneisses and granites.

Petrographic -mineralogical features

Macroscopically the rock is of leucocratic appearance due to the large amount of light minerals compared to femic minerals.

It can be noticed that the rocks possess a lepidoblastic to granoblastic structure, whereas the texture is moderate to pronounce schistose.

Besides macroscopic minerals that are macroscopically visible and present as quartz, feldspars, mica such as muscovite and biotite can also be seen.

It is of note, also, that macroscopically the rocks look fairly fresh.

Under a microscope it can be noticed that the rock is explicitly leucocratic, or in its composition predominate light minerals whose amount attains to 90%, whereas the amount of femic minerals is in the range from 10 to 15%.

Under a microscope the rock structure is granoblastic with elements of lepidoblastic and poprhyroblastic. It is exceptionally fresh with no visual transformation of basic minerals.

The light minerals are present as quartz occurring as large irregular grains that tarnish in a wavy mode, microcline occurring as exceptional crosscuts that make the lattice structure clearly visible. There are occasional occurrences of albite as well.

From the femic minerals predominant are muscovite and biotite which give the impression that muscovite is more abundant.

It is also of note that the rocks contain epidote with occasional occurrences of garnet, alanite, titanite and zircon.

Accessory minerals have not been noticed. This may cause problem in case the rock is used as architectural dimension stone.

Potential

The Surun locality is potential regarding the exploitation of gneiss-granites. The reserves are estimated at 100 year exploitation with 3000 m3 per year.

Physical-mechanical features

Compressive strength in dry state

Psr = 58.20 MPa

Compressive strength in water saturated state

Psr = 55.40 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Psr = 53.65 MPa

Water absorption

σ = 0.520%

Volume mass

γ = 2770 kg/m3

Resistance to wear

A = 27.0 cm3/50 cm2

DRENOVCI

Locality

The Drenovci locality is situated near the village of the same name, some 20 km north of Prilep. The Pilep – Nebregovo – Drenovci local road provides good connection to the locality. The infrastructure is good and Drenovci has good connections with other places in the surrounding.
However, there is no power supply yet sufficient to allow large mining activity.

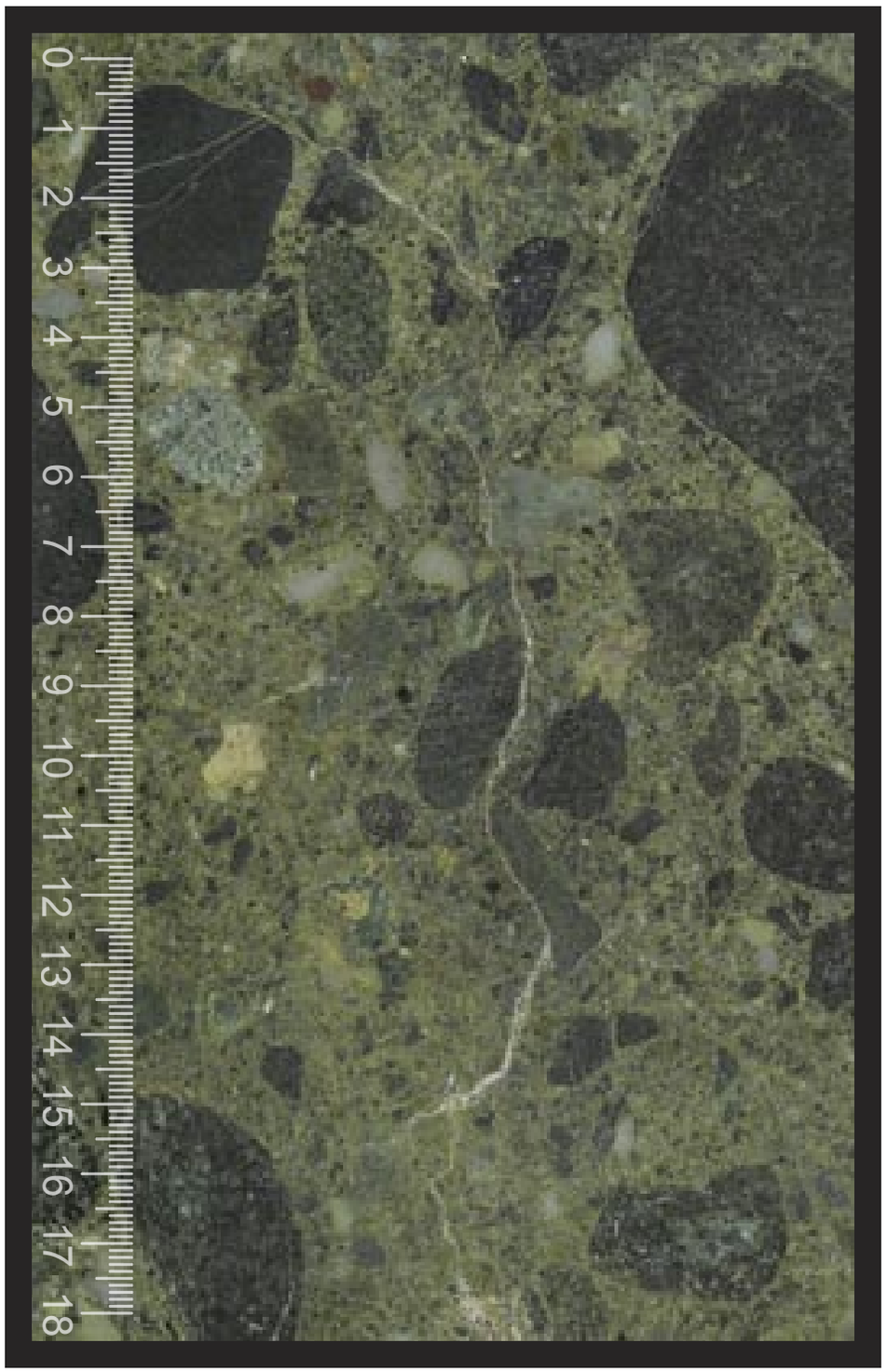
The geology of the site is located in the northern part of the Pelagonian complex and the immediate surrounding is built of various types of gneisses (biotite, two mica gneisses, muscovite etc.). Regarding the tectonic pattern it can be pointed out that it is an area with several larger fault structures that do not have any effects regarding normal operation and exploitation of biotite gneiss commercial blocks.

Petrographic -mineralogical features

This dark grey stone possesses exclusively decorative properties. The stone possesses porphyroblastic structure and shistose texture and is built of feldspars present as albite, biotite, muscovite, amphibole. Secondary minerals are also present. It is of note, also, that the rock does not contain minerals that can be unstable in surface conditions and, in that regard, it can be said that the stone is constant in colour and quality.

Potential

The Drenovci locality is a promising area regarding the exploitation of green biotite gneisses. The reserves are estimated at 100 year exploitation with 2000 m3 per year.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RAKLE

Locality

The Rakle locality is situated close to the village of the same name, some 5 km from the Gradsko – Prilep regional road. The infrastructure provides good connections to the locality. There is an access macadam road to the village that is in good condition. There is electric power supply grid to the village, but it needs overhaul and reconstruction if more mining equipment is used.

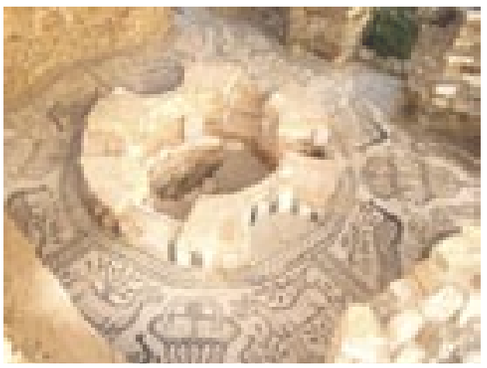
The Rakle deposit is situated in the Vardar zone. The immediate vicinity is built of serpentinites, limestones, diabases and sediments. The Rakle occurrence itself is a serpentinite breccia that lies on both sides of the periodical water flow that passes through the village.

Petrographic -mineralogical features

The serpentinite of Rakle is of breccia composition. It is built of serpentinite fragments and gabbroic rocks with occasional occurrences of diabases. Breccia is of greenish colour with variable shades from light green to dark green. Fragments in the breccia are constant as is the cement material in it. This allows us to say that the rock possesses very good architectural-ornamental features. Fragment size is variable and ranges from 2 to 4 cm.

Potential

The Rakle site is an area of limited potential in terms of the production of large amounts of srepentinite breccia. However, it has generally been estimated that some 1000 m3 can be excavated per year for a period of 25 years.



Physical-mechanical features

Compressive strength in dry state

Psr = 109.10 MPa

Compressive strength in water saturated state

Psr = 104.80 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Psr = 83.20 MPa

Water absorption

σ = 2.3%

Volume mass

γ = 2685 kg/m3

Resistance to wear

A = 20.3 cm3/50 cm2

Physical-mechanical features

Compressive strength in dry state

Psr = 59.80 MPa

Compressive strength in water saturated state

Psr = 59.80 MPa

Compressive strength after freezing and unfreezing of 25 cycles

Psr = 43.20 MPa

Water absorption

σ = 3.8%

Volume mass

γ = 2260 kg/m3

Resistance to wear

A = 38.20 cm3/50 cm2

MARIOVO

Locality

The locality is situated some 45 km southeast of Prilep in an area called Mariovo, close to Bešišhte and Manastir. The infrastructure in and around the locality is favourable. The locality is connected by the Prilep – Vitolište regional road. There are installations of good electric power supply grid nearby and with some investments the whole area will receive good electric supply that can create conditions for mining activities.

Geologically, the site represents a Pliocene plateau built of carbonates, clayey carbonate and volcanic materials. Two horizons occur in the Pliocene plateau of which the lower one is built of onyx and the upper one of travertine.
The thickness varies and ranges from 1 m to 3 m.

Petrographic-mineralogical features

Samples of onyx of Mariovo indicate that they are brown-yellowish in colour, that they possess striped texture and built of aragonite. Aragonite crystals are ring radially distributed that give the stone very decorative look.
The onyx is transparent with no admixtures that can lower its quality.

The travertine from the locality is characterized by brown to yellowish color, hollow texture with occasional occurrence of breccoid texture.

Potential

Mariovo is an exceptionally potential area in terms of the exploitation of onyx and travertine. The reserves are estimated at 100 year exploitation with some 2000 m3 per year.

Note: the parameters of the physical – mechanical features of the rocks have been provided by the Institute for Civil Engineering of the R. of Macedonia in Skopje and by the Faculty of Civil Engineering in Skopje.

Relevant Institutions

The Government of the Republic of Macedonia
www.vlada.mk

Ministry of Economy of the Republic of Macedonia
www.economy.gov.mk

Sector for energy and minerals
http://www.economy.gov.mk/default-MK.asp?ItemID=1E4A6481788E0E49B4C8BBC38D29F9CC

Agency for foreign investments of the Republic of Macedonia – Macinvest
www.macinvest.org.mk

Municipality of Prilep
www.prilep.gov.mk

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Prilep Region Enterprise Development Agency (PREDA)
www.preda.com.mk

Association Kamen
www.kamen.org.mk

May 2006