Bulletin of the Chemists and Technologists of Macedonia, Vol. **22**, No. 2, pp. 111–141 (2003)
GHTMDD – 429
ISSN 0350 – 0136
Received: November 15, 2003
UDC: 549.6 : 543.422.4
Accepted: January 30, 2004

Review

MINERALS FROM MACEDONIA

XI. SILICATE VARIETIES AND THEIR LOCALITIES – IDENTIFICATION BY FT IR SPECTROSCOPY

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Among the rich ore deposits present in Macedonia, the silicate minerals are the most numerous group. The great majority of these minerals appear as rather large and well formed single crystal aggregates in the nature. Sometimes, however, some of the mineral species appear in association with other minerals whose crystals are not well developed. Here an overview of the basic morphological, physico-chemical and crystallographic characteristics of the most typical silicates collected from various localities within the Republic of Macedonia is given. The mineralogical and petrological features of the localities where the specimens are collected from are presented as well. Also an attempt to identify the minerals using the FT IR spectroscopy and to classify them according to their structural characteristics is performed. The identification of the minerals was based on the comparison of the infrared spectra of our specimens with the corresponding literature data for the mineral species originating all over the world. The coloured pictures of all studied silicate minerals are presented as well.

Key words: silicate minerals; silicate assemblage; silicate localities; Republic of Macedonia; FT IR spectroscopy.

INTRODUCTION

In the past few years, a study of the carbonate [1–4], sulfide [5–9], and sulfate [10, 11] minerals originating from the localities in the Republic of Macedonia has been performed using vibrational (infrared and Raman) spectroscopy. The research has predominantly been focused on mineral identification and characterization, recently being spread to the determination of the content of trace elements i.e. elements which do not take part in the regular mineral composition [2, 12]. Thus, in the process of mineral separation, purification and characterization, significant number of non-silicate minerals has been systematically investigated.

Recently the study was extended to the most abundant group of the silicate minerals. Here, are presented the results of the collection of the great majority of the silicate mineral specimens originating from Macedonia as well as their separation, purification, structural classification and identification using the FT IR spectroscopy. Identification was based on the comparison of our IR results with the corresponding literature data for the analogous mineral species originating all over the world. Presented are also the most typical representatives for each locality where they have grown up. In this context, the petrologic and mineralogical characteristics of the localities throughout the country where the specimens were collected from are also discussed. The coloured pictures as well as the FT IR spectra of all studied silicate mineral samples are presented.

Here, it should be mentioned that the detailed IR analysis as well as the overall Raman and XRD investigation will be carried out in the near future.

atomic absorption spectrometry for determination of the chemical composition (major, minor and trace elements) and the purity of the minerals, soon, will also be employed.

STRUCTURALLY BASED CLASSIFICATION OF SILICATES

More than 3500 minerals have been identified and named by now tending in the near future to approach the number 4000 [13–15]. Approximately 30 % of them (about 1100) belong to the silicate class which is the most abundant group of minerals in the Earth's crust. A few silicates are used as precious gemstones, while most of them are drab and commonplace. However, they are very important economic resources being used as industrial materials. The silicate minerals also make agriculture possible as a most dominant component of soil (mostly quartz and clays).

The elementary building unit of the silicate minerals is the SiO_4 tetrahedron consisting of four O^{2-} anions around a Si^{4+} cation. Consequently, the isolated SiO_4 tetrahedron has a net –4 charge. It means that each O^{2-} has satisfied one of its two valence charges by bonding with the Si^{4+} in the tetrahedron, whereas the remaining –1 charge is available to be bonded with Si^{4+} from another tetrahedron. This enables linking of one SiO_4 tetrahedron to another resulting in formation of various polymers. The structural classification of the silicate minerals is in fact based on the extent of sharing of oxygen anions between the adjacent tetrahedra. It makes the silicates the largest and the most complicated class of minerals.

The resulting structural classification of silicates based on the degree of polymerization is given in Table 1 [13].

T a b l e 1

Structurally based classification of the silicate minerals

Silicate class configuration	Number of O^{2-} shared per tetrahedron	Si:O ratio*	Structural configuration
Nesosilicates (orthosilicates)	0	1:4	Isolated tetrahedra
Sorosilicates (disilicates)	1	2:7	Double tetrahedra
Cyclosilicates (ring silicates)	2	1:3	Rings of tetrahedra
Inosilicates (chain silicates)			Chains of tetrahedra
– Single chain	2	1:3	
– Double chain	2 or 3	4:11	
Phylosilicates (sheet silicates)	3	2:5	Sheets of tetrahedra
Tectosilicates (framework silicates)	4	1:2	Framework of tetrahedra

*Instead of Si^{4+}, Al^{3+} can also occupy the tetrahedral sites.

Nesosilicates (orthosilicates)

The silicate minerals where the SiO_4 tetrahedra are not bonded to other tetrahedra (no oxygen anions are shared between the adjacent tetrahedra) belong to the nesosilicates (orthosilicates). The net negative charge of the isolated silicon tetrahedra is balanced by bonding with other cations such as Mg^{2+}, Fe^{2+}, Al^{3+} etc. They show great structural similarities with other mineral classes consisted of tetrahedral ionic units such as the sulfates (SO_4^{2-}), phosphates (PO_4^{3-}) etc. Nesosilicates are characterized by stronger bonds and more expressed close packing of ions and consequently by higher density, index of refraction and hardness compared to other silicate classes.

Sorosilicates (disilicates)

As result of sharing single oxygen (O^{2-}) between two (SiO_4^{4-}) tetrahedra, the basic chemical unit in the sorosilicates (disilicates) is the anion group Si_2O_7 with a net –6 charge. In addition to the double tetrahedra, some of the minerals belonging to this class may also contain single tetrahedra. They are a relatively small but widely distributed group of minerals. Some members of this group (e.g. epidote) are very common accessory minerals in many metamorphic rocks.

Cyclosilicates (ring silicates)

In the ring silicates (cyclosilicates) each SiO_4^{4-} tetrahedron shares two O^{2-}, forming thereby rings with three, four, eight but most frequently with six members. The symmetry of these minerals is usually influenced by the corresponding ring symmetry, at least in the case of the less complex ring silicates. Due to their high hardness, luster and durability, some representatives of this group are very well known gemstones. Similarly to disilicates, the ring silicates are a small group of minerals.

Inosilicates (chain silicates)

Inosilicates consist of two distinct subgroups: the single chain and the double chain silicates. In the single chain silicates two O^{2-} per tetrahedra are shared, whereas in the double chain group some tetrahedra share two and other share three O^{2-}. Endless single or double chains are thereby formed. The ratio of silicon to oxygen is thus 1:3 in the single chains and 4:11 in the double chains. The single chain silicates are known as pyroxenes, whereas the double chain as amphiboles. In general, both types of minerals are very common, although the amphiboles are not as abundant as the pyroxenes.

Phylosilicates (sheet silicates)

The sharing of three O^{2-} per tetrahedra forming two-dimensional planes (continuous layers) is characteristic of the sheet silicates (phylosilicates). The sheets are connected to each other by layers of cations. Therefore their crystals are flat and display basal cleavage. Almost all members of this group of sheet silicates are very soft. Phylosilicates are abundant and very important in geological environments. They are hydrous, which means that OH^- groups (not water molecules) are included in their structure.

Tectosilicates (framework silicates)

In the tectosilicates (framework silicates) all four oxygens (O^{2-}) are shared with the adjacent tetrahedra forming thereby three-dimensional framework. Contrary to other silicate groups where the extent of substitution of Si^{4+} by Al^{3+} cations is lower, in tectosilicates it often reaches up to 50 %. Thereby caused transformation of the normal net –4 charge (for SiO_4) into –5 (for AlO_4) is balanced by the presence of additional cations in the structure of framework silicates. It is the main reason for the high extent of variations within this group of silicates.

GEOLOGICAL COMPOSITION OF THE REPUBLIC OF MACEDONIA

In general, four geotectonic regions (units) are present in the territory of the Republic of Macedonia: Serbian-Macedonian Massive (SMM); Vardar Zone (VZ); Pelagonian Metamorphic Complex (PMC); West-Macedonian Zone (WMZ) (see Fig. 1) [16].

The Serbo-Macedonian Massive (SMM) is located in the eastern part of the Republic of Macedonia being spread to Serbia on the north**,** to Greece on the south and slightly to Bulgaria on the east. In general, it is built-up of metamorphic rocks of Precambrian and Paleozoic age and consists of lower and upper metamorphic complex. The lower metamorphic complex contains gneisses, schists as well as small bodies of amphibolites, ophiolites, quartzites and marbles. The upper complex consists of volcanogeno-sedimentary constituents being methamorphozed in the series of the green schists. The most dominant among them are chloritic, amphibolo-biotitic, chlorito-sericitic and quartz schists.

The Vardar Zone (VZ) as a distinct structural unit is situated between the Serbian-Macedonian Massive on the east and the Pelagonian Metamorphic Complex and partly the West-Macedonian Zone on the west. In general, it is a rift structure of continental type which consists of the fragments of Precambrian crust of the earth as well as Paleozoic volcanogeno-sedimentary complex, acid mezozoic and tertiary calco-alcaline magmatism. The rest of the oceanic crust are presented by greater gabro-diabasis ophiolitic complexes.

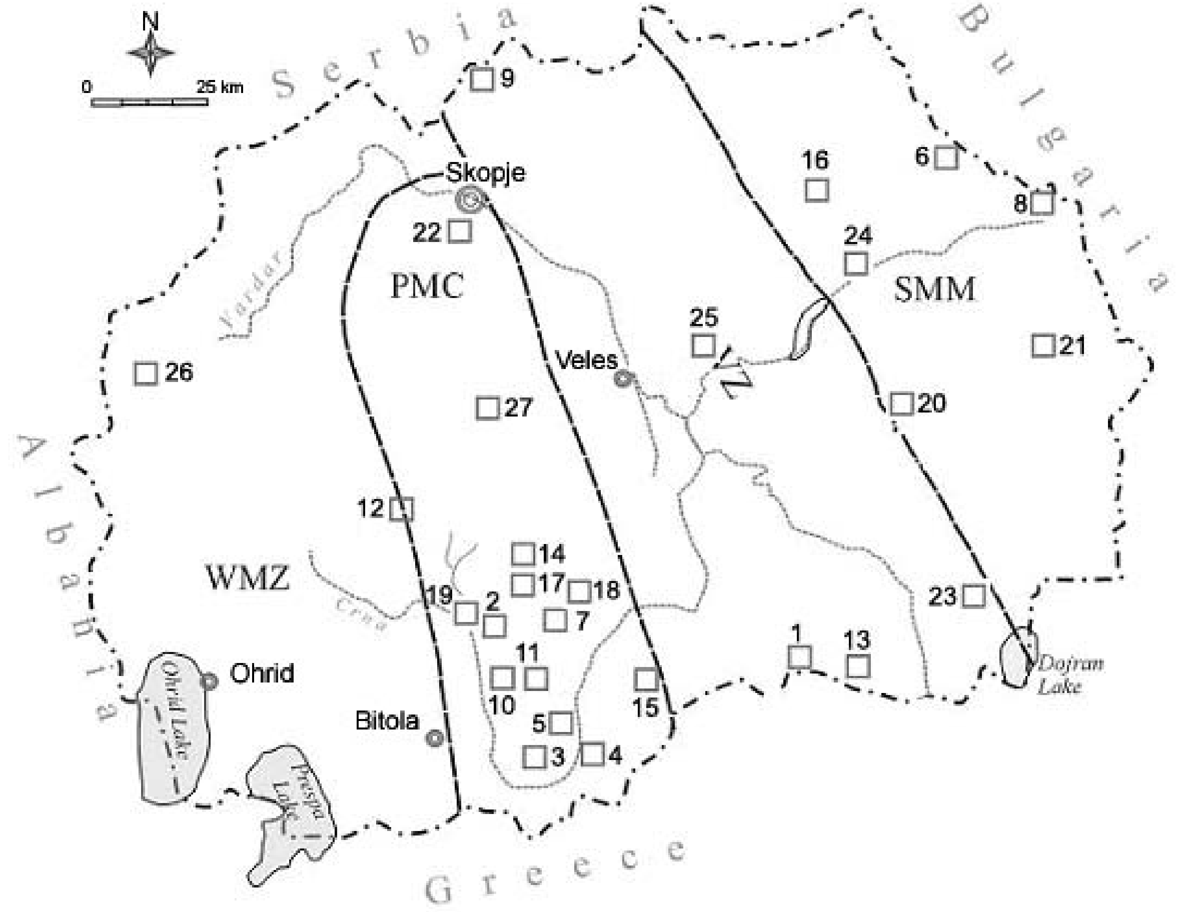


Fig. 1. The silicate localities in the Republic of Macedonia: 1) Ržanovo, 2) Alinci, 3) Čanište, 4) Belutče, 5) Dunje, 6) Sasa, 7) Štavica, 8) Zvegor, 9) Lojane, 10) Staro Bonče, 11) Bonče, 12) Košino, 13) Kožuf, 14) Pelagon, 15) Vitolište, 16) Zletovo, 17) Sivec, 18) Prilepec, 19) Veselčani, 20) Bučim, 21) Budinarci, 22) Vodno, 23) Rabrovo, 24) Češinovo, 25) Bogoslovec, 26) Nistrovo, 27) Nežilovo

Pelagonian Metamorphic Complex (PMM) is of Precambrian and Paleozoic age. The present complexes of rocks in this zone vary from those appearing as a constituents of other tectonic units. This zone consists of high metamorphic crystalline rocks, gneisses, micachists and marbles as well as of regional metamorphic complexes where huge masses of palingenic granites are included. Their age vary from 800 to 1000 Ma.

West-Macedonian Zone (WMZ) consists of several formations. The oldest one is the volcanogeno-sedimentary spilite-ceratophiric formation of old Paleozoic age. The upper philito-carbonate and/or limestone series is of Paleozoic (Ordovicium, Silur, Devon) and Mesozoic (Triasic) age. Besides other components this zone contains quartzporphirites.

The above discussed geologic constitution of the Republic of Macedonia is characterized by the presence of a large number of silicate minerals in all mentioned geotectonic units, the most prominent one being the Pelagonian Metamorphic Complex (PMM). Their occurrences are discussed in the next chapter.

SILICATE DEPOSITS AND OCCURRENCES IN THE REPUBLIC OF MACEDONIA

Ržanovo locality

In the west ophiolitic belt of the Vardar Zone a rich iron-nickel locality Ržanovo is located. The basic geological constitution of this deposit includes the following stratigraphic units: Triasic limestones, Jurassic serpentinites, iron-nickel ore from the lower Cretaceous age, upper Cretaceous limestones and schists [17]. From the mineralogical point of view a variety of minerals are present: magnetite, hematite, chromite, limonite, pyrite, chlorite, riebeckite, chrysotile, talc, brucite and other [18, 19]. Serpentinite minerals are also widespread because this locality is placed at the ultrabasic rocks subjected to the continuous process of serpentinization. Also, as a consequence of the weak metamorphic processes and under conditions of high pressure and low temperatures on the contact area between serpetinites and ore layer, a notable quantity of talc mineral is established. Its appearence is in massive aggregates with white, but sometimes greenish color. The basic characteristic of talc from Rzanovo deposit is the presence of significant content of nickel.

Alinci locality

The Alinci locality is situated 11 km southwest of Prilep city, nearby the Alinci village. From the geological point of view this locality is built up of alcalic syenites, amphibolites, gneisses, muscovite schists and marbles. Alcalic sienites appear in the form of magmatic body about 2 km long surrounded by amphiboles from its east and west side. Large and small grained syenites are made of microcline, arfvedsonite, albite and modest content of titanite, augite, zircon, apatite and davidite. Gneisses and quartz-microcline veins are inside the syenitic body. Amphibolitic schists represent the southern part of the syenite massif [20]. Furthermore, it is important to emphasize the specific and very rare mineral parageneses of the uranium and other radioactive minerals, as well as abundant appearance of nests (few tenths of centimeters) filled with the needle-like arfvedsonite crystals [21].

Arfvedsonite is a member of the amphibole group characterized with needle-like crystals, green, black or blue colored in transmitted light. It is the first to crystallize and therefore, it can be found embedded in all present, but later crystallized minerals in the paragenesis. It also accompanies the feldspar group minerals.

Albite mineral is frequently present in well-developed and lath-formed crystals, from totally transparent to white colored. The largest crystals reach 10 cm in length. Very common appearence of polysynthetically twinned specimens as well as Karlovar's twins is typical. Also, the arfvedsonite crystal inclusions are present in this mineral.

Čanište locality

The location is on the western edge of Selečka Planina near by the village Čanište. This deposit is interesting because of large number of scattered minerals from the pegmatite in the garnet's and gneiss series [22], of which the most widespread are:

(a) Microcline mineral is rarely in the form of typically white crystals. The most interesting is the appearance of a green colored variety – amazonite which is present in the cleavage fragments (on the cleavage surfaces) instead of forming regular crystals.

(b) Epidote mineral is embedded in the pegmatite bodies, dominantly in the quartz-feldspar rocks. Therefore, it is practically impossible to remove it undamaged from the mother rock [23]. It is characterised with green colored, regular column-like crystals. They are not transparent, but are ideomorphly developed in more than 1 m long.

(c) Muscovite mineral is fixed on the contact surfaces between quartz and feldspar as a constituent of the pegmatite bodies, in few centimeters thick layers.

Belutče locality

On the southern part of Mariovo, on the saddle of this mountain, a pegmatite deposit at the locality Belutče lies. Basicaly, it is quartz-pegmatite vein once being used for the production of sodium feldspar (albite). Additional minerals originating from this vein are apatite, orthoclase, microcline as well as large beautiful quartz prismatic monocrystals over 10 cm long [24]. In this study the results of the investigation of the orthoclase and microcline from this locality are presented.

Dunje locality

In the nearby village of Dunje, on the contact parts between the garnets and specially gneiss, a hydrothermal-pegmatite vein appears. During World War II the Germans explored and used the micas from this zone for insulators in electric tubes. At this location also more specific, interestingly combined mineral bodies are present, such as albite, adular, titanite, pyrite, quartz, stilbite and completely transparent epidote morphologically presented in various regular crystallographic forms [25, 26].

Sasa locality

The lead-zinc province of Sasa belongs to the ore region Sasa-Toranica. The metallogenetic zone is familiar with the semimetal lead-zinc ore mineralization, paragentically related with the subvolcanic Tertiary calcium-alcalic magma. During the Alpine-metalogenetic age, the mineralization in four phases had taken place which led to the significant lead and zinc formations followed by varying content of Cu, Au, Ag, Mo, Sb. The dominant part of the ore mineralization is located not only in the contact gneiss–quartzgraphite schist's and cipolines fragments, but also minerals within the quartzgraphite schist's and gneiss appear as well [27].

The mineral composition of the ore mineralization is much more complex and basically represented by variety of minerals formed in the different mineralization stages (metamorphic, skarns, hydrothermal). The most known minerals in the Sasa deposit appeared to be: galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, tetrahedrite, freibergite, tennantite, marcasite, bornite, bismuthine, native bismuth, pentlandite, cubanite, vallerite, arsenopyrite, altaite, emplectite. The scarn mineral is represented by the garnet's (grossular, andradite), bustamite, augite, diopside, ilvaite, hedenbergite, johannsenite, rhodonite, actinolite as well as minerals from the hydrothermal-scarn stadium like chlorite, magnetite and hematite. Despite these, an oxide and carbonate minerals are also present, the most well-known being calcite, ankerite, dolomite, kutnahorite, rhodochrosite, siderite, otavite as well as secondary minerals like cerusite, anglesite, malachite, azurite, hemimorphite [28, 29].

Štavica locality

Close to the Prilep-Vitolište road, on the Selečka Planina the Štavica locality is situated. This locality is basically built up of metamorphic rocks and micashists'. Garnet, dystane and staurolite monocrystals also appear along the occasional river flow alluvium. About 1 km left from the mentioned road towards Vitolište village (aside from Štavica) in the quartzlatite bodies of the gneiss series, the presence of kyanite monocrystals (blue distenes) is evident. Kyanite appears as intensively blue colored crystals and large crystal aggregates with enormous dimensions – over 20 cm [30, 31].

Zvegor locality

Not far from the small city of Delčevo, in the Zvegor village a volcanic quartzlatite rocks are found. In this series of rocks, towards the Bulgarian border, there is an outcrop full of large crystals of sanidine. The crystals are typical, with regular crystallographic forms. Often twinned crystals are present [31].

Lojane locality

In the serpentinite mass of the ultrabasic Lojane complex, ahead the tectonic structures, the most spread mineral – talc is registered. Another, not that frequent, but typical mineral for this locality which appears as intense green color thin curved layers is chlorite [32].

Staro Bonče locality

The Staro Bonče village is located on the Selečka Planina, primarily built up of micaschists (high metamorphic rocks). Kyanite, staurolite and garnets are also found above the village. The latter appear in the form of large crystals with regular crystallographic forms, mostly represented by almandine mineral [33].

Bonče locality

From the right side of the Bonče-Sliva road, in the unique metamorphic complex represented by the micachists, a tourmaline mineral appears in the quartz veins associated in the large prismatic and intensively black colored crystals up to 10 cm [34]. Among other present minerals are: disten, staurolite and quartz veins accompanied by apatite.

Košino locality

In the west contact edge between the Pelagonian Metamorphic Complex and West-Macedonian Zone a variety of Paleozoic-metamorphic rocks represented by different schist's series appears [34]. It is to emphasize that close to the Košino village an epidote-chlorite-amphibole schists series is present, often composed by little content of talc-schists, actinolite, schists, metagabbros, serpentinites and metadiabases. The light-green colored schists have massive texture and nematoblastic structure. In the series about 500 meters in length, the most known are the large crystals (20 cm) of green actinolite [35]. Other common minerals are amphibole, chlorite, epidote and coisite. The less content of albite, quartz, sericite, biotite, talc, titanite, pyrite and magnetite are also found.

Kožuf locality

In the series of the volcanic rocks of the volcanic complex of Kožuf Mountain a numerous petrologic types appear: andesites, quartzlatites, latites, thachyte, rhyolites and several transition rocks for their connection. These volcanic rocks are built up of intermediary plagioclases: andesite, biotite, sanidine, quartz, augite as well as amphibole represented with hornblende. The latter mineral appears in regular crystallographic forms being black colored and amounting up to 1 cm. It should be pointed out here that from time to time the hornblende transforms into thin opacite edge [36].

Pelagon locality

In the series of the trachitic muscovite-biotite gneisses in the central and west part of the Pelagon, near the contact bodies to the granodioritic masses, a high concentration of mica is found, mostly represented by biotite and muscovite. The biotite from this locality is typical with its massive appearence and variety of large crystal forms up to 10 centimeters. Sometimes, especially in the pegmatite bodies, even larger lath-shaped biotite crystals are located [22]. It should be point out that often a large crystals of almandine over 2 cm appear in Krastov Kamen and Veprčani deposits.

Vitolište locality

Between the Vardar Zone and Pelagnian Metamorphic complex near the Vitolište village (on the Melnica – Vitolište road) a filito-micaschists and green carbonates schists appear. A green muscovite called fuxite, is present in the rocks [22].

Zletovo locality

The lead-zinc vein type hydrothermal deposit is genetically associated with the processes of Tertiary magmatic activity. Several major types of ore parageneses are established at this deposit particulary the low temperature paragenesis including the quartz and chalcedony minerals in the dominatly oxide carbonate associations [37–39].

Sivec locality

Near the city of Prilep, in the marble series of the Pelagonian Metamorphic Complex, a surface mine (Sivec) for white dolomite marble exploitation is activated. These marbles, according to the degree of metamorphism and mineral association, belong to the group of regional-metamorphic and igneous rocks, being basically composed of carbonates (dolomite, calcite) and oxides (diaspore, corundum, rutile). Also some common (tourmaline, diopside, muscovite, chlorite) as well as some very rare silicates (phlogopite, cymrite, kosmatite) are present as well [40, 41].

Prilepec locality

The Prilepec locality is about 5 km south from the city of Prilep. The deposit is built up of metamorphic rocks, dominantly micaschists. The most known silicates are kyanite, almandine and staurolite. It is important to point out that kyanite from this locality forms intergrown crystals spotted in the quartzlatitic rocks.

Veselčani locality

In the micachists series of the Pelagonian Metamorphic Complex of Macedonia which is basically build up of gneisses, micachists, amphibolites and marbles, a Veselčani village is recognized by the presence of large well-formed crystals of rutile (even 10 cm) [22]. This mineral has common origin with muscovite and quartz and is associated in the pegmatic-quartz veins. Another silicate minerals present in this locality are microcline and actinolite.

Bučim locality

The ore deposit is located on about 10 km west from Radoviš city. From the geologic point of view it is built up of Precambrian metamorphic rocks (various types of gneisses and amphiboles) and Tertiary volcanics (andesites and latinoandesites). Here the presence of copper mineralization of the porphyry type in the area of 1.5–2 km^2

is established. The most represented silicate mineral is quartz [42].

Budinarci locality

The Budinarci village is situated about 12 km southwest from the Berovo city. The rocks surrounding the village are micashists, gneisses and granites. Very wide granite and quartz veins are found in the above mentioned rocks [23]. Quartz is the most abundant mineral in this locality found in the form of beautiful monocrystal species being from transparent, across slightly smoky, up to totally dull.

Vodno locality

The first literature data about the occurrence of glaucophane mineral on the field of Vodno is found in the work of Kosmat [43] who has performed detailed research of the geologic profiles of this mountain. It is mentioned that an alcalic amphibole of the glaucophane type is present in the series of Palaeozoic schist's and cipolines. The further study in the series of metamorphic rocks from the Palaeozoic age on Vodno and Osoj has also shown the presence of glaucophane [44].

Rabrovo locality

Ultrabasic tectonites in the Rabrovo locality manifest the part of the east-ophiolitic belt of the Vardar Zone. They are covered and surrounded by the younger and transgressive Dedeli series which is situated between the rocks of the Paleozoic age. Here, the ultrabasic rocks are built up of dunites, lherzolites and verlites occasionally followed by leucocrate garnets. In the verlite series a large specimen of calcium clinopyroxene mineral – augite is typical [32].

Češinovo locality

The great content of volcanic tuffs occurs in the series of the Kratovo-Zletovo volcanic area. The tuffs are found in the places where the processes of hydrothermal metamorphosis are present [45, 46]. These hydrothermal changes are represented with silicification of quartz, cristobalite and the most dominant being the opal mineral form. Some found specimens are recognizable with the presence of tridymite occurring on the opal surface.

Bogoslovec locality

In the series of the ultrabasic rocks in the east-ophiolitic belt of the Vardar Zone in the Bogoslovec locality, an occurrence of the large body of tectonic ophiolites is established. The ophiolitic rocks are built up of dunites, harzburgites and less common gabrites. Along the gaps of the dunite series a large content of serpentinite minerals is formed, the most frequent being chrysotile. Here, this mineral is found in the little needle-like form or needle conglomerates amounting up to 0.5 cm each [32].

Nistrovo locality

Nearby Vrbjani village, Nistrovo village, Štirovica locality, Brodec village as well as Kobilno Pole locality, a serpentine body localized across the deeper tectonite structures are found. On the surface, these serpentines are tectonically crashed and changed with grey- or dark-greenish up to black colored. Their bodies are rarely accompanied by the needle-like chrysotile (asbestos). Although, basically built up of chrysotile and antigorite a low content of pyroxenes, magnetite and chromite are present [47]. The secondary minerals like calcite, chlorite and actinolite are also typical.

Nežilovo locality

The Nežilovo locality is situated 40 km southwest of Veles in the cental part of the Pelagonian massif. Two parts – the lower and upper one are divided from the complex metamorphic series of Precambrian rocks. The latter consists of massive marbles, whereas the former is built up of gneisses, micaschists, barite-bearing schists, quartz-cymrite schists and pink dolomitic marbles [34, 48].

ASSEMBLAGE OF INDIVIDUAL TYPES OF SILICATE MINERALS

T a b l e 2

Studied silicate minerals from the territory of the Republic of Macedonia

No.	Mineral	Formula	Crystallographic system; Space group
Orthosilicates = Nesosilicates			
1	Almandine	$Fe_3Al_2(SiO_4)_3$	Cubic; *Ia*3*d*
2	Staurolite	$Fe_2Al_9O_6(SiO_4)_4(OH)_2$	Monoclinic; *C*2/*m*
3	Kyanite	Al_2SiO_5	Triclinic; $P\bar{1}$
4	Olivine	$(Mg,Fe)_2SiO_4$	Orthorhombic; *Pbnm*
5	Titanite	$CaTiSiO_5$	Monoclinic; $P2_1/a$
6	Spessartine	$Mn_3Al_2(SiO_4)_3$	Cubic; *Ia*3*d*
Disilicates = Sorosilicates			
7	Epidote	$Ca_2Al_2(Al,Fe^{3+})OOH[Si_2O_7][SiO_4]$	Monoclinic; $P2_1/m$
8	Hemimorphite	$Zn_4Si_2O_7(OH)_2{\cdot}H_2O$	Orthorhombic; *Imm*2
Ring Silicates = Cyclosilicates			
9	Tourmaline	$NaFe^{3+}{}_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	Trigonal; *R*3*m*
Chain Silicates = Inosilicates			
10	Arfvedsonite	$Na_3(Mg,Fe^{2+})_4(Fe^{3+},Al)Si_8O_{22}(OH)_2$	Monoclinic; *C*2/*m*
11	Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	Monoclinic; *C*2/*m*
12	Glaucophane	$Na_2Mg_3(Al,Fe)_2Si_8O_{22}(OH)_2$	Monoclinic; *C*2/*m*
13	Ilvaite	$CaFe^{2+}{}_2Fe^{3+}Si_2O_8(OH)$	Orthorhombic; *Pbnm*
14	Augite	$(Ca,Mg,Fe^{2+},Fe^{3+},Al)_2(Si,Al)_2O_6$	Monoclinic; *C*2/c
15	Diopside	$CaMgSi_2O_6$	Monoclinic; *C*2/c
16	Rhodonite	$MnSiO_3$	Triclinic; $P\bar{1}$
17	Johannsenite	$CaMnSi_2O_6$	Monoclinic; *C*2/*c*
18	Hornblende	$(NaK)_{0-1}Ca_2(Mg,Fe,Fe^{3+},Al)_5(SiAl)_8O_{22}(OH)_2$	Monoclinic; *C*2/*m*
Sheet Silicates = Phyllosilicates			
19	Antigorite	$(Mg,Fe^{2+})_3Si_2O_5(OH)_4$	Monoclinic; *Cm*
20	Chrysotile	$Mg_3Si_2O_5(OH)_4$	Monoclinic; *A*2/*m*
21	Biotite	$K(Mg,Fe^{2+})_3AlSi_3O_{10}(OH,F)_2$	Monoclinic; *C*2/*m*
22	Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$	Monoclinic; *C*2/*m*

23	Talc	$Mg_3Si_4O_{10}(OH)_2$	Monoclinic; *C*2/*c*
24	Phlogopite	$KMg_3(Si_3Al)O_{10}(F,OH)_2$	Monoclinic; *C*2/*m*
25	Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	Monoclinic; *C*2/*m*
26	Cymrite	$BaAl_2Si_2O_8{\cdot}H_2O$	Monoclinic; $P2_1$
27	Kosmatite	$Ca_3MgAl_2AlSi_3O_{10}(OH,F)_8$	?
28	Paragonite	$NaAl_2(Si_3Al)O_{10}(OH)_2$	Monoclinic; *C*2/*c*
29	Vermiculite	$(Mg,Fe^{2+},Al)_3(Al,Si)_4O_{10}(OH)_2{\cdot}4H_2O$	Monoclinic; *C*2/*m*
Framework Silicates = Tectosilicates			
30	Albite	$NaAlSi_3O_8$	Triclinic; $P\bar{1}$
31	Analcime	$NaAlSi_2O_6{\cdot}H_2O$	Triclinic; *P*1
32	Microcline	$KAlSi_3O_8$	Triclinic; $P\bar{1}$
33	Orthoclase	$KAlSi_3O_8$	Monoclinic; *C*2/*m*
34	Opal	$SiO_2{\cdot}nH_2O$	Amorphous
35	Quartz	SiO_2	Trigonal; $P3_12_1$
36	Sanidine	$(K,Na)(Si,Al)_4O_8$	Monoclinic; *C*2/*m*
37	Stilbite	$NaCa_4Al_8Si_{28}O_{72}{\cdot}30H_2O$	Monoclinic; *C*2/*m*

T a b l e 3

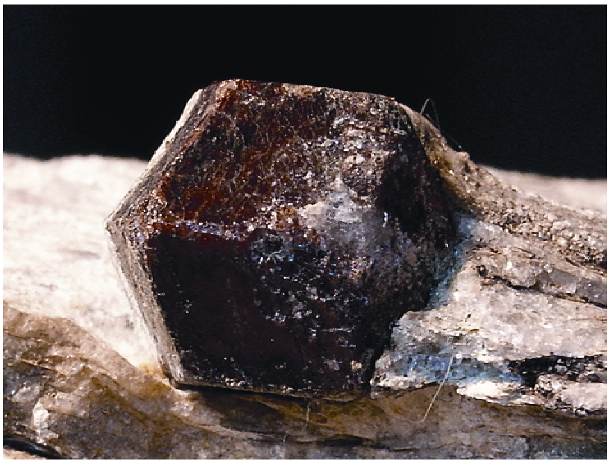
Non-studied silicate minerals from the territory of the Republic of Macedonia

No.	Mineral	Formula	Crystallographic system; Space Group
Orthosilicates = Nesosilicates			
1	Zircon	$ZrSiO_4$	Tetragonal; $I4_1/amd$
Ring Silicates = Cyclosilicates			
2	Beryl	$Be_3Al_2Si_6O_{18}$	Hexagonal; *P*6/*mmc*
Chain Silicates = Inosilicates			
3	Palygorskite	$(Mg,Al)_2Si_4O_{10}(OH){\cdot}4(H_2O)$	Monoclinic; *C*2/*m*
4	Bustamite	$(Ca,Mn)_3Si_3O_9$	Triclinic; $P\bar{1}$
Sheet Silicates = Phyllosilicates			
5	Zinnwaldite	$KLiFe^{2+}Al(AlSi_3)O_{10}(F,OH)_2$	Monoclinic; *C*2/*m*
6	Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2{\cdot}nH_2O$	Monoclinic; *C*2/*m*

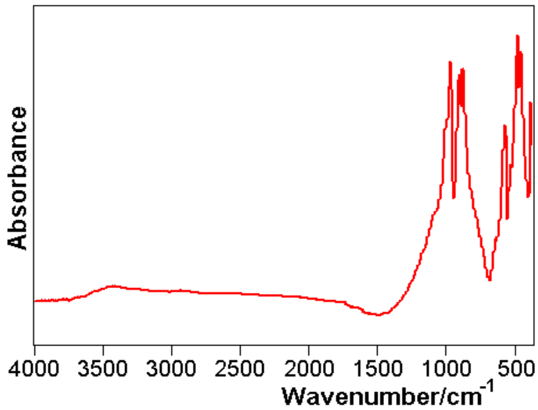
Nesosilicates (orthosilicates)

Almandine $Fe_3Al_2(SiO_4)_3$

Environment: Metamorphic and pegmatitic rocks
Locality: Prilepec, Štavica, Pelagon, Staro Bonče
Name Origin: Named after the locality Alabanda in Asia
Density (Calc): 4.32
Cleavage: None
Color: Brown, brownish red, red, black or black red
Hardness: 7-8 – Quartz-Topaz



Above: Almandine collected from Pelagon



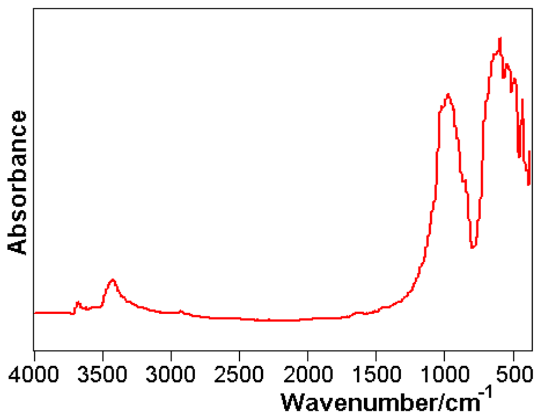
Left: FT IR spectrum of almandine

Mineral identification based on the IR spectral data given in the references: [49–55]

Staurolite $Fe_2Al_9O_6(SiO_4)_4(OH)_2$

Environment: Metamorphosed aluminous sedimentary rocks
Locality: Štavica, Staro Bonče
Name Origin: From the Greek, *stauros* – "cross" and *lithos* – "stone" in allusion to the common cross shaped twins of the crystals
Density (Calc): 3.64
Cleavage: [010] Distinct
Color: brownish yellow, brownish black, yellow brown, dark brown, or reddish brown
Hardness: 7-7.5 – Quartz-Garnet

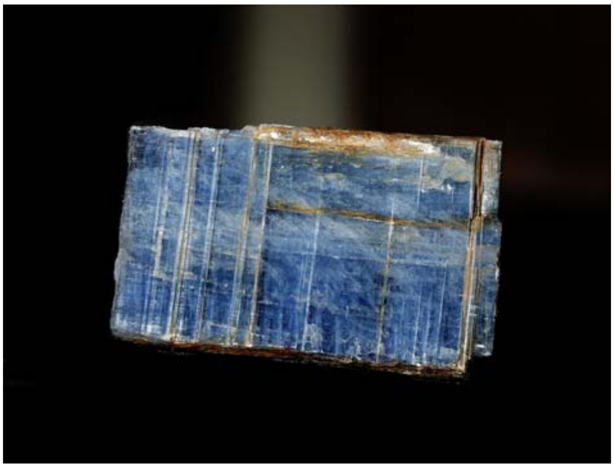
Above: Staurolite collected from Štavica



Left: FT IR spectrum of staurolite

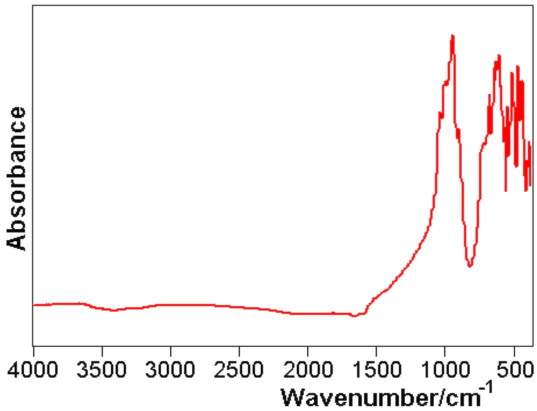
Mineral identification based on the IR spectral data given in the references: [49, 50], [56]

Kyanite Al_2SiO_5



Above: Kyanite collected from Štavica

Environment: Metamorphosed peri-aluminous sedimentary rocks
Locality: Štavica, Staro Bonče, Pelagon, Prilepec
Name Origin: From the Greek *kyanos* – "blue"
Density (Calc): 3.67
Cleavage: [100] Perfect, [010] Imperfect
Color: Blue, white, gray, green, or black
Hardness: 4-7 – Fluorite-Quartz



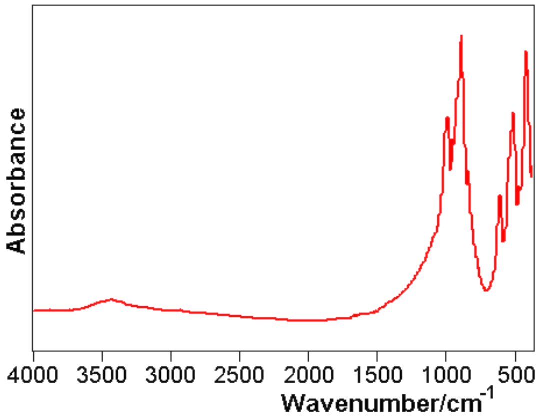
Left: FT IR spectrum of kyanite

Mineral identification based on the IR spectral data given in the references: [49, 50, 57, 58]

Olivine $(Mg,Fe)_2SiO_4$

Above: Olivine collected from Ržanovo

Environment: Basic and ultra basic igneous rocks
Locality: Ržanovo
Name Origin: Named after the green color
Density (Calc): 3.22
Cleavage: [001] Good, [010] Distinct
Color: Colorless, green, yellow, yellow green or white
Hardness: 6-7 – Orthoclase-Quartz



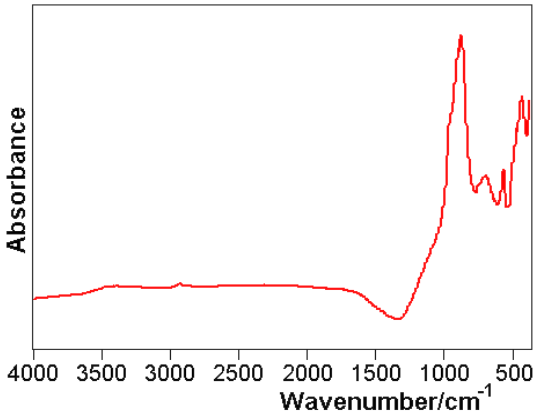
Left: FT IR spectrum of olivine

Mineral identification based on the IR spectral data given in the references: [50, 58–65]

Titanite $CaTiSiO_5$

Above: Titanite collected from Alinci

Environment: Magmatic, metamorphic and hydrothermal rocks
Locality: Alinci, Dunje
Name Origin: Named after presence of titanium in chemical composition
Density (Calc): 3.52
Cleavage: [110] Distinct, [100] Imperfect, [112] Imperfect
Color: Reddish brown, gray, yellow, green or red
Hardness: 5-5.5 – Apatite-Knife Blade



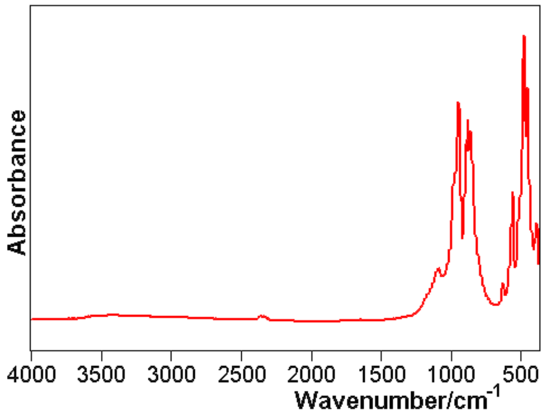
Left: FT IR spectrum of titanite

Mineral identification based on the IR spectral data given in the reference: [50]

Spessartine $Mn_3Al_2(SiO_4)_3$

Above: Spessartine collected from Lojane

Environment: Magmatic, metamorphic and pegmatitic rocks
Locality: Lojane
Name Origin: Named after its locality – Spessart, Germany
Density (Calc): 4.18
Cleavage: [???] Distinct
Color: Red, reddish orange, yellowish brown, reddish brown, brown
Hardness: 6.5-7.5 – Pyrite-Garnet



Left: FT IR spectrum of spessartine

Mineral identification based on the IR spectral data given in the references: [50, 64]

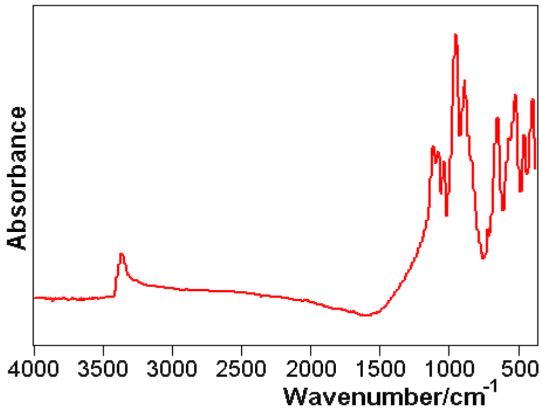
Sorosilicates (disilicates)

Epidote

$Ca_2Al_2(Al,Fe^{3+})OOH[Si_2O_7][SiO_4]$

Environment: Contact metamorphic rocks
Locality: Dunje, Čanište
Name Origin: From the Greek epidosis – "addition"
Density (Calc): 3.69
Cleavage: [001] Perfect
Color: Yellowish green, brownish green, black, yellow or gray
Hardness: 7 – Quartz

Above: Epidote collected from Čanište



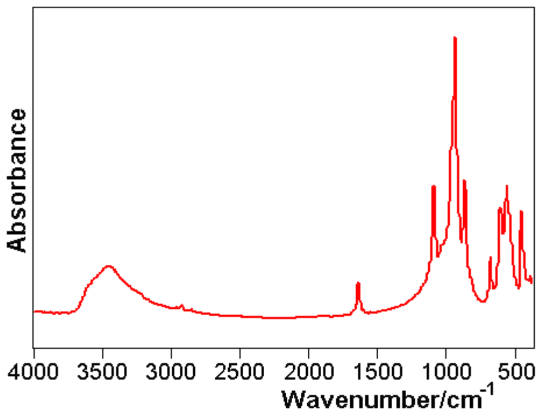
Left: FT IR spectrum of epidote

Mineral identification based on the IR spectral data given in the references: [50, 66]

Hemimorfite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Environment: Veins and beds in stratified calcareous rocks
Locality: Sasa
Name Origin: Named after the hemimorphic nature of the crystals
Density (Calc): 3.48
Cleavage: [110] Perfect
Color: Brown, colorless, greenish gray, yellow brown or white
Hardness: 5 – Apatite

Above: Hemimorfite collected from Sasa



Left: FT IR spectrum of hemimorfite

Mineral identification based on the IR spectral data given in the reference: [50]

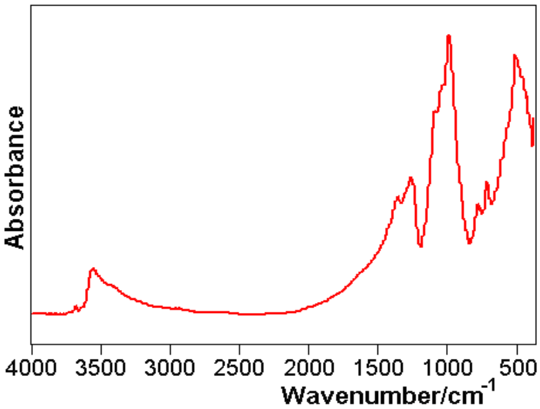
Cyclosilicates (ring silicates)

Tourmaline (Schörl)

$NaFe^{3+}{}_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Environment: Garnets, diorites, gabbro pegmatites, greisens, skarns and quartz veins
Locality: Dunje, Bonče, Sasa,
Name Origin: Old name of unknown origin
Density (Calc): 3.27
Cleavage: [1011] Indistinct
Color: Black
Hardness: 7.5 – Garnet

Above: Tourmaline collected from Bonče



Left: FT IR spectrum of tourmaline

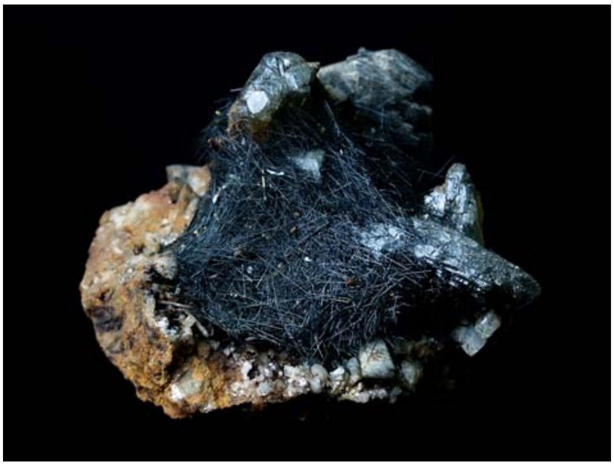
Mineral identification based on the IR spectral data given in the references: [50, 67]

Inosilicates (chain silicates)

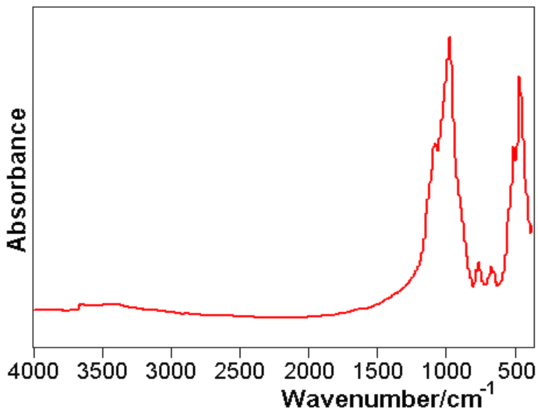
Arfvedsonite

$Na_3(Mg,Fe^{2+})_4(Fe^{3+},Al)Si_8O_{22}(OH)_2$

Environment: Igneous syenites and pegmatites
Locality: Alinci
Name Origin: Named after the Swedish chemist, J. A. Arfvedson (1792-1841)
Density (Calc): 3.47
Cleavage: [110] Perfect
Color: Black, gray
Hardness: 5.5-6 Knife Blade-Orthoclase



Above: Arfvedsonite collected from Alinci



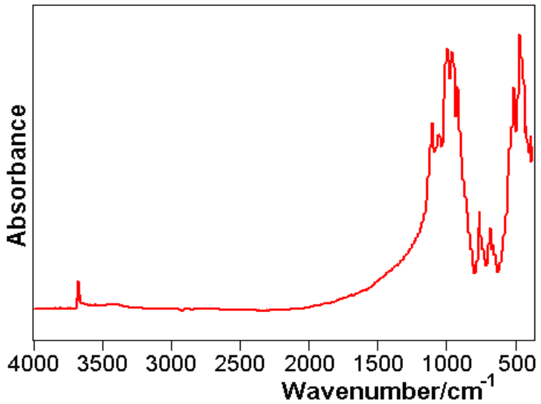
Left: FT IR spectrum of arfvedsonite

Mineral identification based on the IR spectral data given in the reference: [50]

Actinolite $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$

Environment: Metamorphic rocks
Locality: Košino, Veselčani
Name Origin: From the Greek, *aktinos*, meaning "ray" in allusion to actinolite's fibrous nature
Density (Calc): 3.20
Cleavage: [110] Perfect, [110] Perfect
Color: Light to blackish green
Hardness: 5.5 – Knife Blade

Above: Actinolite collected from Košino



Left: FT IR spectrum of actinolite

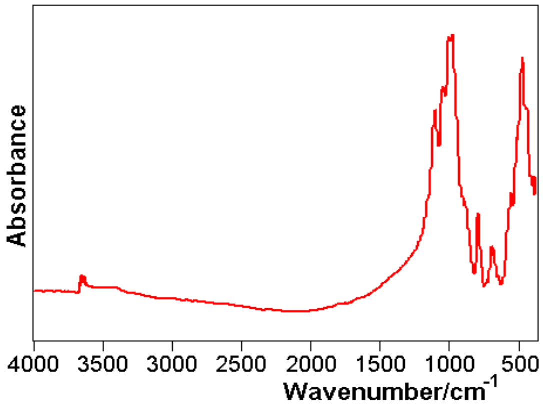
Mineral identification based on the IR spectral data given in the references: [50, 68, 69]

Glaucophane

$Na_2Mg_3(Al,Fe)_2Si_8O_{22}(OH)_2$

Environment: Metamorphic blue shists
Locality: Vodno
Name Origin: From the Greek *glaukos* – "blue" and *fanos* – "appearing"
Density (Calc): 2.99
Cleavage: [110] Good, [001] Good
Color: Gray, blue, bluish black or lavenderblue
Hardness: 6-6.5 – Orthoclase-Pyrite

Above: Glaucophane collected from Vodno



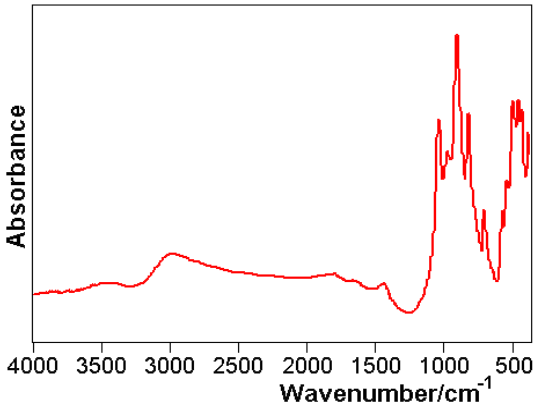
Left: FT IR spectrum of glaucophane

Mineral identification based on the IR spectral data given in the reference: [70]

Ilvaite $CaFe^{2+}{}_2Fe^{3+}Si_2O_8(OH)$

Above: Ilvaite collected from Sasa

Environment: Occurs with magnetite ore bodies, with zinc and copper ores, and in contact deposits and zeolites
Locality: Sasa
Name Origin: From the Latin name of the island of Elba
Density (Calc): 4.07
Cleavage: [010] Distinct, [001] Distinct
Color: Black, grayish brown or brownish black
Hardness: 5.5-6 – Knife Blade-Orthoclase



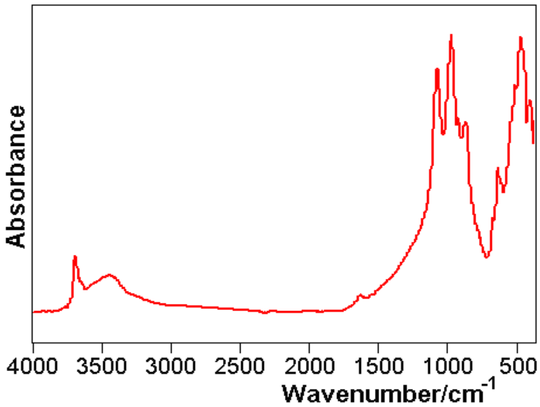
Left: FT IR spectrum of ilvaite

Mineral identification based on the IR spectral data given in the references: [50, 71]

Augite $(Ca,Mg,Fe^{2+},Fe^{3+},Al)_2(Si,Al)_2O_6$

Above: Augite collected from Rabrovo

Environment: Basic igneous and metamorphic rocks
Locality: Rabrovo, Sasa
Name Origin: From the Greek *auge* – "luster"
Density (Calc): 3.51
Cleavage: [110] Perfect, [010] Indistinct
Color: Brown green, green, light brown, dark brown or black
Hardness: 5-6.5 – Apatite-Pyrite

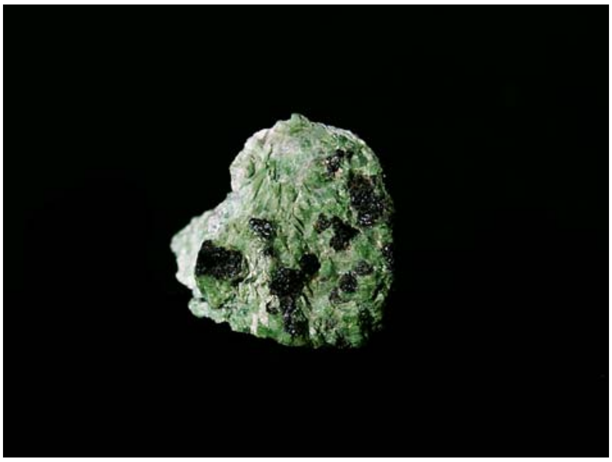


Left: FT IR spectrum of augite

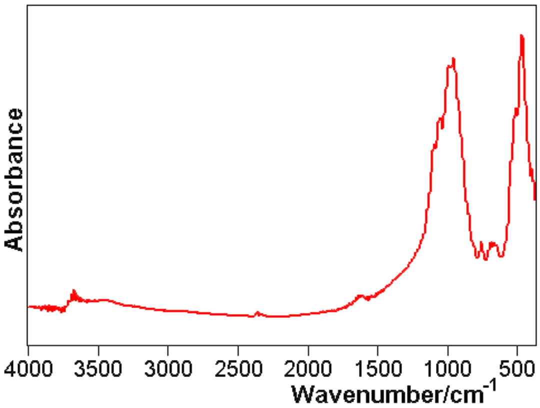
Mineral identification based on the IR spectral data given in the references: [50, 72]

Diopside $CaMgSi_2O_6$

Environment: Basic and ultrabasic igneous and metamorphic rocks
Locality: Lojane
Name Origin: From the Greek *dis* – "two kinds" and *opsis* – "opinion"
Density (Calc): 3.4
Cleavage: [110] Good, [???] Indistinct
Color: Blue, brown, colorless, green, gray
Hardness: 6 – Orthoclase



Above: Diopside collected from Lojane



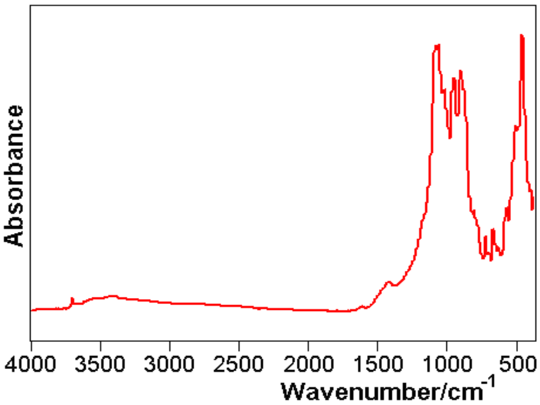
Left: FT IR spectrum of diopside

Mineral identification based on the IR spectral data given in the references: [50, 58, 72, 73]

Rhodonite $MnSiO_3$

Environment: Hydrothermal, metamorphic and, metasomatic rocks
Locality: Sasa
Name Origin: From the Greek *rhodos* – "rose colored"
Density (Calc): 3.74
Cleavage: [110] Perfect, [110] Perfect
Color: Pink, rose red, brownish red, black or yellow
Hardness: 6 – Orthoclase

Above: Rhodonite collected from Sasa

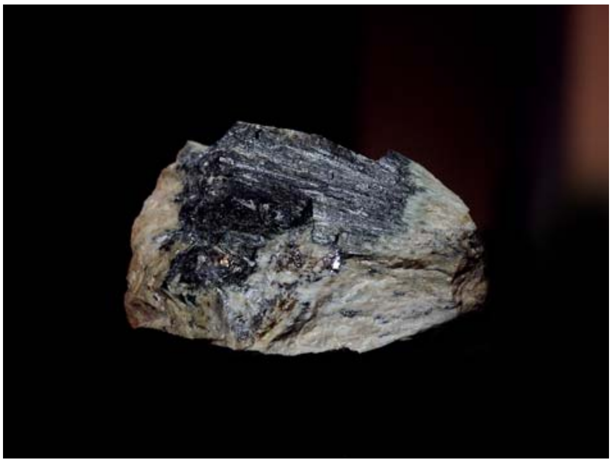


Left: FT IR spectrum of rhodonite

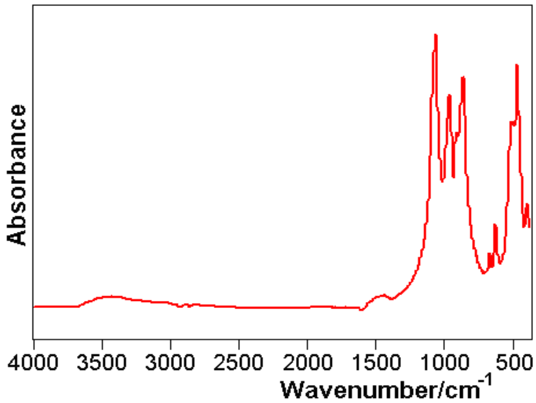
Mineral identification based on the IR spectral data given in the reference: [50]

Johannsenite $CaMnSi_2O_6$

Environment: Contact metasomatic rocks
Locality: Sasa
Name Origin: Named after Prof. Albert Johannsen, the University of Chicago
Density (Calc): 3.56
Cleavage: [110] Good
Color: Brown, brownish black, greenish, gray, gray green
Hardness: 6 – Orthoclase



Above: Johannsenite collected from Sasa



Left: FT IR spectrum of johannsenite

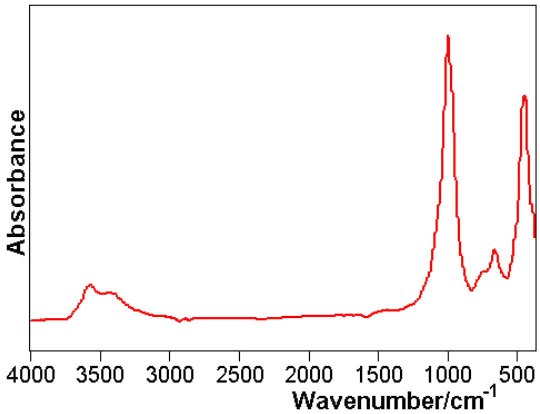
Mineral identification based on the IR spectral data given in the reference: [73]

Hornblende

$(NaK)_{0-1}Ca_2(Mg,Fe,Fe^{3+},Al)_5(SiAl)_8O_{22}(OH)_2$

Environment: Igneous, metamorphic and sedimentary rocks
Locality: Kožuf
Name Origin: Given to a series of minerals that are rather difficult to distinguish by ordinary means
Density (Calc): 3.23
Cleavage: [110] Distinct
Color: Brown, green, greenish brown, greenish black, dark green
Hardness: 5-6 – Apatite-Orthoclase

Above: Hornblende collected from Kožuf



Left: FT IR spectrum of hornblende

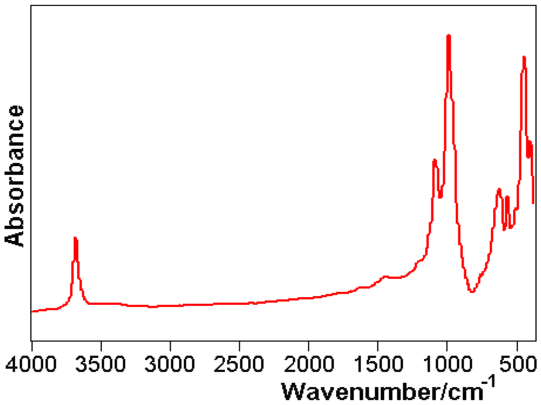
Mineral identification based on the IR spectral data given in the references: [50, 74]

Phillosilicates (sheet silicates)

Antigorite $(Mg,Fe^{2+})_3SI_2O_5(OH)_4$

Environment: In a network of veins crosscutting a metamorphic antigorite serpentinite, in an ophiolite
Locality: Ržanovo
Name Origin: Named after the locality Val Antigorio, Italy
Density (Calc): 2.73
Cleavage: [001] Good
Color: Green, gray, bluish gray, brown or black
Hardness: 3.5-4

Above: Antigorite collected from Ržanovo



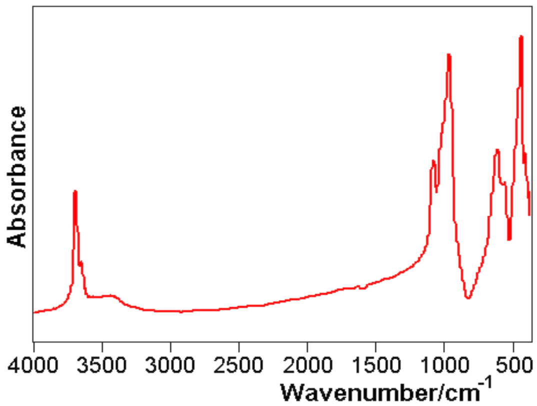
Left: FT IR spectrum of antigorite

Mineral identification based on the IR spectral data given in the references: [75-78]

Chrysotile $Mg_3Si_2O_5(OH)_4$

Environment: Metamorphosed and hydrothermally-altered ultra-basic rocks
Locality: Bogoslovec, Kobilno Pole, Nistrovo, Ržanovo
Name Origin: From the Greek *chrysos* – "gold" and *tilos* – "fiber"
Density (Calc): 2.60
Cleavage: [???] Distinct
Color: Green
Hardness: 2.5 – Finger Nail

Above: Chrysotile collected from Ržanovo



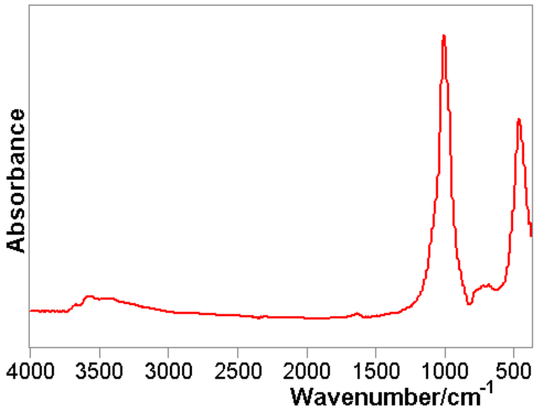
Left: FT IR spectrum of chrysotile

Mineral identification based on the IR spectral data given in the references: [75, 78-80]

Biotite $K(Mg,Fe^{2+})_3AlSi_3O_{10}(OH,F)_2$

Environment: Granitic rocks. Forms a series with phlogopite
Locality: Pelagon, Čanište
Name Origin: Named after the French physicist, Jean Baptiste Biot (1774 – 1862), who studied the optical properties of the micas
Density (Calc): 2.89
Cleavage: [001] Perfect
Color: Dark brown, greenish brown, blackish brown, yellow or white
Hardness: 2.5-3 – Finger Nail-Calcite

Above: Biotite collected from Pelagon



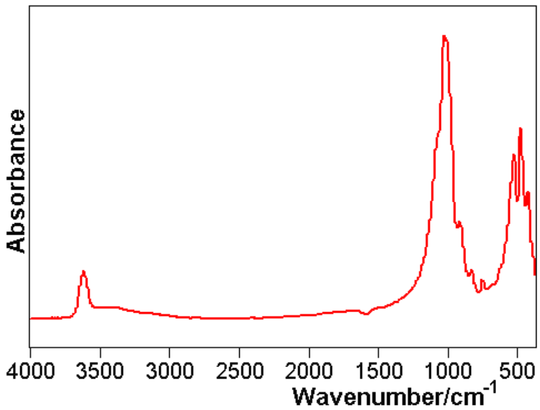
Left: FT IR spectrum of biotite

Mineral identification based on the IR spectral data given in the references: [78, 81, 82]

Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Environment: Granites and pegmatites
Locality: Kokre, Pelagon, Belutče, Čanište, Vitolište, Dunje
Name Origin: From Muscovy glass, alluding to the Russian province of Muscovy
Density (Calc): 2.83
Cleavage: [001] Perfect
Color: White, gray, silver white, brownish white or greenish white
Hardness: 2-2.5 – Gypsum-Finger Nail

Above: Muscovite collected from Pelagon



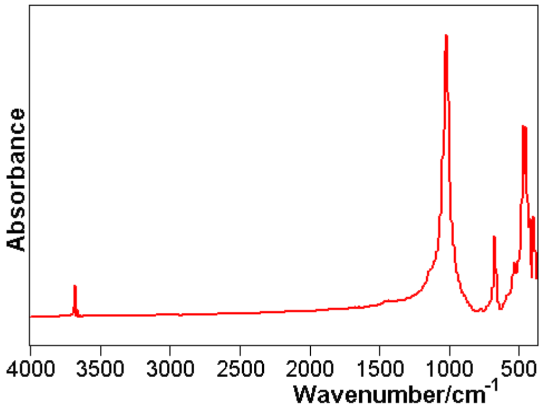
Left: FT IR spectrum of muscovite

Mineral identification based on the IR spectral data given in the references: [50, 77, 82-85]

Talc $Mg_3Si_4O_{10}(OH)_2$

Environment: Hydrothermal alteration of non-aluminous magnesian silicates
Locality: Ržanovo
Name Origin: From the Arabic word for mica – *talq*
Density (Calc): 2.82
Cleavage: [001] Perfect
Color: Pale green, white, gray white, yellowish white or brownish white
Hardness: 1 – Talc

Above: Talc collected from Ržanovo



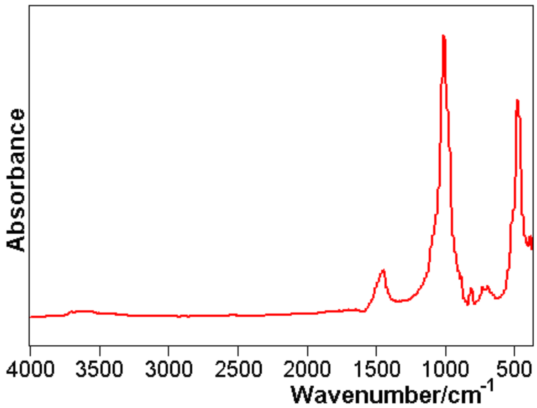
Left: FT IR spectrum of talc

Mineral identification based on the IR spectral data given in the references: [50, 77, 81, 83, 85-87]

Phlogopite $KMg_3(Si_3Al)O_{10}(F,OH)_2$

Environment: Contact and regional metamorphic limestones and dolomites
Locality: Sivec
Name Origin: From the Greek *flogopos* – "resembling fire"
Density (Calc): 2.81
Cleavage: [001] Perfect
Color: Brown, gray, green, yellow or reddish brown
Hardness: 2-2.5 – Gypsum-Finger Nail

Above: Phlogopite collected from Sivec



Left: FT IR spectrum of phlogopite

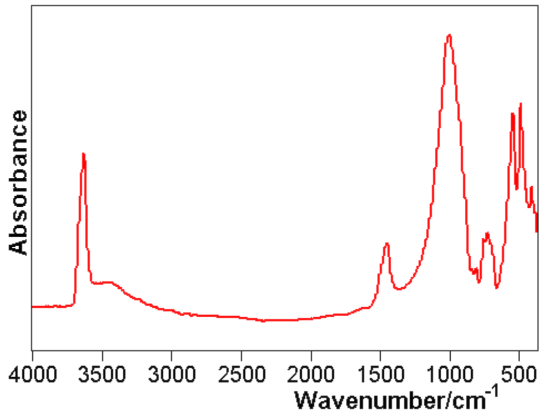
Mineral identification based on the IR spectral data given in the references: [77, 81, 83, 85, 88]

Clinochlore

$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$

Environment: Contact, hydrothermal, and regional metamorphism of mafic minerals
Locality: Sivec
Name Origin: Clinochlore from the Greek *klino* – "oblique" and *chloros* – " green"
Density (Calc): 2.83
Cleavage: [001] Perfect
Color: blackish green, bluish green, white, yellowish green, or olive green
Hardness: 2-2.5 – Gypsum-Finger Nail

Above: Clinochlore collected from Sivec



Left: FT IR spectrum of clinochlore

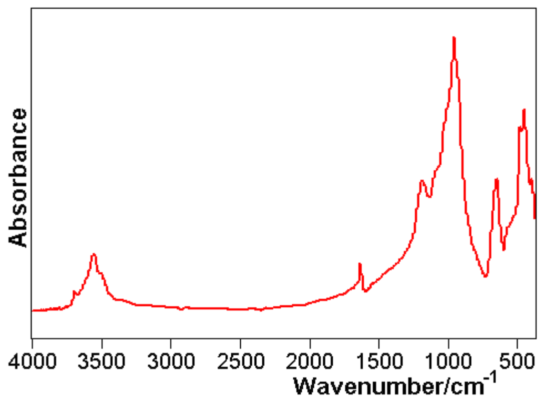
Mineral identification based on the IR spectral data given in the reference: [86]

Cymrite

$BaAl_2Si_2O_8{\cdot}H_2O$

Environment: Bedded manganese ore deposits that have undergone low- and medium-grade metamorphism
Locality: Nežilovo
Name Origin: Named after Cymru, the old Welsh name for Wales
Density (Calc): 3.49
Cleavage: [001] Good, [101] Fair
Color: Brown, colorless, green, dark green
Hardness: 2-3 – Gypsum-Calcite

Above: Cymrite collected from Nežilovo

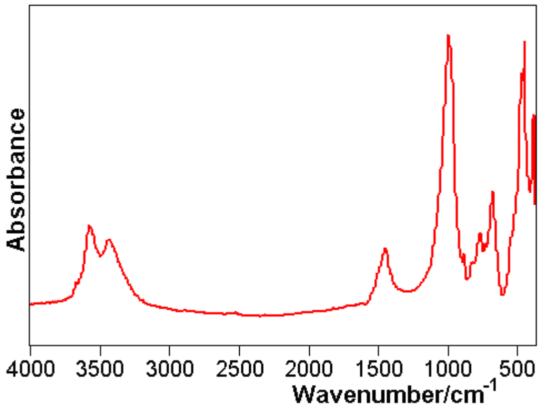


Left: FT IR spectrum of cymrite

Kosmatite $Ca_3MgAl_2AlSi_3O_{10}(OH,F)_8$

Environment: Metamorphic rocks – marbles
Locality: Sivec
Name Origin: After the German geologist F. Kosmat
Density (Calc): –
Cleavage: –
Color: Green, Light-green
Hardness: –

Above: Kosmatite collected from Sivec

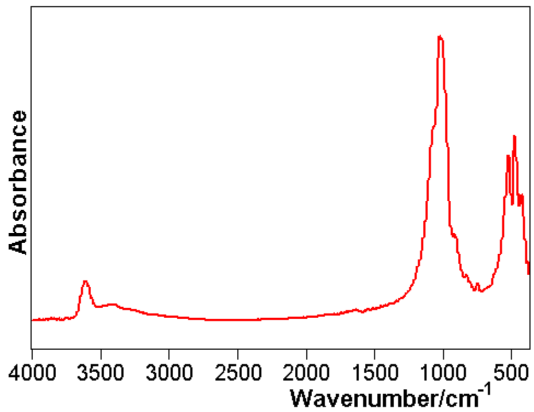


Left: FT IR spectrum of Kosmatite

Paragonite $NaAl_2(Si_3Al)O_{10}(OH)_2$

Environment: Granites and pegmatites
Locality: Nežilovo
Name Origin: From Greek, meaning *to mislead*
Density (Calc): 2.78
Cleavage: [001] Perfect
Color: White, yellow
Hardness: 2.5 – Finger Nail

Above: Paragonite collected from Nežilovo



Left: FT IR spectrum of paragonite

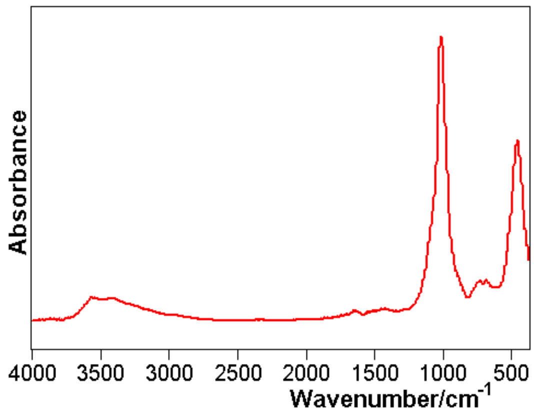
Mineral identification based on the IR spectral data given in the reference: [78]

Vermiculite

$(Mg,Fe^{2+},Al)_3(Al,Si)_4O_{10}(OH)_2 \cdot 4H2O$

Environment: Granitic rocks
Locality: Nežilovo
Name Origin: From the Latin *vermiculus*, "little worm"
Density (Calc): 2.32
Cleavage: [001] Perfect
Color: Colorless, green, gray white, yellow brown
Hardness: 1.5-2 – Between talc and gypsum-Gypsum

Above: Vermiculite collected from Nežilovo



Left: FT IR spectrum of vermiculite

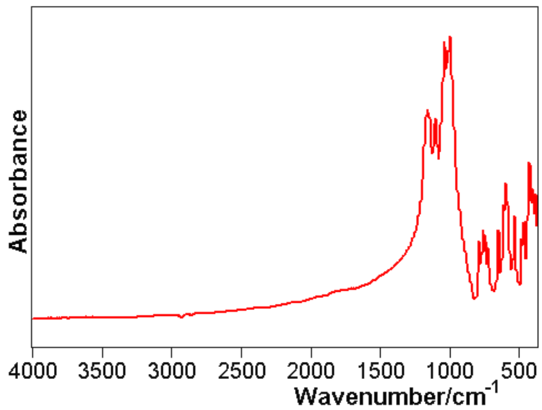
Mineral identification based on the IR spectral data given in the reference: [78]

Tectosilicates (framework silicates)

Albite $NaAlSi_3O_8$

Environment: Magmatic and pegmatitic rocks
Locality: Alinci, Čanište, Dunje
Name Origin: From the Latin, *albus*, in allusion to the common color
Density (Calc): 2.63
Cleavage: [001] Perfect, [010] Good
Color: White, gray, greenish gray, bluish green or gray
Hardness: 7 – Quartz

Above: Albite collected from Alinci



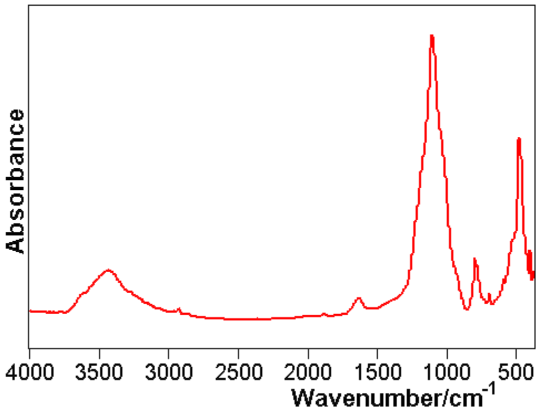
Left: FT IR spectrum of albite

Mineral identification based on the IR spectral data given in the references: [50, 58, 67, 89]

Analcime $NaAlSi_2O_6 \cdot H_2O$

Environment: Frequently in basalts and other basic igneous rocks associated with other zeolites
Locality: Alšar, Bučim
Name Origin: From the Greek word *analkis*, meaning weak, referring to a weak electrical charge developed on rubbing
Density (Calc): 2.27
Cleavage: [001] Indistinct, [010] Indistinct, [100] Indistinct
Color: White, grayish white, greenish white, yellowish white or reddish white
Hardness: 5 – Apatite

Above: Analcime collected from Alšar



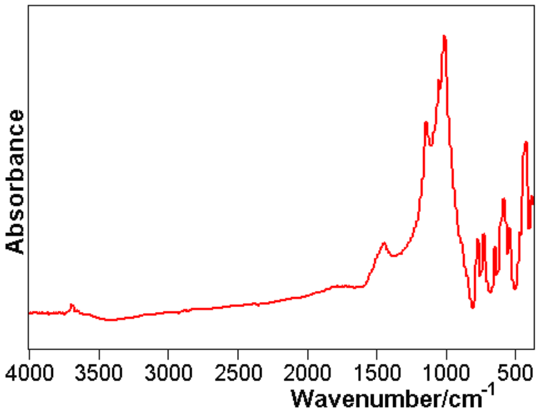
Left: FT IR spectrum of analcime

Mineral identification based on the IR spectral data given in the references: [50, 67]

Microcline $KAlSi_3O_8$

Environment: Granitic pegmatites, hydrothermal and metamorphic rocks
Locality: Čanište, Pelagon, Alinci, Dunje, Belutče
Name Origin: From the Greek *mikron* – "little" and *klinein* – "to stoop"
Density (Calc): 2.56
Cleavage: [001] Perfect, [010] Good
Color: Bluish green, green, gray, grayish yellow or yellowish
Hardness: 6 – Orthoclase

Above: Microcline collected from Alinci



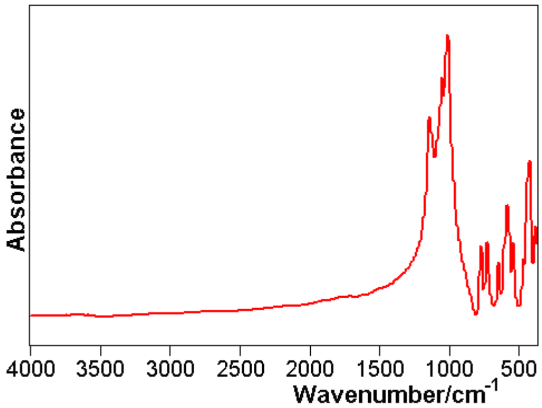
Left: FT IR spectrum of microcline

Mineral identification based on the IR spectral data given in the references: [50, 67]

Orthoclase $KAlSi_3O_8$

Environment: Intrusive and extrusive igneous, and metamorphic rocks
Locality: Belutče, Pelagon, Veselčani
Name Origin: From the Greek *orthos* – "right" and *kalo* – "I cleave" in allusion to the mineral's right angle of good cleavage
Density (Calc): 2.55
Cleavage: [001] Perfect, [010] Good
Color: colorless, greenish, grayish yellow, white, or pink
Hardness: 6 – Orthoclase

Above: Orthoclase collected from Belutče



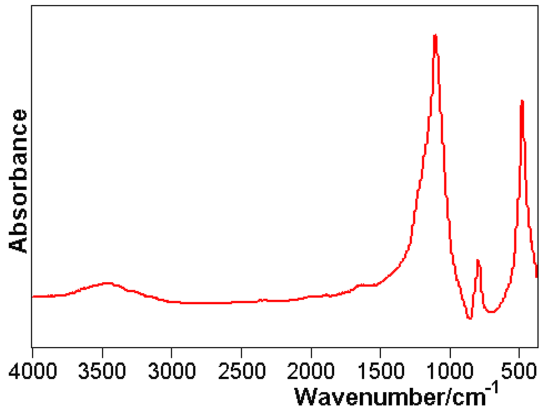
Left: FT IR spectrum of orthoclase

Mineral identification based on the IR spectral data given in the reference: [50]

Opal $SiO_2 \cdot nH_2O$

Environment: Sedimentary and secondary from the alteration of high silica igneous extrusive rocks
Locality: Češinovo
Name Origin: From the Old Indian *upala* – "precious stone"
Density (Calc): 2.09
Cleavage: None
Color: White, yellow, red, brown or blue
Hardness: 5.5-6 – Knife Blade-Orthoclase

Above: Opal collected from Češinovo



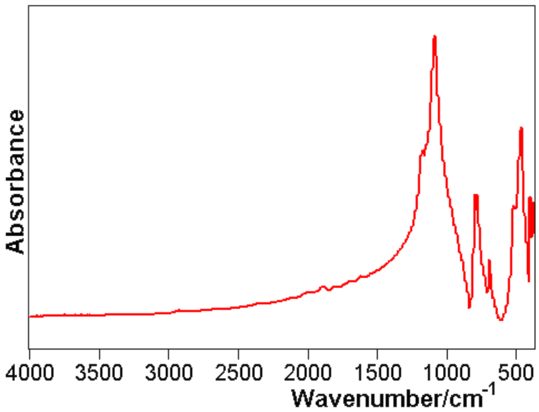
Left: FT IR spectrum of opal

Mineral identification based on the IR spectral data given in the references: [50, 67, 90]

Quartz SiO_2

Environment: Sedimentary, metamorphic, and igneous rocks
Locality: Belutče, Budinarci, Alinci, Čanište, Saždevo, Mariovo, Sasa, Zletovo, Bučim, Košino
Name Origin: From the German *quarz*, of uncertain origin
Density (Calc): 2.65
Cleavage: [0110] Indistinct
Color: Brown, colorless, violet, gray or yellow
Hardness: 7 – Quartz

Above: Quartz collected from Sasa



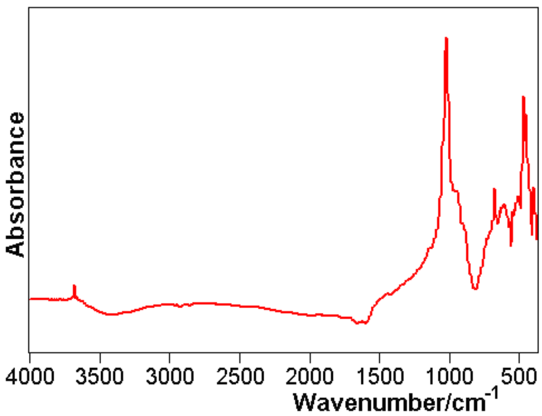
Left: FT IR spectrum of quartz

Mineral identification based on the IR spectral data given in the references: [50, 67, 91]

Sanidine $(K,Na)(Si,Al)_4O_8$

Environment: Acid volcanic rocks
Locality: Zvegor
Name Origin: From the Greek *sanis* – "little plate" and *idos* – "to see"
Density (Calc): 2.53
Cleavage: [001] Perfect, [010] Good
Color: Colorless, white, gray, yellowish white or reddish white
Hardness: 6 – Orthoclase

Above: Sanidine collected from Zvegor



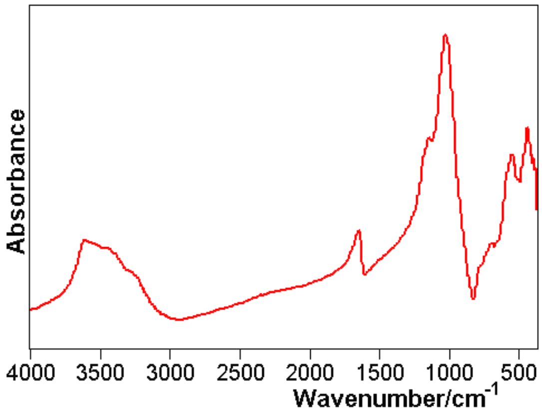
Left: FT IR spectrum of sanidine

Mineral identification based on the IR spectral data given in the reference: [89]

Stilbite $NaCa_4Al_8Si_{28}O_{72}\cdot 30H_2O$

Environment: Acid volcanic rocks
Locality: Dunje
Name Origin: From the Greek *stilbe* – "luster" in allusion to the pearly to vitreous luster
Density (Calc): 2.20
Cleavage: [010] Perfect
Color: White, red, yellow, brown or cream
Hardness: 3.5-4 – Copper Penny-Fluorite

Above: Stilbite collected from Dunje



Left: FT IR spectrum of stilbite

Mineral identification based on the IR spectral data given in the reference: [50]

Acknowledgments: The financial support from the Ministry of Education and Science of the Republic of Macedonia as well as Mako – Trading from Kavadarci is gratefully acknowledged. The authors cordially thank Marin Aleksandrov, Dzvonko Gruevski and Vladimir Bermanec for kind donation of some of the studied minerals.

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Р е з и м е

МИНЕРАЛИ ОД МАКЕДОНИЈА
XI. СИЛИКАТНИ МИНЕРАЛИ И НИВНИТЕ ЛОКАЛИТЕТИ – ИДЕНТИФИКАЦИЈА СО ФТ-ИЦ СПЕКТРОСКОПИЈА

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[3]Природонаучен музеј на Република Македонија, Булевар Илинден 86, MK-1000 Скопје, Република Македонија

Клучни зборови: силикатни минерали; силикатно богатство; силикатни локалитети; Република Македонија; ФТ-ИЦ спектроскопија

Меѓу разновидното рудно богатство на Република Македонија силикатните минерали ја претставуваат најмногубројната група. Најголемиот дел од нив се појавуваат во големи и убаво оформени монокристални агрегати, но понекогаш овие типови минерали се појавуваат во асоцијации со други минерали чии кристали не се добро оформени. Во овој труд се сумирани основните морфолошки, физичко-хемиски и кристалографски карактеристики на најтипичните силикатни минерали колектирани од различни локалитети во Република Македонија. Исто така, презентирани се и минеролошките и петролошките особини на локалитетите од кои се собрани изучуваните минерали. Овие минерали понатаму се класифицирани во однос на нивните структурни карактеристики и идентификувани користејќи ја Фуриеовата трансформна инфрацрвена спектроскопија. Идентификацијата е заснована на споредба на добиените ИЦ спектри на нашите минерали со литературните податоци за соодветните минерали. Исто така, прикажани се и слики во боја од сите изучувани примероци.