

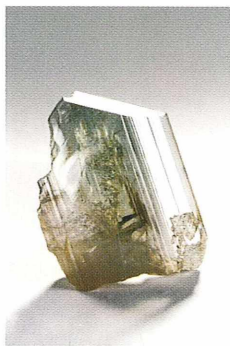
PRIRODOSLOVNI MUZEJ SLOVENIJE
MUSEUM HISTORIAE NATURALIS SLOVENIAE

BIO I 90.403/Suppl. 2



**SKRITA BOGASTVA MAKEDONIJE
HIDDEN TREASURES OF MACEDONIA**

SCOPOLIA
SUPPLEMENTUM 2



BIO I 90,403/Suppl.2

ÖÖ. Erdmuseum

ÖÖ. Erdmuseum

Inw. 2000/11.172

SKRITA BOGASTVA MAKEDONIJE
HIDDEN TREASURES OF MACEDONIA

Vsebina

Contents

Matija Gogala

- 7 Uvodne misli k publikaciji in razstavi
Introductory Thoughts on the Publication and Exhibition

Mirjan Žorž, Miha Jeršek & Gute Mladenovski

- 9 NEKATERA NAHAJALIŠČA MINERALOV V MAKEDONIJI
IN NJIHOVA PARAGENEZA
SOME MINERAL LOCATIONS IN MACEDONIA AND THEIR
PARAGENESIS

- 9 Geografska lega
Geographical Position

- 9 Geologija Makedonije
Geology of Macedonia

- 11 Kosovrasti

- 14 Alšar

Radomir Ilić

- 17 Lorandit in sončni nevtrini
Lorandite and Solar Neutrinos

- 20 Crni (Kara) kamen

- 26 Sivec

- 34 Sasa

Tadej Dolenec & Todor Serafimovski

- 39 Zgodba o otavitu
The Otavite Story

- 41 Dobrevo

- 46 Selečka planina

- 47 Belučje

- 48 Bonče

- 50 Čanište

- 52 Dunje

- 56 Orehovo

- 58 Prilepec

- 59 Berovo

- 62 Zvegor

Gute Mladenovski & Katarina Krivic

- 64 Pikermijska favna Makedonije
Pikermian Fauna of Macedonia

- 67 Literatura
References

- 69 Zahvala
Acknowledgments

Two years after the Slovenian Museum of Natural History's small exhibit of some of the marvelous mineral treasures of Macedonia, a group of Slovenian and Macedonian geologists has prepared a much larger exhibition: "Hidden treasures of Macedonia"

This fine exhibit displays some of the most beautiful and interesting examples of Macedonia's unique mineral wealth. The exhibition displays more than 150 samples selected from the Macedonian Museum in Skopje, and complemented by specimens of Macedonian minerals held in various Slovenian collections. To emphasize the importance and preciousness of these samples, we need only to mention the World-famous locality of Alšar with its rare thallium minerals, the gypsum deposits near Debar, or the minerals from the mines of Sasa and Dobrevu that yield interesting forms of sphalerite, amethyst, and paragenesis of galenite, pyrite, quartz and other rarities. A white marble of excellent quality comes from the Sivec Quarry, but here one can also find beautiful corundum crystals and the unique mineral diaspor. Titanite crystals come from deposits near the village of Alinci and from Selečka planina - the latter being famous for the mineral epidote. Also at Alinci can be found specimens of arfvedsonite covered with various other crystals. Many of these minerals are highly valued as gemstones, as shown in this display.

I am delighted that the longstanding co-operation between the Macedonian Museum of Natural History in Skopje and the Slovenian Museum of Natural History in Ljubljana reaches a peak with this exposition, coupled with a simultaneous scientific meeting and the present publication. Previous collaborations between the two institutions have included investigations of the mammal fauna of Macedonia, entomological researches into aquatic flies (family Empididae) and stoneflies (Plecoptera), investigations of singing cicadas (Cicadoidea), and the monitoring of bird migrations: all have led to interesting discoveries. Slovenian geologists have visited Macedonia on several occasions, and our Macedonian colleagues recently took part in the "International Days of Minerals and Fossils" held at Tržič, Slovenia.

This attractive exposition, plus the scientific meeting and the subsequent representative research papers that will form a supplement to our journal *Scopolia*, will give impetus to further fruitful co-operations. This collaboration has long been desired by scientists from both institutions, and for many years has been supported by the corresponding ministries and diplomatic representatives of both countries: Slovenia and Macedonia.

Dve leti po-manjši razstavi v Prirodoslovnem muzeju Slovenije, ki je predstavila le majhen del čudovitih mineralov iz makedonskih najdišč, je skupina slovenskih in makedonskih geologov pripravila veliko razstavo *Skrita bogastva Makedonije*, ki obsega najlepše in najzanimivejše primerke edinstvenih mineralov iz te države.

Razstava obsega več kot 150 izbranih eksponatov iz Prirodoslovnega muzeja v Skopju in iz raznih drugih makedonskih in slovenskih zbirk. Da poudarim pomembnost in dragocenost razstavljenih primerkov, naj omenim vsaj svetovno znano najdišče Alšar, ki slovi po redkih talijeveh mineralih, najdišče sadre pri Debru ter zanimive pojave oblike mineralov iz rudnikov Sasa in Dobrevu. Od tam so posebno zanimivi primerki sfalerita, ametista ter skupki galenita, pirita, kremena in drugih mineralov. Iz kamnoloma Sivec pridobivajo najbolj kakovosten marmor, v katerem najdemo tudi lepe korunde in edinstveni mineral diaspor. Titanit predstavljajo primerki iz nahajališča pri vasi Alinci in iz Selečke planine, kjer je eden izmed najzanimivejših mineralov tudi epidot. Iz Alincev so tudi eksponati arfvedsonita, preraščeni z raznimi drugimi kristali. Od omenjenih mineralov imajo marsikateri uporabno vrednost kot okrasni kamni, kar bo tudi prikazano na razstavi.

Veseli me, da se dosedanje sodelovanje med makedonskim Prirodoslovnim muzejem v Skopju in Prirodoslovnim muzejem Slovenije v Ljubljani nadaljuje s to razstavo, sočasnim znanstvenim srečanjem in pričujočo publikacijo. Dosedaj sta obe ustanovi sodelovali pri raziskavah sesalcev iz Makedonije, kar je privedlo do zanimivih novih odkritij, pri entomoloških raziskavah dvokrilcev iz družine Empididae, škržadih (Cicadoidea), vrbnicah (Plecoptera), kjer smo objavili že veliko tehtnih prispevkov, in pri raziskavah selitev ptic. Slovenski geologi so nekajkrat obiskali Makedonijo in makedonski kolegi so sodelovali na Mednarodnih dnevih mineralov in fosilov v Tržiču.

Naj bo ta atraktivna razstava z znanstvenim srečanjem in vsebinsko bogatimi prispevki v tem posebnem zvezku revije *Scopolia* vzpodbuda za nadaljnje sodelovanje, ki si ga želijo strokovnjaki obeh ustanov in ga finančno in moralno podpirajo tudi ustrezni organi ministrstev in diplomatski predstavniki obeh držav.

Srečno!

Matija Gogala

Direktor Prirodoslovnega muzeja Slovenije
Director of the Slovenian Museum of Natural History

SOME MINERAL LOCATIONS IN MACEDONIA
AND THEIR PARAGENESIS

Mirjan Žorž¹, Miha Jeršek² & Gute Mladenovski³

¹ Prešernova 53, 1290 Grosuplje, Slovenija

² Prirodoslovni muzej Slovenije, Prešernova 20, 1000 Ljubljana, Slovenija

³ Prirodonaučen muzej na Makedonija, Bulevar Ilinden 86, 95000 Skopje 55, Makedonija

Geographical position
of Macedonia

Due to its position in the heart of southern part of the Balkan Peninsula is Macedonia a continental country. Almost from all sides the territory is surrounded by high mountain chains. Osogovske planine, Plačkovica, Vlanina and Ogražden to the north-east and east, and Belasica, Kožuf and Kajmakčalan to the south. Korab and Šarplanina are two mighty mountain chains in western Macedonia that spread towards the north as well. Their highest peaks reach over 2700 m a.s.l.. Least mountainous is the central part with the Vardar valley. Vardar is the largest and longest river with such major tributaries as the Treska, the Pčinja, the Babuna, the Bregalnica and the Crna reka. Ohrid lake in the south-west part is the source of the Crni Drim that flows into Albania after gathering the waters of the picturesque river Radika. The Prespa and Dojran lakes lying in the south should also be mentioned. Hot continental climate is responsible for the development of the country's largest cities on the main rivers and beside lakes, e.g. Skopje, Kumanovo, Tetovo, Veles and Štip, or in the foothills of the mountains with abundant water supply such as Bitola and Prilep.

Geology of Macedonia

The regional geotectonic complex is comprised of the following units: Serbian-Macedonian mass, Vardar zone, Pelagonijski massif and East-Macedonian zone.

The Serbian-Macedonian mass (SMM) encompasses eastern Macedonia, whereas to the north extending itself into Serbia and to the south into Greece. It is built up from the metamorphic complex of Precambrian-Riffeic-Cambrian and Palaeozoic age. It can be divided into an upper and a lower complex. The lower one is, from lithological point of view, represented by micaceous gneisses, micaschists and to a lesser extent by amphibolites, quartzites, marbles and magmatites. The upper complex is

Geografska lega Makedonije

Makedonija je celinska država, saj leži v osrčju južnega dela Balkanskega polotoka. Ozemlje je skoraj z vseh strani obkroženo z visokimi gorstvi. Na vzhodu so to Osogovske planine, Plačkovica, Vlanina in Ogražden. Južni del omejujejo Belasica, Kožuf in Kajmakčalan. V zahodnem delu Makedonije se dvigata visoki gorstvi Korab in Šarplanina, ki se širi še na severno stran. Njuni vrhovi so le nekaj nižji kot najvišji v osrednjih Julijskih Alpah. Še najmanj gorat je osrednji del države z dolino Vardarja, ki je največja reka, v katero se zlivajo še Treska, Pčinja, Babuna, Bregalnica in Crna reka. V jugozahodnem delu leži Ohridsko jezero, iz katerega izvira Crni Drim, ki nadaljuje svoj tok v Albanijo, po tem, ko se vanj izlije še slikovita Radika. Omeniti velja še Prespansko in Dojransko jezero na jugu države. Zaradi vročega celinskega podnebja so se večja mesta, kot so Skopje, Kumanovo, Tetovo, Veles in Štip, razvila ob rekah in jezerih, ali pa kot Bitola in Prilep, pod planinami, kjer vode ne primanjkuje.

Geologija Makedonije

V regionalnem geotektonskem sklopu ločimo naslednje enote: Srbsko-makedonski masiv, Vardarska cona, Pelagonijski masiv in Zahodno-makedonska cona.

Srbsko-makedonski masiv (SMM) obsega vzhodno Makedonijo, pri čemer na severu prehaja v Srbijo, na jugu pa v Grčijo. Gradijo ga metamorfne kamnine predkambrijske do paleozojske starosti. Ločimo gornji in spodnji kompleks. Spodnji kompleks je v litološkem pogledu predstavljen s sljudnimi gnajsi, sljudnimi skrilavci in manj z amfiboliti, kvarciti, marmorji in magmatiti. Gornji kompleks predstavljajo pretežno vulkanogeno-sedimentne kamnine, ki so metamorfirane do zelenih skrilavcev. Tu dominirajo kloritni skrilavci, amfibolsko-biotitni, kloritno-sericitni in kremenovi skrilavci.

Vardarska cona se je izoblikovala med SMM in Dinaridi (zahodna Makedonija). V osnovi jo sestavljajo jurski ofioliti, ki najverjetneje predstavljajo ostanke oceanskega dna. Poleg gabroperidotitnega kompleksa se pojavljajo še vulkanogeno sedimentni členi. Ofiolit je prekrit z zgornjekrednim flišem.

Pelagonijski masiv predkambrijske starosti predstavljajo v njegovem bazalnem delu gnajsi z lečami marmorjev. Nad gnajsi ležijo sljudni skrilavci. Zgornji del masiva sestavljajo

10 sedimenti, ki ležijo transgresivno iznad gnajsev in sljudnih skrilavcev. V tem masivu so še magmatske kamnine - prilepski granitoidi.

Zahodno-makedonsko cono sestavlja več formacij. Najstarejša je vulkanogena sedimentna spilitno-keratofirska formacija (staro-paleozojska). Zgornja filitno-apnenčeva serija je paleozojske starosti (ordovicij, silur in devon) in vsebuje tudi kremenove porfirje.

represented by volcanogenic-sedimentary rocks that are metamorphosed into greenschists. Predominant in the area are chlorite amphibolite-biotite, chlorite-sericitic and quartz schists.

The Vardar zone was formed between SM and the Dinarides (western Macedonia). It is basically expressed through Jurassic ophiolites most probably representing the remnants of the ocean crust. Apart from the gabbroperidotitic complexes volcanogenic sedimentary links are present. Ophiolite is covered with Upper Cretaceous flysch.

The Pelagonian massif is of the Precambrian age and is represented in its base part by gneisses with embedded marble lenses. Schists are placed above gneisses. The upper part of the massif is represented by sediments lying transgressively over gneisses and micaschists. The igneous Prilep granitoides are present within this massif as well.

The West-Macedonian zone is comprised of several formations. The oldest among them is vulcanogene-sedimentary phyllitic ceratophiric formation (Old Palaeozoic). Upper phyllitic-calcareous is of the Palaeozoic age (Ordovician, Silurian and Devonian) and contains quartz porphyry.



The small picturesque city of Debar is situated in the foothills of Korab. The gypsum deposit lies five kilometres due east in the Radika river valley. The mine entrance is just above the river level. Not far away from the mine is Banja Kosovrasti spa with warm water springs carrying dissolved gypsum into the river. The gypsum is precipitated when the warm water flows into the cold Radika waters leaving white curtains along the stream. Gypsum is precipitated already at the spring forming white pillows seen from far away. There is an overwhelming sulphur smell due to dissolved sulphur compounds in the thermal water.

Geological setting

Gypsum is placed in upper Triassic flysch sediments making part of the tectonic unit Debar zone and is a constituent of the West-Macedonian tectonic unit. The location covers an area of 8x2 kilometres. Gypsum layer was determined by drilling to be as thick as 70 meters. The gypsum genesis is connected with metasomatic processes inside quartz rocks that are embedded in flysch. There are several other active gypsum mining locations i.e. Melničani, Melnički most and Alčija. Gypsum is excavated in pits and transferred to a nearby crushing plant.

Mineral paragenesis

This is simple involving only anhydrite, sulphur and a fine grained gypsum variety - alabaster.

Gypsum $\text{CaSO}_4 \times 2 \text{H}_2\text{O}$

Crystals from this location can reach dimensions of over one meter. They are colourless and completely transparent. It is almost impossible to remove them from the completely crystallised caves. This is why they are quite rarely found in the form of freely developed crystals. However, the crystal fragments can be found in large quantities throughout the mine. Swallow tale (001) twins are frequent and can be found in fragments as well. Rehealed corrosion traces can be seen on the crystals caused by underground waters. Such crystals are jagged.

Sulphur S

Yellow coatings can be seen on crystallised gypsum. They are in the form of spherical aggregates and only exceptionally as well-developed crystals with several crystallographic forms. Their dimensions do not exceed a diameter of several millimetres.

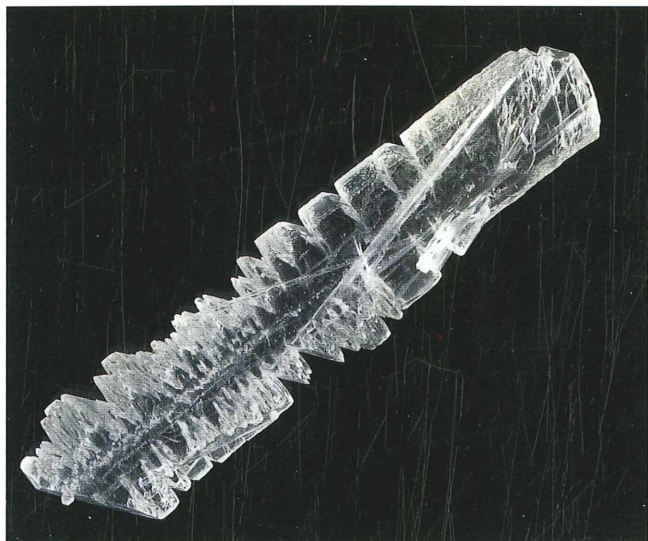
V vznožju Koraba je značilno zahodnomakedonsko mesto Debar. Nahajališče sadre je pet kilometrov vzhodnjeje v dolini reke Radike. Vhod v rudniško lokacijo Kosovrasti je tik nad rečno gladino. Nedaleč od rudnika je zdravilišče Banja Kosovrasti, kjer izvirajo topli vrelci, ki nosijo s seboj raztopljeno sadro. Ob stiku s hladnejšo vodo reke Radike se sadra obarja. Zaradi tega nastajajo beli sledovi, ki se vijejo po reki navzdol. Sadra se izloča tudi ob samem izviru v obliki blazinastih belih tvorb, ki so vidne daleč naokoli. Zaradi raztopljenega žveplovodika ima voda značilen vonj po žveplu.

Geološki podatki

Sadra leži v zgornjekrednih flišnih sedimentih, ki so del Debarske cone, ki je sestavni del zahodnomakedonske tektonske enote. Nahajališče sadre je na nadmorski višini med 500 in 1500 m. Ležišče se razteza na površini 8 km x 2 km. Na posameznih mestih so z vrtnami dokazali več kot 70 m debelo plast kristalne sadre. Nastanek sadre na tem mestu je povezan z metasomatskimi procesi znotraj kremenovih kamnin, ki so vložene v flišu. Poleg omenjene lokacije so aktivne še Melničani, Melnički most in Alčija. Sadro odkopavajo v jamah z miniranjem in jo odvažajo v bližnjo drobilnico.

Mineralna parageneza

Mineralno paragenezo v tem rudniku sestavlja le nekaj mineralov. Poleg velikih količin kristalizirane sadre najdemo še drobnokristalinični različek sadre - alabaster, anhidrit in žveplo.



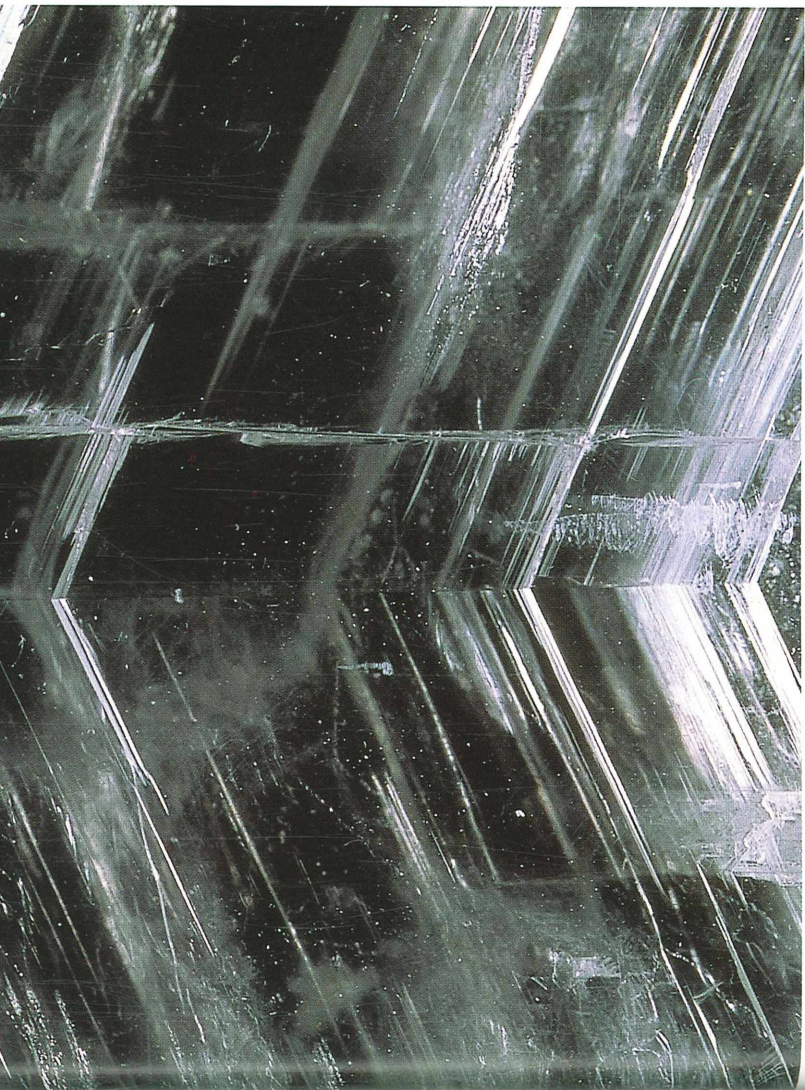
Slika 1: Kristali sadre v nahajališču sadre Kosovrasti so lepo oblikovani in popolnoma prozorni. Kristal na sliki je izrazil nazobčan zaradi raztapljanja. Dolg je 20 cm. Zbirka Oddelek za geologijo Naravoslovnotehniške fakultete Univerze v Ljubljani (NTF).

Picture 1: Gypsum crystals from the mine Kosovrasti are well developed and transparent. This crystal shows corrosion traces in the form of re-entrant faces. The crystal from the collection of the Naravoslovnotehniška fakulteta in Ljubljana (NTF) is 20 cm long.



Risba
b{010

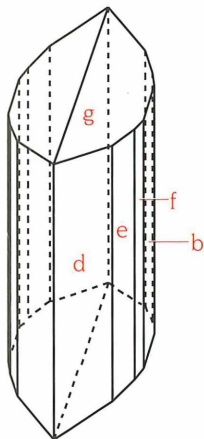
Risba
(100), r
tail twin
Kosovita
g{012}



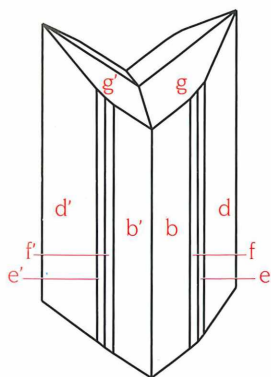
Slika
imenuje
Na foto
dvoični
M. Kar
Pictu
are kni
pholog
fragmen
(100) i
M. Kar

Slika 2: Na prejšnji strani: Dvojčke sadre po (100) imenujemo zaradi značilne oblike "lastovičji rep". Na fotografiji je razkolek, v katerem je dobro vidna dvojlična ravnina (100). Izrez meri 3 x 5 cm. Zbirka M. Kardelj.

Picture 2: Previous page: Gypsum (100) twins are known under the term of "swallow tail". The photograph shows a 3 x 5 cm large cleavage fragment from the Kosovrasti mine with a distinctive (100) twinning plane in the middle. Collection M. Kardelj.



Risba – Drawing 1: Sadra - Gypsum, Kosovrasti: $b\{010\}$, $d\{120\}$, $e\{140\}$, $f\{160\}$, $g\{012\}$.

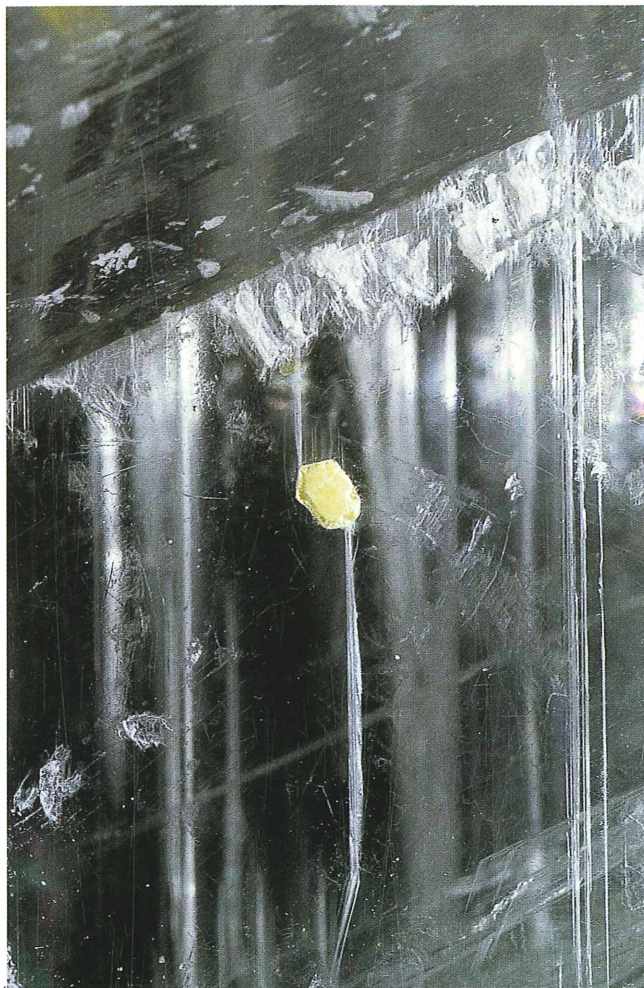


Risba – Drawing 2: Lastovičji dvojček sadre po (100), neklinografska projekcija - Gypsum swallow tail twin along (100), nonclinographic projection, Kosovrasti: $b\{010\}$, $d\{120\}$, $e\{140\}$, $f\{160\}$, $g\{012\}$.

Sadra nastopa v preraščenih kristalih, ki dosežejo večmeterske velikosti. Kristali so brezbarvni in prozorni. Težava je v tem, da popolnoma zapolnjujejo vse votline, zato jih je le redko najti v obliki prostorastočih kristalov z lepo oblikovanimi kristalnimi ploskvami. Na odkopih najdemo več decimetrov velike razkolke kristalizirane sadre. Pogosti so dvojčki po (100), ki jih imenujemo lastovičji rep. Tudi značilno zraščene odlomke kristalnih dvojčkov po tem zakonu brez težav najdemo na odkopih. Na kristalih je velikokrat opaziti sledi raztapljanja, ki jih povzroča voda. Taki kristali so nazobčani.

Žveplo S

Rumeno obarvane oprhe žvepla opazimo na kristalizirani sadri. Bolj zanimivi so njegovi vključki v kristalih sadre. Največkrat so kroglaste oblike, redkeje pa imajo obliko lepo razvitih idiomorfni kristalov. Njihova velikost navadno ne presega nekaj milimetrov.



Slika 3: Kristal sadre z vključenim kristalom samorodnega žvepla. Primerek iz rudnika Kosovrasti je iz zbirke NTF. Kristal žvepla meri 2 mm.

Picture 3: Gypsum crystal with crystallised sulphur inclusion. The diameter of the inclusion is 2 mm. Mine Kosovrasti specimen from the NTF collection.

Rudišče leži ob severnem vznožju pogorja Kožuf na jugovzhodu Makedonije, v neposredni bližini meje z Grčijo. Dosegljivo je preko Kavadarcev po dobri asfaltni cesti do Mrežička, naprej pa po slabem kolovozu. Možnost dostopa je tudi preko Vitolišta na Selečki planini, vendar le s terenskim vozilom. Ime rudišča izhaja iz začetnih črk banke **Allatini**, ki je konec 19. stoletja imela sedež v Solunu in je finančno podpirala rudnik ter začetnih črk priimka francoskega inženirja **Charteaux-a**, ki je to rudišče temeljito raziskal. Pravilno zapisano ime je torej **Allchar**, ki pa se je kasneje poenostavilo v Alšar, ki zveni v tistih krajih čisto domače.

Geološki podatki

Rudišče predstavlja redkost v svetovnem merilu. Zanj je značilno antimonovo, arzenovo in talijevo orudenje. V rudi je tudi zlato. Znanstvenike iz vsega sveta zanima predvsem redka talijeva mineralizacija. Gre za metasomatsko oziroma žilno-impregnacijsko rudišče. Značilna za to rudišče so nepravilna rudna telesa. Leži med zahodnim robom Vardarske cone in Dinaridi ter Pelagonidi. Najstarejše kamnine na tem področju so predkambrijski albitni gnajsi, ki vsebujejo vložke amfibolitov. Tem stratigrafsko sledijo paleozojski skrilavci in filiti. Njim se v manjšem obsegu pridružujejo kvarciti. Nad njimi so jurske kamnine, v katerih prevladuje diabas. Preko njih nalegajo še zgornjejurski sedimenti, njim sledijo zgronjeeocenske kamnine, ki jih sestavljajo konglomerati, prekrti s flišnimi sedimenti. V zaključku sledijo še jezerski sedimenti in piroklastiti pliocenske starosti.

V rudišču ločimo dve glavni rudni telesi: Centralni del in Crven dol. V prvem je matična kamnina okremenjeni dolomit, ki prehaja v diasporit. Rudno telo Crven dol se razlikuje od prvega po karbonatnih kamninah. V njih je intrudirano intenzivno hidrotermalno spremenjeno subvulkansko rudno telo. Rudišče je relativno mlado. Čas nastanka mineralov je ocenjen na 4,2 milijona let.

Rudnik je bil aktiven večkrat v svoji zgodovini, zadnjikrat pa konec osemdesetih let, ko so v projektu "Nevtrino" skušali pridobiti nekaj deset kilogramov lorandita, ki ga uporabljajo pri detekciji nevtrinov. Ob tej priložnosti so zopet obnovili nekaj rovov.

Mineralna parageniza

Najpogostejši rudni minerali v Centralnem delu so: antimonit, realgar, avripigment, pirit in markazit. Poleg njih je še nekaj drugih sulfidnih mineralov, magnetit in zlato. V rudišču Crven dol so najpogostejši realgar, avripigment, samorodno srebro, markazit in pirit. Največjo posebnost predstavlja skupina talijevih mineralov: lorandit, vrbait, raguinit, picotpaunit, parapierrrotit, bernardit, fangit, jankovičit in rebulit, ki je imenovan po slovenskem geologu B. Rebuli, ki je prvi odkril ta mineral v Alšarju. Poleg teh se pojavljajo še številni sekundarni minerali, od katerih naj omenimo sadro in goethit. Celotno rudišče in minerali v njem so podvrženi močni oksidaciji, kar se odraža na vonju celotne doline in primerkov, ki so kemijsko zelo nestabilni. Talij akumulirajo nekatere rastline, ki imajo zato atipično obarvane cvetove in so precej strupene. Tamkajšnji pastirji pa se tega dela izogibajo.

The mine is situated at the foothills of the mountain chain Kožuf in the south-eastern part of Macedonia in the vicinity of the Greek-Macedonian border. It can be reached from Kavadarci and from Vitolište, in the latter case only by a terrain car. The name of the ore deposit derives from the initials of the name of the bank **Allatini** that financially sponsored the mine activities in the late 19th century and the French engineer **Charteaux** who thoroughly investigated this ore deposit. The properly written name should, therefore, be **Allchar**. It has been simplified into Alšar, which is quite a familiar name in those places.

Geological setting

The ore deposit represents an exceptional world-wide. The antimony, arsenic, gold and thallium mineralisation is characteristic of this deposit. It is the rare thallium mineralisation that attracts scientists from all over the world. The ore deposit is a result of metasomatic or vein impregnation processes. The deposit is composed out of irregular ore bodies. It is positioned between the west edge of the Vardar zone and the Dinarides and the Pelagonides. The oldest rocks in this territory are Pre Cambrian albit gneisses with amphibolite insertions. They are stratigraphically followed by Palaeozoic schists and phyllites accompanied by quartzites in smaller quantities. Overlain are Jurassic rocks represented by diabases. Over them are placed Upper Triassic sediments followed by Upper Eocene sediments composed of lake sediments and Pliocene pyroclasts.

Two ore bodies are distinguished within the deposit, i.e. Centralni del and Crven dol. The first one is characterised by quartz dolomite passing over to diasporite and the second one by carbonate rocks in which the intruded subvulcanic ore body is placed, which is, at the same time intensively hydrothermally changed. The ore deposit is relatively young. It is assumed to be about 4.2 million years old.

The mine was active several times in its history. The last activities had their cause at the end of 1980' were associated with the "Nevtrino" project in which an attempt was made at obtaining some 60 kilograms of thallium to be used in neutrino detection. Several pits were restored at the time.

Mineral paragenesis

The most frequent minerals in Centralni del are: stibnite, realgar, orpiment, pyrite and marcasite. Some other sulphide minerals magnetite and gold are present as well. The ore deposit Crveni dol is characterised by realgar, orpiment, native silver, marcasite and pyrite. The most unique minerals are represented by lorandite, vrbait, raguinite, picotpaunit, parapierrrotite, bernardite

Stibnit

Well-d

Centraln

inside th

acicular

10 cm in

and frequ

on the c

ore for t

Risba

a{100}

f{211}

Realg

Realg

the form

Idiomor

can be c

rich red

white m

millime

crystal

Realgar

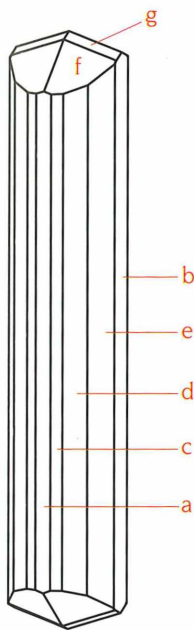
the air

As₂S₃. A

fangite, jankovičite and rebulite. The last was named after Slovene geologist B. Rebula who discovered it in Alšar. Secondary minerals are represented by gypsum and goethite to mention just a few. The complete ore body and minerals within it are subject to strong oxidation resulting in a characteristic smell in the valley. The specimens themselves are unstable, too. The thallium present in the soil dyes the flowers of the otherwise common plants differently, thus making them poisonous. The shepherds, therefore, avoid certain pasture areas.

Stibnite Sb_2S_3

Well-developed crystals are not rare in Centralni del. They can be found in caverns inside the quartz dolomite in the form of acicular aggregates. Prismatic crystals reach 10 cm in length. They are of steel-grey colour, and frequently iridescent due to the oxidation on the crystal surfaces. Stibnite was the main ore for the antimony production.



Risba – Drawing 3: Antimonit - Stibnite, Alšar: $a\{100\}$, $b\{010\}$, $c\{210\}$, $d\{110\}$, $e\{120\}$, $f\{211\}$, $g\{111\}$.

Realgar As_4S_4

Realgar is present in both ore bodies in the form of red coatings and massive veins. Idiomorph crystals are less frequent. Realgar can be encountered in geodes in marble. Its rich red colour is in excellent contrast with white marble. Crystals reach up to several millimetres having a diamond lustre on the crystal faces. Some of them are translucent. Realgar is unstable under light; exposed to the air it decomposes quite quickly into As_2S_3 . As a matter of fact, the decomposition

Lepo oblikovani kristali antimonita v osrednjem delu niso redki. Pojavljajo se največkrat v votlinah okremenjenega dolomita v radialnih skupkih. Kristali so prizmatski in lahko dosežejo do 10 centimetrov v dolžino. So jeklenosive barve, vendar so pogosto nahukli zaradi oksidacije. Antimonit je bil glavna ruda za pridobivanje antimona.

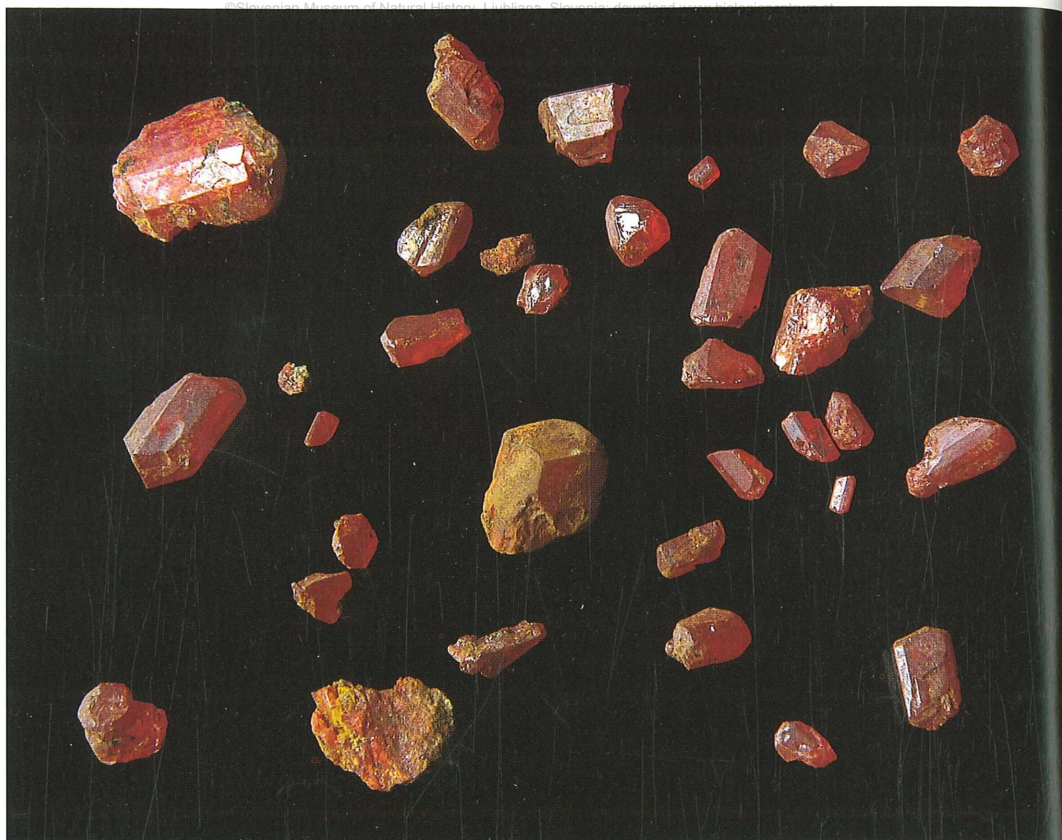


Slika 4: Skupek preraščenih kristalov antimonita iz rudišča Centralni del v Alšarju. V spodnjem delu so priraščeni kristali realgarja, ki so že kemijsko spremenjeni. Velikost primerka 70x25mm; zbirka NTF.

Picture 4: Group of intergrown stibnite crystals from the Centralni del ore deposit in Alšar. Chemically deteriorated realgar crystals can be seen at its lower part. Specimen dimensions: 70x25mm, collection NTF.

Realgar As_4S_4

Realgar se v obeh rudiščih pojavlja v prevlekah in masivnih žilah. Idiomorfni kristali so redkejši. Pogosto ga je najti v votlinah v marmorju, kjer je njegova rdeča barva v imenitnem kontrastu z belim marmorjem. Kristali so do nekaj milimetrov veliki, imajo diamantni sijaj na ploskvah in so prosojni. Na zraku in svetlobi je neobstoje in hitro oksidira v As_2S_3 , ki pa ni avripigment, kot se v splošnem misli, temveč substanca s popolnoma drugačno kristalno strukturo. Ima izrazito oranžnorumeno razo, po katerem ga takoj ločimo od lorandita in obratno.



Slika 5: "Ščepec" realgarjevih kristalov iz Alšarja. Kristali značilne barve so ploskovno bogati. Največji meri 1 cm v dolžini. Zbirka NTF.

Picture 5: "A pinch" of realgar crystals from Alšar. Crystals of characteristic colour are rich in crystallographic forms. The largest measures 1 cm in length. NTF collection.

Avripigment As_2S_3

Pojavlja se v rozetah, ki lahko dosežejo do nekaj centimetrov premera. Na prelomu se pokaže njegova značilna zlatorumena barva in dobra razkolnost v obliki lusk, podobno kot pri sljudah. V oranžnih drobnih rozetah ga je često moč najti na okremenjenem dolomitu. Pod Centralnim delom je več velikih odvalov, iz katerih spira voda gomolje avripigmenta, ki jih nato najdemo v potoku. Kristali realgarja so dostikrat prraščeni na rozetah avripigmenta.

Lorandit TlAsS_2

Lorandit je bil prvi iz serije novih talijevih mineralov, ki so bili odkriti v tem nahajališču. Odkril ga je v letih 1894/95 madžarski mineralog Krenner. Čeprav je najpogostejši od vseh tukaj prisotnih talijevih mineralov, je še vedno zelo redek. Pojavlja se v do 1 cm velikih karminsko rdečih kristalih z diamantnim sijajem. Kristali so ploskovno bogati.

Drugi talijevi minerali

V tem rudišču so odkrili celo vrsto talijevih mineralov, katerih imena smo že navedli. Ti minerali so zelo redki, določeni le na nekaj primerkih, zato jih tu ne bomo posebej opisovali. Vsekakor gre za edinstveno paragenezo v svetovnem merilu, ki je zanimiva predvsem z znanstvenega vidika.

product is not orpiment, but a substance with a completely different crystal structure. It has a characteristic orange-yellow streak which differentiates it from lorandite.

Orpiment As_2S_3

Orpiment can be found in rosettes of up to several centimetres in diameter. Its characteristic golden-yellow colour can be seen on cleavages and is similar to that of micas. It is quite frequent on quartz-dolomite. An interesting fact is the overgrowth of realgar on orpiment crystals. There are several dumpings under Centralni del where the old torrent waters leach out orpiment nodules which can afterwards be found in the water down the stream.

Lorandite TlAsS_2

Lorandite was the first discovered. It is representative in the series of thallium minerals from Alšar. Its discoverer was the Hungarian mineralogist Krenner who in 1894/95 recognised it as a new mineral species. In spite of its being the most frequent thallium mineral on this location it is still very rare. It appears in carmine-red crystals from

Lorandit in sončni nevtrini Lorandite and Solar Neutrinos

Radomir Ilić

Fakulteta za gradbeništvo, Univerza v Mariboru, Smetanova 17, 2000 Maribor
in Institut "Jožef Stefan", Jamova 39, 1000 Ljubljana

Neutrinos are one of the fundamental particles that make up the universe. They are one of the least understood particles. A neutrino is similar to the more familiar electron, with one crucial difference: it does not carry an electrical charge. Since neutrinos are electrically neutral, they are not affected by the electromagnetic forces acting on electrons.

Three types of neutrinos exist. Each neutrino type is related to a charged particle (which gives the corresponding neutrino its name). The electron neutrino (ν_e) is associated with electron (e). Two other neutrinos ν_μ and ν_τ are associated with heavier versions of the electrons called the muon (μ) and the tauon (τ). A primary interest of the study of solar neutrinos arises from the fact that they can reveal the inner structure of the Sun. Detection of solar neutrinos at the Earth may also reveal as yet undetected intrinsic properties of neutrinos. The neutrino has very low cross-section ($< 10^{-44} \text{ cm}^2$) for interactions with matter, which makes its measurement extremely difficult. Because the neutrino interaction with matter is very weak, neutrino detectors should meet the following conditions. First, they should be very large with an enormous active volume, where the interaction of a neutrino with matter takes place and this volume should, in addition, be controlled by extremely sensitive sensors. The detectors are usually buried deeply under the earth to avoid charged cosmic rays which disturb the

of experiments. In addition to man-made detectors some natural mineral deposits in the Earth that have been unattended for millions of years were proposed for a time averaged neutrino flux measurements. In LOREX (Lorandite Experiment) the mineral lorandite (TIAsS_2) of the old (5×10^6 years) mine Alšar (Kavadarci, Macedonia) will be used to estimate average solar neutrino flux from the amount of ^{205}Pb isotope ($T_{1/2} = 1.5 \times 10^7$ years) induced by the interaction of neutrinos with thallium via $^{205}\text{Tl}(\nu_e, e^-)^{205}\text{Pb}$ reaction.

The current research of this thallium multidisciplinary project, proposed by Freedman *et al.*, aims at the following: development of a suitable procedure for the mineral separation of lorandite from the ore, frequent determination of trace elements in lorandite, investigation of erosion rate, extraction of crystal Pb from lorandite, determination of log f,

Nevtrini so osnovni delci, ki sestavljajo vesolje. Vendar je o njih med vsemi zbranih najmanj podatkov. Podobni so bolj znanemu delcu elektronu, a z eno bistveno razliko: niso nosilci električnega naboja. Nevtrino zelo šibko sodeluje z materijo. Ker je nevtralen, ne reagira elektromagnetno, prav tako ne preko močne interakcije (to je sile, ki drži protone in nevtrone v jedru). Njegov stik z okoliškimi jedri poteka le preko tako imenovane šibke interakcije.

Poznamo tri vrste nevtrinov, ki se ločijo po svojem leptonskem številu. Vsakemu izmed osnovnih delcev pripišemo pripadajoči nabiti delec. Tako elektronu (e) pripada elektronski (ν_e), mionu (μ) mionski (ν_μ) in tauonu (τ) tauonski nevtrino (ν_τ). Raziskovalci intenzivno raziskujejo lastnosti sončnih nevtrinov, ker predvidevajo, da bodo z njimi lahko določili notranjo zgradbo Sonca. Poleg tega bi z detekcijo sončnih nevtrinov na Zemlji



lahko dokazali njegove notranje lastnosti. Nevtrino ima zelo majhen presek ($< 10^{-44} \text{ cm}^2$) za interakcijo s snovjo. Zato je merjenje zelo težko. Ker je njihova interakcija s snovjo zelo šibka, morajo detektorji nevtrinov izpolnjevati naslednje temeljne pogoje. Imeti morajo ustrezno veliko aktivno prostornino, kjer lahko poteka interakcija nevtrinov s snovjo. Poleg tega morajo ta prostor nadzorovati zelo občutljivi senzorji. Detektorji so ponavadi spravljani globoko pod zemljo, ker se s tem izognemo nabitim kozmičnim žarkom, ki lahko motijo poizkus.

Poleg takšnih instrumentov lahko tudi nekatere minerale v zemlji uporabimo kot detektorje povprečnega fluksa nevtrinov. V poizkusu LOREX (Lorandite Experiment) bodo mineral lorandit (TIAsS_2) iz starega (5×10^6 let) rudnika Alšar (Kavadarci, Makedonija) uporabili za oceno povprečnega fluksa sončnih nevtrinov. Merili bodo količino izotopa ^{205}Pb ($T_{1/2} = 1.5 \times 10^7$ let), ki nastaja v reakciji $^{205}\text{Tl}(\nu_e, e^-)^{205}\text{Pb}$. Raziskave tega multidisciplinarnega projekta, ki so ga predlagali Freedman in drugi, obsegajo: razvoj primerne tehnologije za separacijo lorandita iz rude, določanje nečistoč v loranditu, študij hitrosti erozije, ekstrakcijo Pb iz lorandita, določanje vrednosti log f, za ^{205}Tl , razvoj tehnik za selektivno merjenje izotopa ^{205}Pb in določanje ozadja sevanja.

V okviru slovensko-makedonskega medvladnega programa sodelovanja na področju znanosti in tehnologije v letih 1997-2000 sta raziskovalni skupini Instituta J. Stefan, Ljubljana in Prirodno-matematične fakultete, Skopje združili raziskovalne zmožnosti v okviru skupnega projekta »Detekcija sončnih nevtrinov s talijevimi minerali«, da bi rešili nekatere od številnih vprašanj tega kompleksnega multidisciplinarnega eksperimenta.

Literatura - References

- FREEDMAN M. S. *et al.*, Science 193 (1976), 1117-1119.
 ILIĆ R. *et al.*, Nucl. Tracks Radiat. Meas. 22, 1-4 (1993), 591-598.
 LAZARU A. *et al.*, Nucl. Tracks Radiat. Meas. 31, 1-6 (1999), in press.
 STAFILOV T., ILIĆ R., Solar Neutrino Detection with Thallium Minerals, IJS-DP-8022 (1999).
<http://www.ps.uci.edu/~superk/>
<http://www.kvarkadabra.net/snov/teksti/nevtrino.htm>.

value for ^{205}Tl , improvements of technique for selective measurements of ^{205}Pb isotope and determination of background radiation.

Within the framework of the Slovenian-Macedonian Intergovernmental S & T Co-operation Programme for 1997-2000, the research group of the J. Stefan Institute, Ljubljana and Faculty of Natural Science, Skopje created a common research project entitled »Solar Neutrino Detection with Thallium Minerals« in order to solve some of the problems of this complex multidisciplinary experiment.



Slika 6: 45 x 45 mm velik agregat kristalov avripigmenta iz rudišča Crven dol, v katerem se v levem spodnjem delu vidi temnordeč kristal lorandita. Zbirka NTF.

Picture 6: 45 by 45 millimetres large orpiment aggregate from the Crven dol ore deposit in Alšar carrying deeply red lorandite crystal at its lower left part. NTF collection.



Slika 7: Skupek preraščenih kristalov avripigmenta iz rudišča Centralni del v Alšarju. Na razkolnih ploskvah se lepo vidi njihova značilna barva. Skupek je velik 6 x 4 cm in izhaja iz zbirke NTF.

Picture 7: Group of intergrown orpiment crystals from Centralni del in Alšar. Its characteristic colour can clearly be seen on the cleavages. The aggregate diameter: 6 cm. Collection NTF.

and with a diamond lustre reaching one centimetre in length. The crystals are rich in crystallographic forms.

Other thallium minerals

A series of rare and previously mentioned thallium minerals has been discovered in this ore deposit. They are extremely rare minerals determined in only few specimens; they will not be discussed here in great detail. However, the unique paragenesis is interesting from the scientific point of view.

Calcite CaCO_3

Calcite scalenohedrons appear in marble veins and geodes. They reach up to 2 cm in length and frequently are covered by realgar crystals.

Gypsum $\text{CaSO}_4 \times 2 \text{H}_2\text{O}$

We will only mention gypsum from the group of supergene minerals. Its crystals, as a result of ore oxidation, can be found throughout the ore body. Some crystals reach several centimetres. Clay inclusions frequently colour them grey.

Calcite CaCO_3

Skalenoedrski kristali kalcita se pojavljajo v razpokah marmorja. Dosežejo do 2 cm v dolžino in so pogosto preraščeni s kristali realgarja.

Sadra $\text{CaSO}_4 \times 2 \text{H}_2\text{O}$

Med sekundarnimi minerali, ki nastajajo pri oksidaciji drugih mineralov, omenimo samo sadro, ki nastopa v nekaj centimetrov velikih kristalih značilne morfologije. Zaradi vključkov je pogosto sivkasto obarvana.

Crni (Kara) kamen

To nahajališče leži na Prilepsko - Bitolskem polju, 11 km jugozahodno od Prilepa, v bližini vasi Alinci. Razprostira se na približno 4 km² gričevnatega sveta, na katerem je nekaj njiv, v večini pa so pašniki. Nahajališče je postalo znano, ko so gradili novo cesto med Prilepom in Bitolo, za katero so potrebovali kamen, ki so ga lomili v tamkajšnjem kamnolomu. Kamnolom ne deluje več, vendar je tam še vedno mogoče najti vse minerale iz opisane parageneze.

Geološki podatki

Samo nahajališče in okolico sestavljajo alkalijski sienit, amfibolit, gnajs, muskovitni skrilavec in marmor. Sienit predstavlja osrednji, približno 2 km dolgi pas kamnin, ki je na vzhodni in zahodni strani omejen z amfibolitom. Debelozmatti in mlajši drobnozmatti sienit sestavljajo mikroklin, arfvedsonit, avgit, kremen, albit in v manjših količinah titanit, cirkon in apatit. Vzdolž prelomov in razpok so se v sienit vtisnili gnajsi in kremenovo-mikroklinože žile. Amfiboliti skrilavec je v južnem delu in v samem sienitskem masivu. Tudi v njem opazimo gnajs in kremenovo-mikroklinože žile. Mineralna sestava kamnin kaže na to, da so nastale s pretvorbo bazičnih kamnin.

Mineralna parageneza

Posebnost nahajališča je dokaj redka mineralna parageneza, ki obsega tudi nekaj uranovih mineralov. Značilno je pogosto pojavljanje več deset centimetrov velikih gnezd, ki so v celoti zapolnjena z dolgimi igličastimi kristali arfvedsonita. Najdišče je na golem grebenu, preko katerega pihajo stalni vetrovi, ki raznašajo tanke iglice iz ravnokar odprtih gnezd, kar je zelo nevarno za oči in neprijetno za nezaščiteni kožo. Idiomorfni kristali drugih mineralov se vedno pojavljajo v žilah glincev, v katerih so že omenjena gnezda. V kamninah je dokazan povišan delež urana, torija, litija, cirkona in rubidija.

Arfvedsonit $\text{NaNa}_2[(\text{Fe}^{2+}, \text{Mg})_4(\text{Fe}^{3+}, \text{Al})]\text{Si}_8\text{O}_{22}(\text{OH})_2$

Dolgi igličasti kristali tega minerala iz skupine amfibolov so črni, zeleni ali modrikasti. Kristali merijo od nekaj stotink milimetra v premeru pa tja do dveh milimetrov. Nikoli ne razvijejo terminacij, ki so zaradi tega nazobčane oziroma nepravilno zaključene. V gnezdih so združeni v prepletene lasaste agregate, v katerih se lahko idiomorfno razvijejo kristali drugih mineralov, zlasti titanita. Arfvedsonit je kristaliziral med prvimi, saj ga najdemo vključenega v večjih ali manjših količinah v vseh drugih mineralih.

Albit $\text{NaAlSi}_3\text{O}_8$

Mineral je v tem nahajališču pogost v lepo oblikovanih kristalih, ki so večinoma prosojni, nekateri pa tudi popolnoma prozorni. Večji kristali in tisti, ki izraščajo iz sten v razpokah, so lahko porcelansko beli. Največji kristali dosežejo do 10 cm v dolžino in debelino preko enega centimetra. Kot drugod, so tudi tu polisintetsko dvojčeni po albitnem zakonu vzdolž (010), poleg tega pa še po karlovarskem zakonu vzdolž (010). Karlovarsko dvojčenje prepoznamo zaradi izrazite razkolnosti po (001), kar se na takem dvojčku odrazi kot prekrizane razkolne smeri v kristalu. Pogosto imajo veliko vključenih igličastih kristalov arfvedsonita.

This location lies in the Prilep-Bitola field, 11 km south-west from Prilep, in the vicinity of the small village of Alinci. It covers an area of 4 square kilometres. The location became known when a new road between Prilep and Bitola was built. The stone material was needed so the stone quarry at the said site was activated. The quarry is now no longer active, but the described representatives of the mineral paragenesis can still be found there.

Geological setting

The location and its vicinity are composed of alkali sienite, amphibolites, gneiss, mica-schist and marble. The sienite represent the central, approximately 2 km long rock belt, limited by amphibolite in its east and west. Coarse- and fine-grained sienites are composed of microcline, arfvedsonite, albite and to a smaller extent of titanite, augite, zircon and apatite. Gneiss and quartz-microcline dikes were intruded into the sienite along faults and cracks. The amphibolite schists are present in the southern part in the sienite massif. The quartz-microcline dikes as well as gneiss can be seen here. The mineral composition seems to indicate rocks formed with the transformation of the basic rocks.

Mineral paragenesis

The uniqueness of this location is associated with a rare mineral paragenesis which encompasses some uranium minerals as well. Characteristic is the appearance of the arfvedsonite nests embedded in feldspar veins. They are completely filled with finely crystallised arfvedsonite needles. As the location is on a bare ridge it can be quite harmful to uncover those nests in the stream of persistent winds blowing over that ridge. Eyes and hands are endangered severely if safety goggles and gloves are not worn during the entire work on the location. Idiomorphic crystals of other minerals always appear in the feldspar veins within the mentioned arfvedsonite nests. Elevated concentrations of uranium, thorium, lithium, zircon and rubidium were proved in the rocks present.

Arfvedsonite $\text{NaNa}_2[(\text{Fe}^{2+}, \text{Mg})_4(\text{Fe}^{3+}, \text{Al})]\text{Si}_8\text{O}_{22}(\text{OH})_2$

Long needle-like crystals of this mineral from the amphibole group are black, green or blue in transmitted light. Their dimensions range from several hundredths of millimetre up to two millimetres in diameter. The terminations are never developed. Crystal terminations are therefore rugged and uneven. Crystals are associated into matted aggregates inside which other minerals, especially titanite, can be crystallised. Arfvedsonite was the first to crystallise for it can be found included or embedded in all other minerals of the present paragenesis.



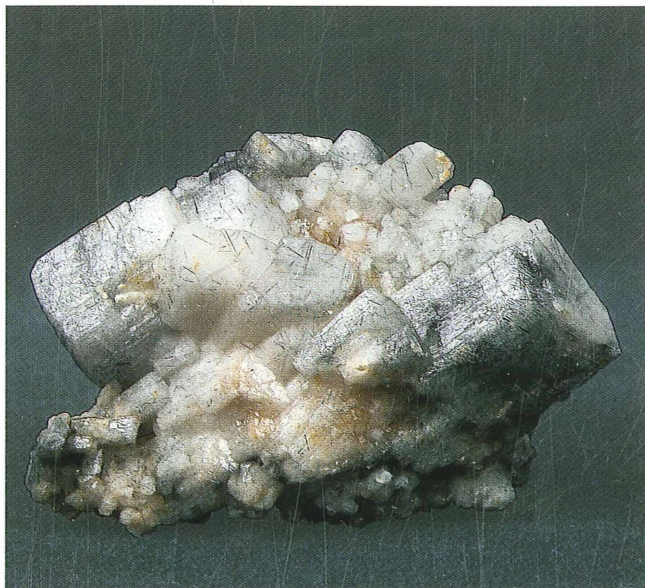
Slika 8: Kremenov kristal, velik 7 cm, iz nahajališča Alinci je črn zaradi vključkov igličastih kristalov arfvedsonita. Zbirka G. Kobler.
 Picture 8: Seven centimetres tall quartz specimen from Alinci near Prilep. Its smoky colour is mimicked by numerous inclusions of arfvedsonite crystals. G. Kobler collection.

Slika 9: Skupek kristalov mikrokлина iz Alincev je preraščen z igličastimi kristali arfvedsonita. Dobra razkolnost kristalov mikrokлина po (100) se lepo vidi. Primerek meri 8 x 5 cm. Zbirka G. Kobler.

Picture 9: Group of microcline crystals from Alinci "spiked" with arfvedsonite needles. The perfect microcline cleavage along (100) can be clearly seen. 8 by 5 cm specimen from G. Kobler collection.

Albite $\text{NaAlSi}_3\text{O}_8$

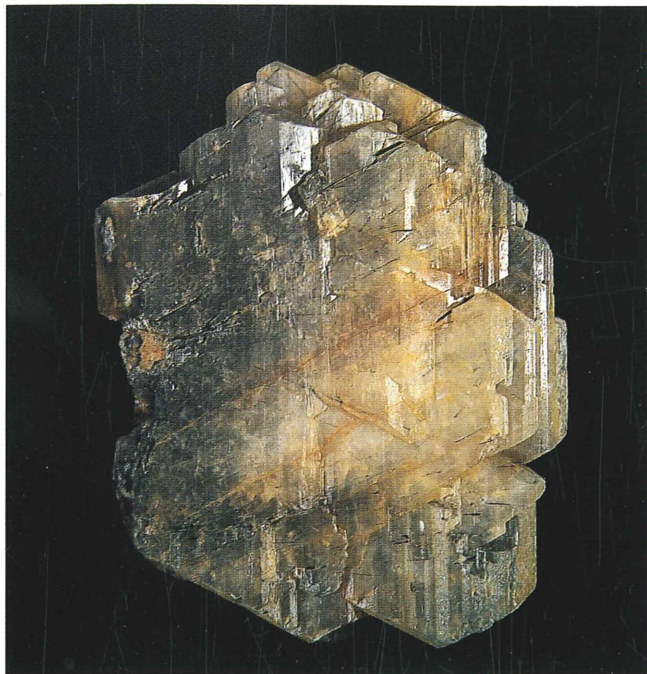
This mineral is frequently present here in well-developed crystals, which are almost always translucent or even transparent. Larger crystals are opaque. The largest crystals reach 10 cm in length and 1 cm in width. As is typical of other locations it is polysynthetically twinned according to the albite law and beside that also according to the Karlsbad law. The latter twinning is distinguished by a good cleavage pattern along the (001) planes, which can be noted in such twins through the crossed cleavage lines of both twinned subindividuals. The arfvedsonite inclusions are typical.





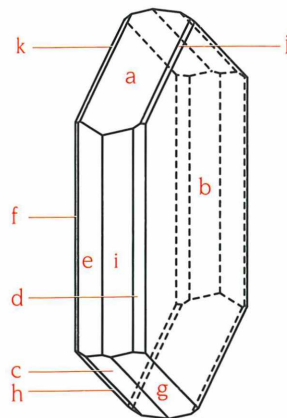
Slika 10: Posebej zanimivi so primerki, kjer je prisotnih več mineralov naenkrat. Na tem 4 x 3 cm velikem skupku si delajo družbo velik kristal albita, ki je polisintetsko dvojčen po albitnem zakonu, poleg tega pa še po karlovarskem zakonu. V njegovem vznožju so priraščeni beli kristali mikrokлина. Vse pa prebadajo igličasti kristali arfvedsonita. Zbirka M. Žorž.

Picture 10: The most characteristic are specimens with several minerals present. The group pictured here is comprised of large polysynthetically albite-twinned and Karlsbad-twinned albite crystal. White microcline crystals are positioned in its shade. Everything is intergrown with arfvedsonite needles. Alinci specimen dimensions: 4 x 3 cm, M. Žorž collection.



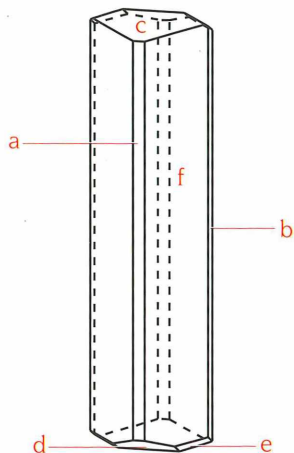
Slika 11: Albitno karlovarski dvojček albita iz Alincev. Velikost 8 x 5 cm. Zbirka M. Kardelj.

Picture 11: Albite crystal twinned simultaneously according to Albite and Karlsbad laws. M. Kardelj collection. Dimensions: 8 x 5 cm.



Risba – Drawing 4: Albit - Albite, Alinci: **a**{100}, **b**{010}, **c**{001}, **d**{130}, **e**{110}, **f**{130}, **g**{021}, **h**{021}, **i**{110}, **j**{112}, **k**{112}.

Large prismatic crystals are opaque. The largest measure up to 20 cm in length but are less developed or corroded. Those nearing the surface are damaged by ice due to a good cleavage along the (100). Baveno twins along (021) are quite rare. Smaller crystals can be transparent with well-formed faces. It frequently appears with albite. Arfvedsonite inclusions can completely darken them. They can be cut and polished into interesting cabochons. Arfvedsonite needles endow them with a unique character.



Risba – Drawing 5: Mikroklin - Microcline, Alinci: $a\{100\}$, $b\{010\}$, $c\{001\}$, $d\{111\}$, $e\{110\}$, $f\{110\}$.

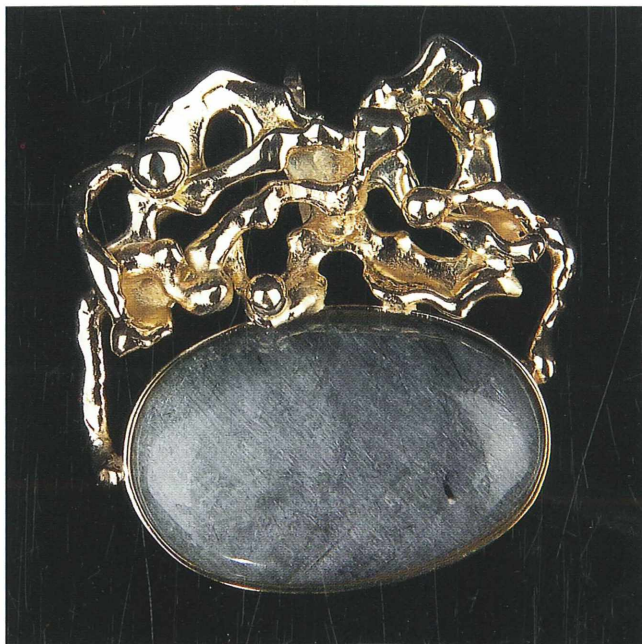
Quartz SiO_2

It was found in over 50 cm long prismatic crystals of the so-called Bambauer-type. Large crystals are milky, whereas smaller completely transparent. Arfvedsonite inclusions are typical of all which, again, represents something special. The arfvedsonite inclusions are sometimes dense enough to give them an appearance as of a smoky quartz. As a rule, quartz crystals here are not twinned. However, Brazil twins and their twinning lamellae are noted. Well-crystallised quartz is, strictly speaking, rare in spite of its wide presence in the veins.

Titanite CaTiSiO_5

This locality is remarkable for extremely large and well-developed titanite crystals. It is typical of them to grow within arfvedsonite nests. Their growth started after the arfvedsonite had been crystallised. Growing titanite crystal embedded more and more arfvedsonite crystals during its growth using

Veliki prizmatski kristali mikrokлина so porcelanasto bele barve. Največji merijo tja do 20 cm, vendar so slabše razviti ali pa korodirani. Tiste, ki so bližje površju, poškoduje mrz zaradi dobre razkolnosti po (001). Redkeje se pojavljajo bavenški dvojčki po (021). Manjši kristali so lahko prozorni in lepo oblikovani z gladkimi ploskvami. Arfvedsonitovi vključki jih včasih popolnoma potemnijo. Možno jih je brusiti v obliki kabošona, pri čemer se lepo odražajo vključki arfvedsonitovih iglic in optični efekt adularescence. Pogosto je skupaj z albitom.



Slika 12: Zanimiva preraščenost mikrokлина s kristali arfvedsonita pride do izraza na obrušenih kristalih. Kabošon na posnetku je obdelal M. Jeršek, vgrnila v originalno oblikovani nakit pa N. Šturm. Velikost kristala 3,0 x 1,5 cm.

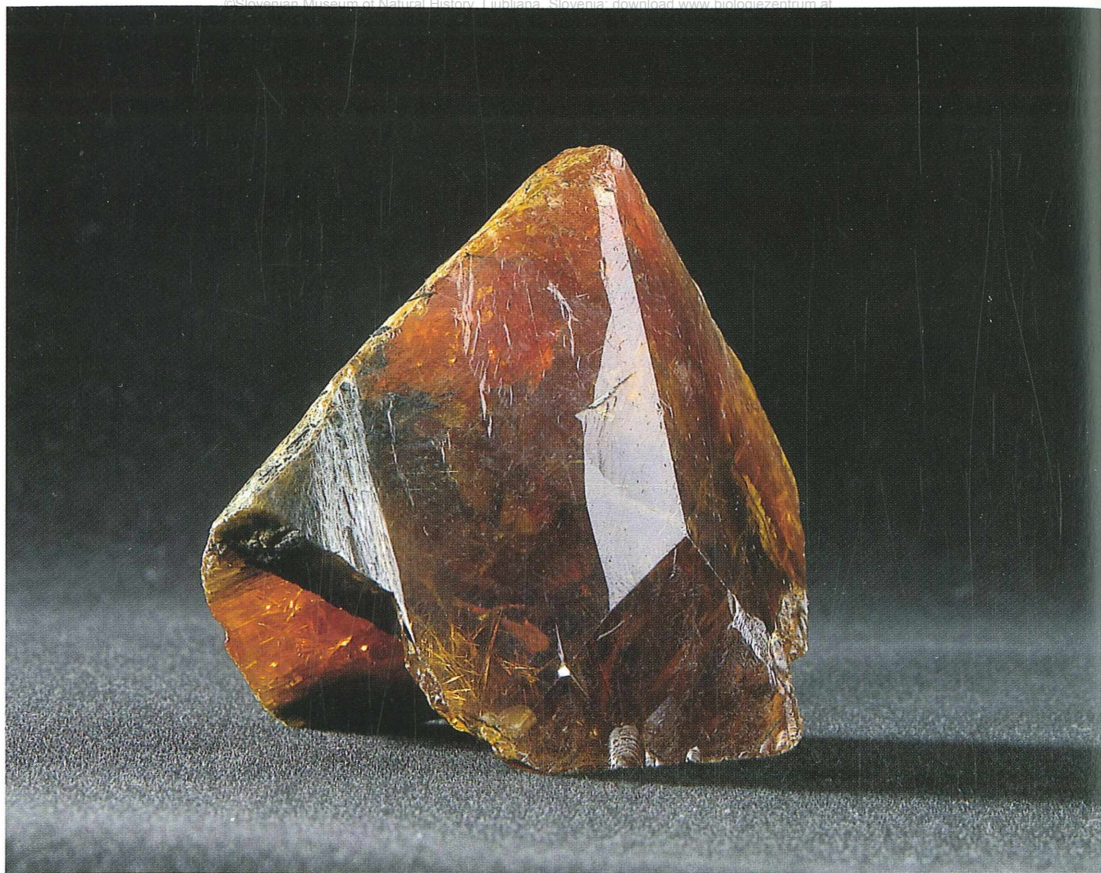
Picture 12: An interesting intergrowth of microcline with arfvedsonite crystals from Alinci finds its expression in cut crystals. The cabochon in the picture designed and manufactured by N. Šturm; cut by M. Jeršek. Crystal dimensions: 3,0 x 1,5 cm.

Kremen SiO_2

Našli so več kot pol metra velike prizmatske kristale vrste bambauer. Večji kristali so mlečni, medtem ko so manjši lahko popolnoma prozorni. Za vse je značilno, da imajo veliko vključkov kristalov arfvedsonita, kar predstavlja posebnost. V nekaterih je teh vključkov toliko, da so temni kot čadavci. Kristali kremenja v tem nahajališču praviloma niso dvojčeni, včasih pa so opazne lamele brazilskega dvojčenja. Kremen v lepih kristalih je pravzaprav redek, čeprav ga je v žilah kar precej.

Titanit CaTiSiO_5

Med največjimi posebnostmi tega najdišča so prav gotovo zelo veliki kristali titanita, za katere je značilno, da prosto rastejo v gnezdih, zapolnjenih s kristali arfvedsonita. Ker je titanit kristaliziral med zadnjimi, se je v prvi fazi prirasel na obstoječi kristal arfvedsonita v gnezdu, nato pa s svojo



Slika 13: Titanit v Alincih se najbolj pogosto pojavlja v značilno oblikovanih dvojčkih po (100), kakršen je tudi na fotografiji. Primerek iz zbirke A. Hinterlechner-Ravnik meri 68 x 58 mm.

Picture 13: Titanite in Alinci is most common in characteristic (100) twins. Their form resembles the steep roof seen in the picture. Twin dimensions: 68 x 58 mm, A. Hinterlechner-Ravnik collection.

rastjo zajemal čedalje več kristalov arfvedsonita, ne da bi se prirasel na steno gnezda. Na koncu se je razvil kristal, ki ga držijo z vseh strani igličasti kristali arfvedsonita. Žal so miniranja poškodovala večino ohranjenih kristalov titanita. Iz najdenih fragmentov v nahajališču je moč sklepati, da so največji kristali titanita dosegli do 25 centimetrov v dolžino in so morali tehtati nekaj kilogramov. Ohranjenih je nekaj kristalov velikosti do 8 cm. Praviloma so vsi dvojčki po (100) z obliko strme strehe. Večji kristali so medenorjave barve in prosojni, manjši pa so rumenkasti in prozorni. Njihov zaščitni znak so seveda vključki arfvedsonita.

Apatit $\text{Ca}_5(\text{PO}_4)_3(\text{F,OH,Cl})$

Apatit je tukaj redek mineral. Pojavlja se v enostavnih heksagonalnih prizmatskih kristalih rahlo rumenkaste barve, ki dosežejo nekaj milimetrov v dolžino. Dobro razvite so ploskve prizme in pinakoida.

Hijalit SiO_2 - amorfni

Hijalit je amorfni kremen, ki se pojavlja kot steklaste prevleke po drugih mineralih. Največkrat ga je opaziti na kristalih mikrokлина in kremena. Pri obsevanju z ultravijolično svetlobo fluorescira v zelenkastorumeni svetlobi.

them as a special sort of growth support. The titanite crystals grew, in this way, into a void as a floater, developing their complete morphological shapes as a single or twinned crystal. The explosions, unfortunately, damaged most of the crystals found. As estimated, from the fragments found on the location, the largest twins reached 25 cm in length and could have weighed several kilograms. Some crystals up to 8 cm in length survived. They are, as a rule, all (100) twins with a typical shape of steep roof. Larger crystals are of honey-brown colour and translucent, whereas those smaller of yellow colour and transparent. Arfvedsonite inclusions are their brand mark.

Apatite $\text{Ca}_5(\text{PO}_4)_3(\text{F,OH,Cl})$

It is quite rare here. It appears in small yellowish crystals up to several millimetres in length. Developed are mostly prisms and pinacoid.

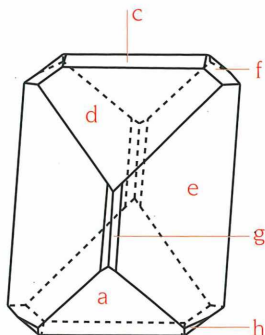
Hyalite - amorphous SiO_2

It can be seen as coatings on other minerals, especially on quartz and microcline. It fluoresces in greenish-yellow colour under UV light.

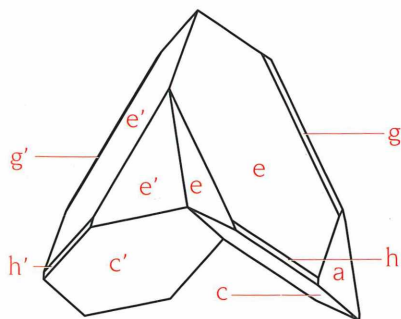
The black crystals of this mineral can be found scattered in the surrounding fields. They were brought there with the weathering of pegmatite dikes. The largest known crystal with black hematite lustre measures 15 cm in length.

Other minerals

Monazite, bernierite, titanohematite and the first discovered and described lead titanate - macedonite were also found here.



Risba – Drawing 6: Titanit - Titanite, Alinci. Neklinografska projekcija - non-clinographic projection: **a**{100}, **c**{001}, **d**{103}, **e**{111}, **f**{013}, **g**{11.9.11}, **h**{110}.

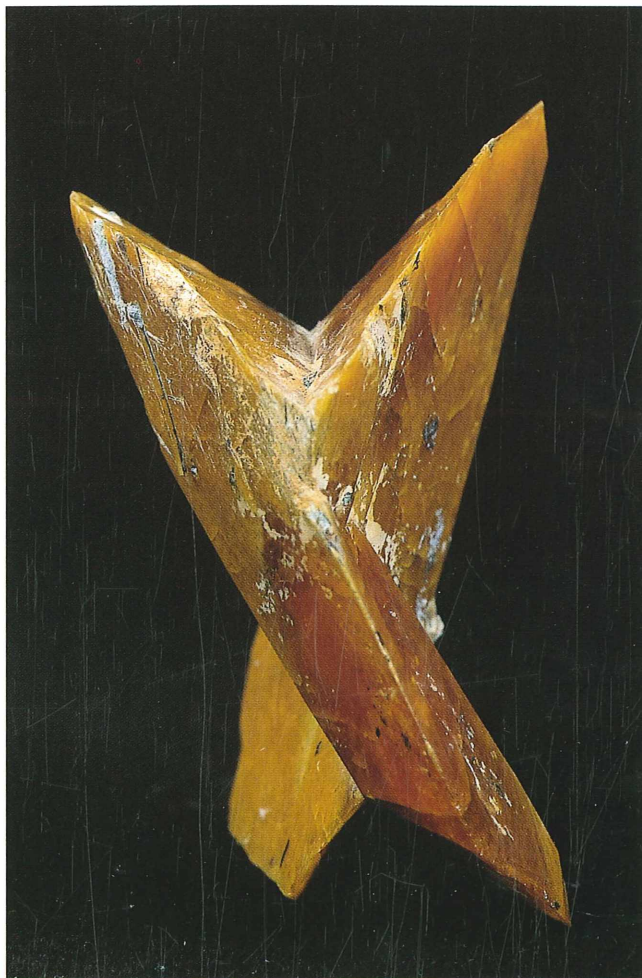


Risba – Drawing 7: Dvojček titanita po (100), neklinografska projekcija - Titanite (100) twin, non-clinographic projection, Alinci: **a**{100}, **c**{001}, **e**{111}, **g**{11.9.11}, **h**{110}.

Črne kristale tega minerala s hematitnim sijajem najdemo po njivah tam okoli, kamor je prišel s preperevanjem iz pegmatitnih žil. Največji najdeni kristal meri 15 cm v dolžino.

Drugi minerali

Našli so še monacit, bernierit, titanohematit ter prvič odkriti in opisani macedonit, ki je svinčev titanat.



Slika 14: Penetracijski dvojček titanita po (100). Velikost: 6 x 3 cm. Zbirka: Geoinštitut Skopje.

Picture 14: A penetrating (100) titanite twin. Dimensions: 6 x 3 cm. Geoinstitut Skopje collection.

Kamnolom dolomitnega marmorja Sivec je od Prilepa oddaljen 8 km v severozahodni smeri. Leži na zahodnem vznožju več kot 1200 m visokega hriba Sivec. V njem pridobivajo zelo kvaliteten dolomitni marmor, ki se odlikuje po dobri obstojnosti in snežno beli barvi. Marmor žaganjo s pomočjo žice z diamantnimi obročki v velike bloke, ki so glavni produkt. V zadnjih letih so razvili tudi višje stopnje obdelave, tako da ga žagajo v plošče in profile različnih velikosti. To ni edini kamnolom v okolici Prilepa. Znan je tudi kamnolom marmorja Čaška, ki je na samem prelazu Pletvar in predstavlja s svojo višino 994 m vrata v Prilep. Marmorje s kristali korunda so našli še v okolici krajev Belovodice in Beloto.

Geološki podatki

Marmorji v okolici Prilepa so nastali z lokalno omejeno metamorfozo karbonatnih kamnin. Pripadajo centralnemu delu Pelagonskega masiva, ki ga v večini sestavljajo visokometamorfne in magmatske kamnine. Stratigrafsko lahko ločimo dva kompleksa. Spodnji je sestavljen iz gnajsov in glinastih skrilavcev, medtem ko sestavljajo zgornjega tudi marmorji. Marmorna serija je zadnja v seriji visokometamorfni kamnin in je ponekod debela do 1500 metrov.

Mineralna parageneza

Minerali v marmorjih Sivca so značilni za t.i. lokalno metamorfozo, ko se povečata pritisk in temperatura. Zaradi tega so karbonatne kamnine prekrystalile v marmorje. Druge prisotne substance, kot so oksidi nekaterih kovin, so se pri tem stalile in prekrystalile v idiomorfne kristale. Pri lokalni metamorfozi pride tudi do nekaterih kemijskih reakcij, v katerih iz obstoječih nastanejo novi minerali. Kljub odpornosti dolomitnega marmorja, ta vseeno relativno hitro prepereva. Sčasoma se v preperini nad njim skoncentrirajo kristali mineralov, ki so bili v marmorju in so sami odporni proti preperivanju.

Korund Al_2O_3

Najbrž je Sivec po svetu bolj znan po kristalih korunda, kot po marmorju. Kristali korunda so tu namreč precej pogosti. Največ jih najdemo v približno meter debeli plasti preperine, ki pokriva nahajališče marmorja, precej pogosto pa jih najdemo tudi *in situ*, torej še v marmorju. Največji kristali so veliki do 15 cm, večinoma pa do 5 cm. Posebno tiste iz preperine pokriva limonitna prevleka, zato so rdečerrjavi, medtem ko imajo tisti iz marmorja nežno rožnato barvo. Posamezni kristali so lahko modro obarvani, najdemo pa se še drugi barvni odtenki. Pod ultravijolično svetlobo oranžnordeče fluorescirajo. Kristali so relativno dobro razviti, vendar redko popolnoma. Značilni so nepopolno razviti deli in vdolbine, ki so posledica hitre rasti kristalov v talini. Morfologija kristalov je relativno enostavna. Največkrat je razvit pinakoid $\{0001\}$, zato so kristali ploščati. Na obodu so omejeni s ploskvami heksagonalne bipiramide, redkeje pa z romboedri in heksagonskimi prizmi. Če so pinakoidi manj razviti, bipiramide ali prizme pa bolj, potem imajo kristali prizmatsko oziroma bipiramidalno obliko.

Prilep is a small city in the central part of Macedonia. A large dolomite marble quarry is opened 8 km due northwest. The quarry itself lies under a more than 1200 m high hill Sivec, hence its name. A white marble of a very good quality is mined there. The main product is marble blocks obtained by cutting with a diamond wire. This is not the only marble quarry in this region. Another is Čaška on the mountain pass of Pletvar, its 992 m representing a door to Prilep. Marbles with corundum crystals were found at places Belovodice and Beloto, too.

Geological setting

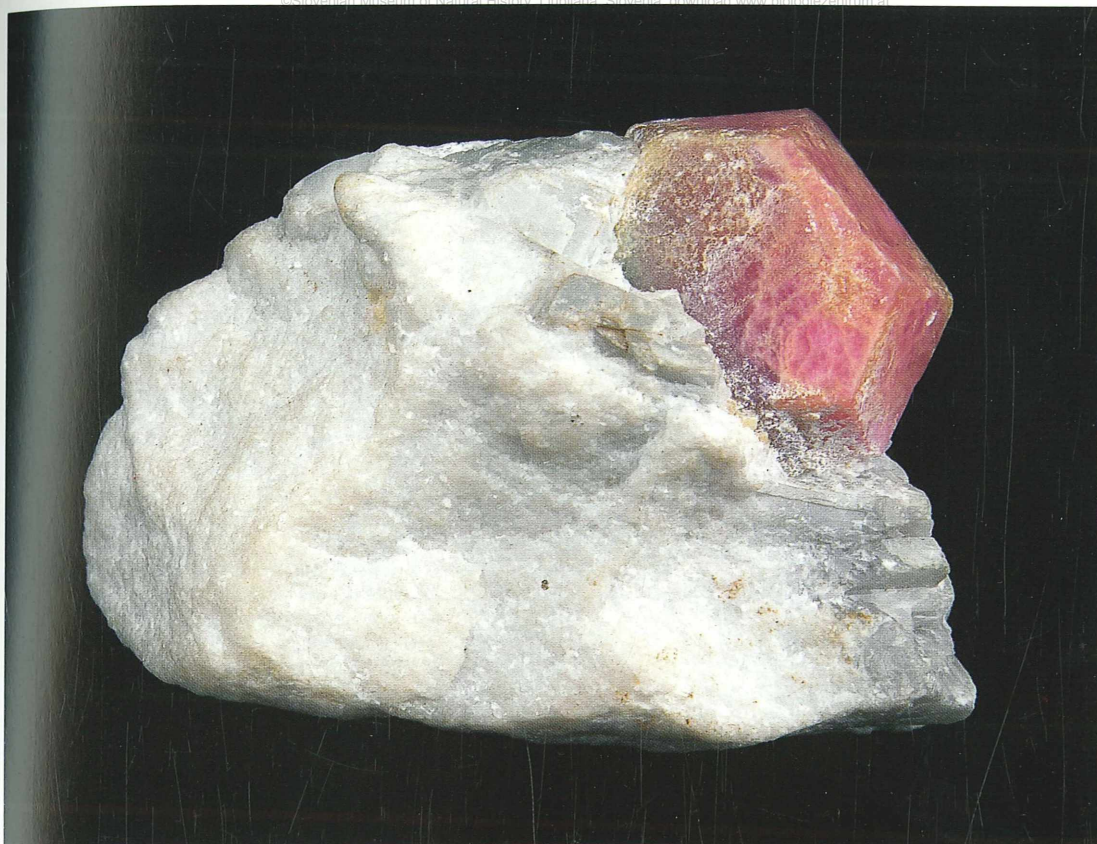
The marbles in the Prilep surroundings were formed through a process of regional metamorphism. They belong to the central part of the Pelagonian massif that consists mainly of highly metamorphic and igneous rocks. Two complexes can be distinguished stratigraphically. The lower is composed of gneisses and clay schists whereas the upper is also of marbles. The marble series is the last in the series of highly metamorphic rocks and sometimes is more than 1500 m thick.

Mineral paragenesis

The minerals present in the Sivec marbles and at the mentioned localities are typical of the formation in the process of the so-called regional metamorphism. During this process the temperature and pressure were elevated and carbonate rocks were recrystallized into marbles. Other substances, for instance several metallic oxides, were molten and recrystallized into idiomorphic crystals. Several chemical reactions took place during metamorphism, whereby new minerals were formed out of those present. In spite of considerable resistance dolomite marble decomposes slowly leaving behind a weathered soil enriched with crystals of the chemically resistant minerals once present in the marble.

Corundum Al_2O_3

The Sivec Quarry is probably more known for its abundant corundum crystals than its marble. They are mostly found in an approximately 1 m thick soil layer covering the marble. They can quite frequently be found *in situ* as well. The largest crystals can reach 15 cm in diameter but most up to 5 cm. Those originating from the weathered soil are coated with a brown limonite layer that can be dissolved away with hydrochloric acid. Those from the marble still have their natural pink colour. Crystals can be blue as well as of several other colours. They fluorescent orange red under UV light. Crystals are relatively well developed, though only exceptionally completely. They are distinguished by their incompletely developed



Slika 15: Kristal korunda prizmatskega habitusa v marmorju. 6 x 6 cm velik kristal iz Sivca je iz zbirke M. Kardelj.

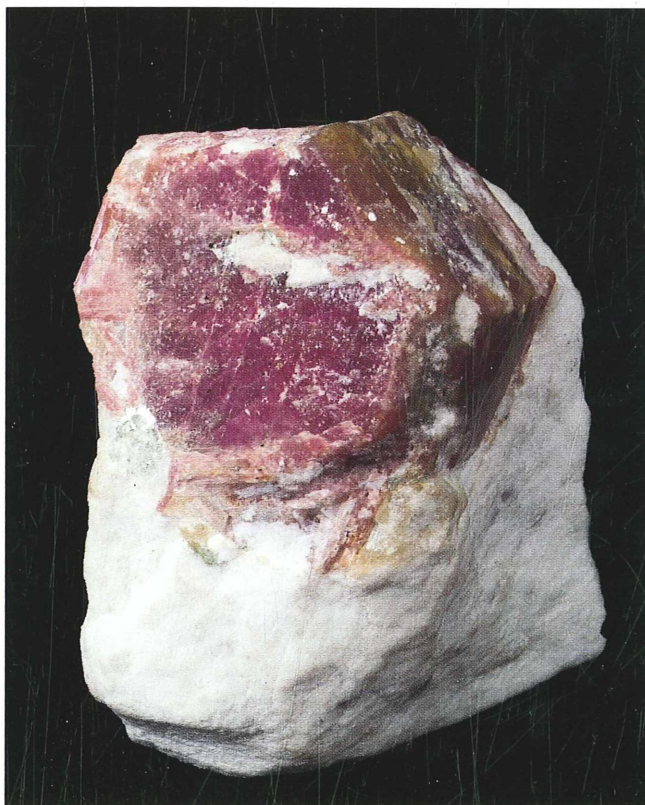
Picture 15: Corundum crystal of prismatic habit in dolomite marble. The 6 by 6 cm large crystal is from the collection M. Kardelj.

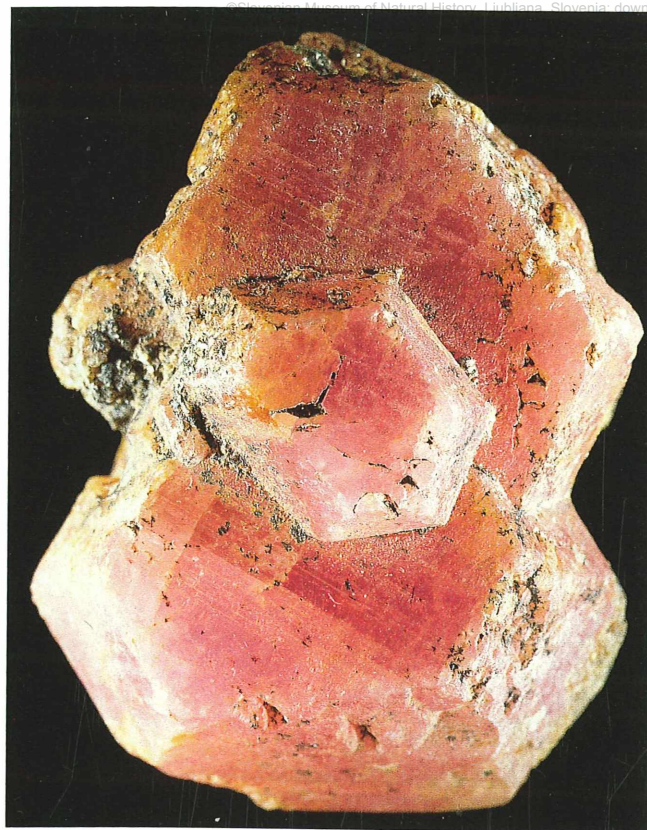
Slika 16: 25 x 25 mm velik kristal korunda v marmorju iz kamnoloma Sivec ima najbolj razvito ploskev pinakoida, zato je ploščat. Zbirka M. Kardelj.

Picture 16: 25 by 25 mm corundum crystal on the marble matrix from Sivec. The most developed is pinacoid, hence the flattened habit of the crystal. Collection M. Kardelj.

parts and holes, which is the outcome of a relatively fast growth rate during their growth. The crystal morphology is quite simple. The pinacoid {0001} is the prevailing crystallographic form, which results in tabular crystals. Crystals are combinations of pinacoid, hexagonal bipyramids and rarely of prisms and rhombohedrons. Crystal morphology is strongly influenced by these crystallographic forms. Crystals are prismatic and bipyramidal if the prisms and bipyramids, respectively, prevail.

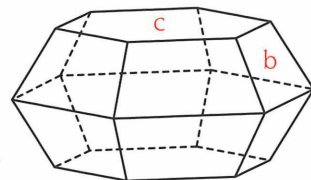
The oriented overgrowth of corundum by diaspore is characteristic of this location and of corundum crystals as such. The crystal faces, therefore, have a special lustre.



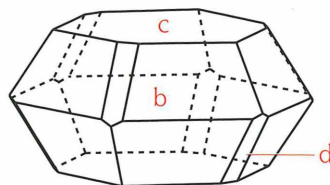


Slika 17: Kristal korunda fotografiran pri dnevni svetlobi (zgoraj) in pod UV svetlobo (spodaj). Pod vplivom UV svetlobe se pojavi značilna fluorescenca, ki je na posnetku lepo vidna kot oranžnordeče žarenje v kristalu. Velikost 5.0 x 2.5 cm. Zbirka M. Kardelj.

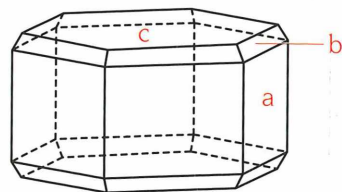
Picture 17: Corundum crystal photographed under daylight (top) and UV light (bottom). The influence of UV light causes a typical fluorescence seen in the picture as an orange - red glowing within the crystal. M. Kardelj collection. Dimensions 5.0 x 2.5 cm.



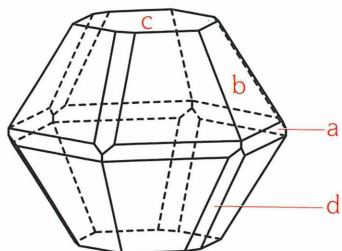
Risba – Drawing 8: Korund - Corundum, Sivec: $b\{22\bar{4}3\}$, $c\{0001\}$.



Risba – Drawing 9: Korund - Corundum, Sivec: $b\{22\bar{4}3\}$, $c\{0001\}$, $d\{10\bar{1}0\}$.



Risba – Drawing 10: Korund - Corundum, Sivec: $a\{10\bar{1}0\}$, $b\{22\bar{4}3\}$, $c\{0001\}$.



Risba – Drawing 11: Korund - Corundum, Sivec: $a\{10\bar{1}0\}$, $b\{22\bar{4}3\}$, $d\{10\bar{1}01\}$.

The corundum from Sivec can be cut into the form of cabochon, which enhances its pink colour. The present diaspore crystals contribute to their special character manifested in a special phenomenon called diasporescence. This effect is strongest when the corundum crystal is cut parallel to its rhombohedron face.

Diaspore $\text{AlO}(\text{OH})$

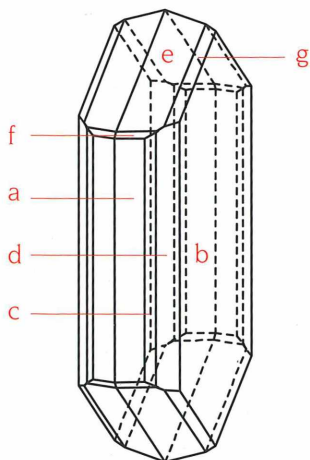
Well-developed crystals are extremely rare in spite of their overall presence on corundum crystals. Just a few macroscopically developed crystals have been stated. The largest gem crystal found measures $4 \times 3 \times 1$ cm and is morphologically the best developed crystal ever found here and possibly also the best one of the species. The crystal is a combination of several crystallographic

Slika 18: Na 7×4 cm velikem kristalu korunda je orientirano priraščen diaspor v luskah bisernatega sijaja. Takšno preraščanje je za kristale korunda iz Sivca posebej značilno. Zbirka M. Kardelj.

Picture 18: Scaly diaspore crystals with pearl lustre overgrow the corundum crystal. The oriented growth of the diaspore on corundum is typical of Sivec. Specimen dimensions: 7×4 cm. M. Kardelj collection.

Slika 19: Naravna barva korundovih kristalov pride najbolj do izraza, če jih zbrusimo in spoliramo. Na fotografiji je obesek z rubinoma, ki ga je oblikovala in izdelala N. Šturm. Oba rubina, od katerih ima večji več kot 17 karatov, je obdelal M. Jeršek.

Picture 19: The true corundum colour is stressed if the crystal is cut and polished. The pendant shown was designed and manufactured by N. Šturm; the crystals cut by M. Jeršek. The large stone has more than 17 carats.



Risba – Drawing 12: Diaspor - Diaspore, Sivec: $a\{110\}$, $b\{010\}$, $c\{120\}$, $d\{130\}$, $e\{111\}$, $f\{221\}$, $g\{121\}$. Modificirano po Barić (1979). Modified after Barić (1979).





Slika 20: Kristal fluorita iz kamnoloma Sivec na podlagi iz belega marmorja. V kristalu je vidna barvna coniranost in razkolnost po (111). Rob kocke meri 1 cm. Primerek je iz zbirke M. Kardelj.

Picture 20: Fluorite cube on a marble matrix. The colour zonation and cleavage along (111) can be clearly seen. Cube has 1 cm on an edge. Collection M. Kardelj.



Slika 21: Na naslednji strani: Kristal diaspora iz kamnoloma Sivec je velik 42 x 32 mm. To je doslej največji in najlepši znani oblikovan kristal, najden v tem nahajališču. Velik del kristala je popolnoma čist in zato draguljarske kvalitete. Zbirka M. Žorž.

Picture 21: Next page: This largest and best developed diaspore crystal found so far at the marble quarry Sivec near Prilep measures 42 x 32mm. A large part of the crystal is completely transparent and suitable for cutting. M. Žorž collection.

forms. Beside that it is also twinned along the (061). All crystal faces are shiny and even. The crystal is completely transparent with a special green hue and for that reason is suitable for cutting. It appears in the poster of this exhibition. Several smaller and less developed crystals have been found.

Fluorite CaF_2

Simple cubic crystals are rare. They can be found within marble cracks that are partially filled with crystallised calcite. Up to 1 cm long crystals on edge are of violet colour with a distinguishable colour zonation. They can also be colourless.

Rutile TiO_2

Black rutile crystals are frequent and easily detectable because of the good contrast on the white marble. The crystals are well developed and mostly (101) twinned. Typical flat knee-twins are thus formed. The largest crystals can reach several centimetres in length. They can occasionally be seen attached to corundum crystals.



Posebnost predstavlja orientirano zraščanje korunda in diaspora, ki je zelo pogosto. Zato imajo kristali korunda na svojih ploskvah značilen sijaj.

Korunde iz Sivca je možno brusiti v obliki kabošona, s čimer pride nežna rožnata barva kristalov najbolj do izraza. Pri tem se zaradi diaspora pokaže tudi njihova posebna narava. Brušeni in polirani korundi iz tega nahajališča imajo edinstveno lastnost, imenovano diasporescenca, ki se odraža v posebnem sijaju zlasti takrat, ko kristal obrusimo vzporedno s ploskvami romboedra.

Diaspor $\text{AlO}(\text{OH})$

Ne glede na njegovo pogosto pojavljanje v obliki orientirano preraščenih kristalov po korundu, so posamezni kristali diaspora zelo redki. Največji, ki so ga doslej našli, meri $4 \times 3 \times 1$ cm. Verjetno gre za najčistejši in morfološko najlepše razvit kristal tega minerala sploh. Razvitih ima precej kristalografskih oblik, poleg tega pa je na manjšem delu zraščen z drugim kristalom kot dvojček po (061), ki je za ta mineral značilen.

Calcite CaCO_3 and dolomite $\text{CaMg}(\text{CO}_3)_2$

Both minerals are, naturally, present in abundance here, however not in the form of idiomorph crystals. Calcite is present in cracks almost always completely filled with it. For that reason it is massive and of grey colour with cleavage along the rhombohedrons. Dolomite is even more rare in the form of small transparent simple rhombohedrons.

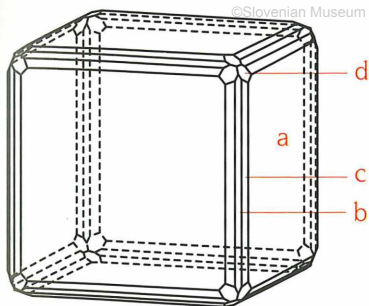
Other minerals

Colourless tourmaline, pyrite, micas, chlorite, illite, kyanite and zoisite have been found.

Slika 22: Dvojček rutila po (101) v marmorju iz Sivca. Velikost dvojčka je 12×11 mm. Zbirka M. Žorž.

Picture 22: Rutile (101) twin on the marble from Sivec. Twin dimensions: 12×11 mm, Collection M. Žorž.





Risba – Drawing 13: Fluorit - Fluorite, Sivec: $a\{100\}$, $b\{110\}$, $c\{001\}$, $d\{113\}$. Modificirano po Barič (1969). Modified after Barič (1969).

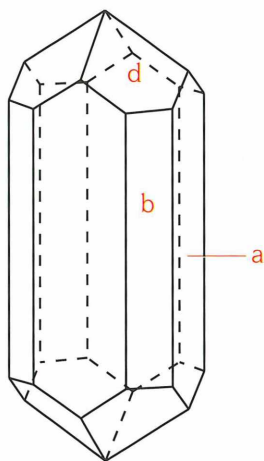
Vse ploskve so izredno gladke. Kristal je popolnoma prozoren, z zelenkastimi odtenki in je primeren za brušenje. Upodobljen je na plakatu te razstave. Našli so še nekaj manjših kristalov, ki pa niso tako lepo razviti.

Fluorit CaF_2

Enostavni kockasti kristali fluorita so redki. Najdemo jih po razpokah, ki so delno zapolnjene s sivkastim kalcitom. Do 1 cm veliki kristali so vijolične barve z izrazito barvno conarnostjo, lahko pa so tudi brezbarvni.

Rutil TiO_2

Črni kristali rutila so kar pogosti in jih zaradi izrazitega kontrasta brez težav opazimo na belem marmorju. Kristali so lepo razviti, s progastimi ploskvami, in večinoma dvojčki po (101). Kristali imajo kovinski sijaj. Največji dosežejo nekaj centimetrov v dolžino. Kristali rutila so večkrat priraščeni na kristalih korunda.



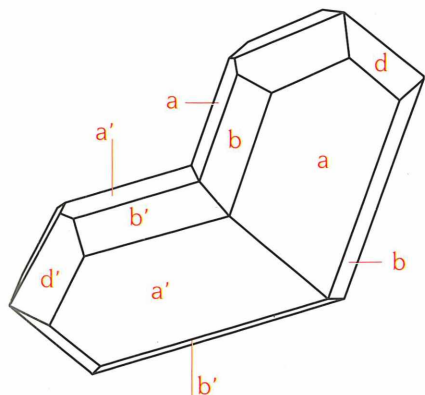
Risba – Drawing 14: Rutil - Rutile, Sivec, Orehovo: $a\{100\}$, $b\{110\}$, $d\{110\}$.

Kalcit CaCO_3 in dolomit $\text{CaMg}(\text{CO}_3)_2$

Obeh mineralov je v tem nahajališču razumljivo v izobilju, vendar ne v obliki dobro razvitih kristalov. Kalcit sive barve se večinoma pojavlja v razpokah, ki jih zapolnjuje, zato je masiven z izrazitimi razkolnimi ploskvami po osnovnem romboedru. Dolomit je precej redek. Najdemo ga v obliki milimetrskih prozornih enostavnih romboedrov.

Ostali minerali

Našli so še brezbarvni različek turmalina, pirit, sljude, klorit, illit, disten in zoisit.



Risba – Drawing 15: Kolenasti dvojček rutila po (101), neklinografska projekcija - Rutile knee twin along (101), nonclinographic projection, Sivec: $a\{100\}$, $b\{110\}$, $d\{110\}$.

Rudnik svinca in cinka Sasa je v severovzhodnem delu Makedonije, v osrednjem delu Osogovskih planin. Rudno ležišče se razteza od višine 1700 metrov navzdol, izpod vrhov Ruen in Carev vrh. Oba sta visoka preko 2000 metrov. Zaradi take lege je podnebje že precej alpsko. V nasprotju z ostalo Makedonijo tukaj nimajo težav z vodo. Najbližje mesto je Makedonska Kamenica.

Geološki podatki

Nahajališče pripada takoimenovani Srbsko-makedonski metalogenetski coni, za katero so značilni svinec, cink, antimon in srebro. Sam rudnik pripada metalogenetski coni Besna kobila - Osogovo - Pehčevo. Rudnik sestavlja več ležišč, od katerih so najpomembnejša: Svinja reka, Golema reka, Kozja reka in Toranica.

Nastanek in formiranje rudišča sta povezana s terciarnimi magmatsko-tektonskimi procesi. Najpogostejše so metamorfne kamnine, skarni in kremenovo-grafitni skrilavci, v katerih so ponekod vloženi cipolini in kot najpomembnejše tudi svinčevo-cinkovo orudjenje. Rudna mineralizacija je potekala v štirih fazah. V kontaktno-pnevmatolitski fazi je prihajalo do magmatskih intruzij v apnenice (cipoline) in zato do tvorbe skarnov (hedenbergit, bustamit, johansenit, granati, diopsid...). V hidrotermalni fazi je prišlo do orudjenja. Nastali so glavni rudni minerali, kot so: sfalerit, pirotin, galenit, pirit in magnetit. V srebronosni fazi se je temperatura ponovno dvignila zaradi reaktivacije magmatskih procesov, pri čemer so nastali nekateri srebrovi minerali (stephanit) in elementarno srebro. V zadnji, supergeni fazi, je prišlo do oksidacije prisotnih mineralov in nastanka tipičnih sekundarnih mineralov, kot so limonit, ceruzit, anglezit, azurit, malahit, hemimorfit in drugi.

V rudniku so vsa obzorja dostopna po dovoznih rampah s težko mehanizacijo za odkop in izvoz rude.

Mineralna parageneza

Že iz omenjenega je razvidno, da je paleta mineralov v tem rudniku precej široka. V bistvu jih lahko razdelimo na minerale skarnske mineralizacije in na rudne minerale. Rudno telo je precej kompaktno in kot tako nima veliko razpok, v katerih bi se pojavljali dobro kristalizirani minerali, vsaj v takih količinah ne, kot smo jih navajeni iz drugih podobnih rudnikov. Kljub temu pa rudarji pri svojem delu naletijo na razpoke z minerali, ki so včasih presenetljivo dobro razviti.

Galenit PbS

V paragenazah s sfaleritom in kremenom se galenit pojavlja v jeklenosivih kristalih kuboektaedrske oblike. Pogosti so sploščeni dvojčki po špinelnem zakonu vzdolž (111). Včasih so na površini močnejše oksidirani, zato so lahko skoraj črni. Najpogostejše so kristali veliki približno centimeter, lahko pa so tudi večji.

Sfalerit ZnS

Največkrat se pojavlja v črnih tetraedrskih kristalih (variante marmatit), ki so polisintetsko zdvojičeni po (111) oziroma špinelnem zakonu. Najbolj presenečajo prozorni medenorjavi

The mine is located in the north-eastern part of Macedonia, in the central part of the Osogovske planine. The ore deposit spreads from 1700 m above sea level below the summits of Ruen and Carev vrh that are both over 2000 m high. As a result of geographical setting the climate is predominantly alpine. Contrary to the other parts of the country this area has no problems with water. The nearest town is Makedonska Kamenica.

Geological setting

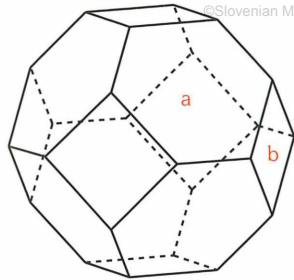
The ore province belongs to the so-called Serbian-Macedonian metallogenetic zone that is characterised by lead, zinc, antimony and silver. The mine itself belongs to the metallogenetic zone of Besna kobila - Osogovo - Pehčevo. The mine is composed of several ore bodies, the most important of which are: Svinja reka, Golema reka, Kozja reka and Toranica.

The origin and formation of the ore deposit is connected to late Tertiary magmatism processes. The most frequent are metamorphic rocks, skarns and quartz-graphite schists in which cipolines are embedded locally, and most important is lead-zinc ore impregnation. Ore mineralization has taken place in four phases. In the contact-pneumatolytic phase the igneous intrusions into limestones (cipolines) occurred which led to skarn formation (hedenbergite, bustamite, johannsenite, garnets, diopside...). Ore mineralisation occurred during the hydrothermal phase. Main ore minerals were formed e.g. sphalerite, pyrrhotite, galena, pyrite and magnetite. The silver-carrying phase distinguished itself by temperature elevation caused by the reactivation of igneous processes. Resulting therefrom was formation of some silver minerals (stephanite) and native silver. In the last (supergene) phase the oxidation of the minerals present took place with the formation of some typical secondary minerals such as cerussite, anglesite, azurite, malachite, hemimorphite and several others.

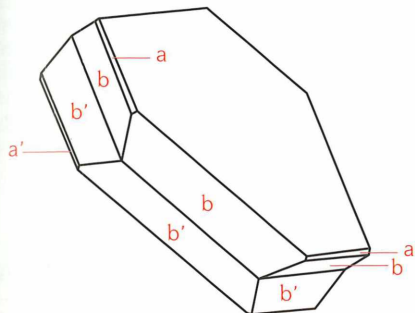
The mine is accessible on all horizons by heavy mechanisation used for the ore removal and transportation.

Mineral paragenesis

As following from the above the array of minerals present in this mine is really wide. Mineral paragenesis can be roughly divided into skarn and ore minerals. The ore body is quite compact and for that reason lacking empty veins or clefts filled with well-crystallised minerals. However from time to time, the miners come across veins with crystallised minerals that can sometimes be surprisingly well formed.



Risba – Drawing 16: Galenit - Galena, Sasa.
 $a\{100\}$, $b\{111\}$.



Risba – Drawing 17: Špinelni dvojček galenita, neklinografska projekcija - Galena spinell twin, nonclinographic projection, Sasa. $a\{100\}$, $b\{111\}$.



Slika 23: Kristali galenita na podlagi deloma limonitiziranega pirita. Rudnik Sasa. Velikost 44 x 40 mm, zbirka I. Derganc.

Picture 23: Galena crystals on partially oxidized pyrite from the Sasa mine. Dimensions 44 x 40 mm, I. Derganc collection.



Slika 24: Prozorni medenorjavi kristali sfalerita na podlagi so obkroženi s kristali galenita na kremenovi podlagi. Taki primerki so bili v Sasi zelo redki. Velikost 85 x 65 mm, zbirka I. Derganc.

Picture 24: Transparent sphaalerite crystals on a quartz matrix surrounded with galena crystals. Specimens of this quality were extremely rare at the Sasa mine. Dimensions: 85 x 65 mm, I. Derganc collection.

kristali, ki dosežejo velikosti nekaj centimetrov. Kristali te kvalitete so tudi v svetu redki. Sfalerit tvori parageneze z ostalimi minerali, ki so na las podobne tistim iz Trepče. Zaradi značilne morfologije kristalov tukajšnjega sfalerita jih od slednjih ločimo brez težav.

Pirit FeS_2

Fazni nastanek rudišča in njegovih mineralov se lepo odraža na kristalih pirita. Ti so seveda značilne zlate barve, vendar morfološko zelo raznoliki. Najti je mogoče kockaste, pentagonskododekaedrske in oktaedrske kristale ter vse vmesne kombinacije. Nekaj milimetrov veliki kristali so pogosti, redkeje pa dosežejo velikosti enega centimetra in več.



Slika 25: Primer parageneze sfalerita, galenita, pirita in kremena iz Sase. Velikost primerka iz zbirke I. Derganc: 7 x 3 cm.

Picture 25: Typical paragenesis from Sasa consisting of sphalerite, galena, pyrite and quartz crystals. Specimen dimensions: 7 x 3 cm, I. Derganc collection.

Pirotin Fe_{1-x}S

Lepo oblikovani kristali pirotina so redki. Značilna je njihova ploščata heksagonalna oblika, pogojena s prevladujočima ploskvama pinakoida $\text{c}\{0001\}$. Pojavljajo se skupaj s sfaleritom in galenitom. Večinoma ne presežejo petih milimetrov v premeru.

Kremen SiO_2

Nekaj centimetrov veliki prizmatski kristali so skoraj na vsakem primerku in lepo dopolnjujejo paragenezo. Kristali so prozorni vsaj na konicah, če ne v celoti. Pripadajo vrsti bambauer, značilni za rudišča. Delovanje tektonike se odraža v obliki deformiranih in nitastih kristalov, kar je v rudiščih redkejši pojav.

Stephanit Ag_5SbS_4

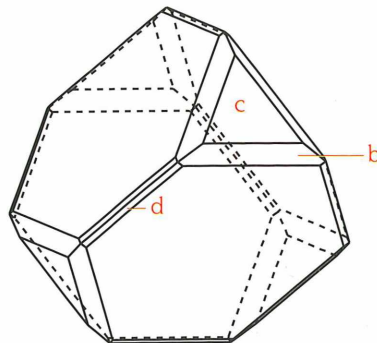
Od prisotnih srebrovih mineralov je stephanit najpogostejši, poleg tega pa se pojavlja v lepo oblikovanih kristalih, ki dosežejo nekaj centimetrov v dolžino. Kristali imajo močan kovinski sijaj. Kristali stephanita so bili po svojem nastanku izpostavljeni razmeram, v katerih je prišlo do njihove pretvorbe v samorodno srebro. To je mogoče opaziti po korodiranosti kristalov in izražanju samorodnega srebra iz njih.

Galena PbS

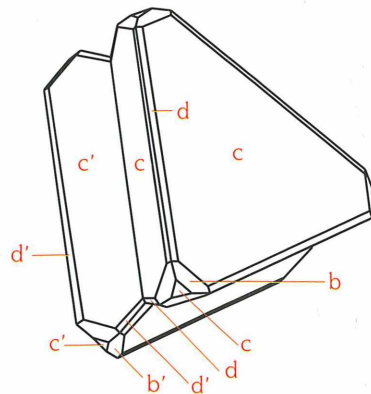
Galena is commonly associated with sphalerite and quartz. It appears in the form of steel-grey cubo-octahedral crystals. The flat spinell-twinned crystals are common. Their surface can sometimes be intensively oxidized thus dull and dark. Crystals are usually up to 1 cm on an edge, though larger specimens can also be found.

Sphalerite ZnS

Most common is its black variety (marmatite) in the tetrahedral crystals that are polysynthetically twinned along (111), i.e. according to spinell twinning law. The most surprising are transparent honey-brown crystals reaching up to several centimetres in diameter. Crystals of this quality represent a rarity in a world-wide sense. Sphalerite forms the paragenesis with other minerals that equal those from Trepča. However, the typical Sasa sphalerite crystal morphology distinguishes them unambiguously from the Trepča material.

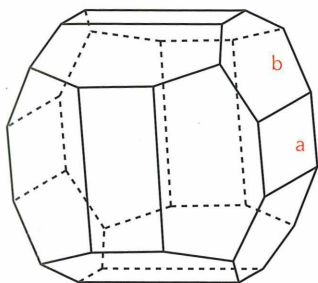


Risba – Drawing 18: Sfalerit - Sphalerite, Sasa. $b\{110\}$, $c\{111\}$, $d\{210\}$.



Risba – Drawing 19: Špinelni dvojček sfalerita po (111), neklinografska projekcija - Sphalerite spinell twin along (111), nonclinographic projection, Sasa. $b\{110\}$, $c\{111\}$, $d\{210\}$.

The four-phased formation of the ore body reflects itself in the morphology of pyrite crystals. They are of golden colour. Cubes, pentagonedodecahedrons and octahedrons, as well as all intermediate combinations thereof can be found throughout the mine. Most common among them are several millimetre crystals. Those with more than one centimetre on an edge are rare.



Risba – Drawing 20: Pirit - Pyrite, Sasa. **a**{100}, **b**{210}.

Samorodno srebro najdemo v obliki žic, ki so do nekaj milimetrov debele in več centimetrov dolge. Njegova barva je odvisna od stopnje pokritosti s sulfidi in variira od značilne srebrenke preko rumenkaste do črne. Najbolj zanimivi so primerki, kjer je srebro na podlagi. Redkejši so tisti, kjer izrašča iz kristalov stephanita.

Kutnohorit $\text{Ca}(\text{Mn}^{2+}, \text{Mg}, \text{Fe}^{2+})(\text{CO}_3)_2$

Zanimivost v tem nahajališču predstavljajo veliki in lepo razviti kristali kutnohorita, ki imajo povečano vsebnost mangana. Večinoma ga zato poimenujejo manganokalcit. Kristali so snežno bele barve, včasih z rožnatim odtenkom in nastopajo v snopastih divergentnih agregatih, ki pa navzven še vedno ohranjajo trigonalno simetrijo. Včasih preraščajo kristale prosojnega kalcita, kar priča o tem, da so rastle kasneje. Dolgo časa so menili, da gre pri teh kristalih za mineral otavit, ki je CdCO_3 in kot tak zelo redek. Kristale so v Sofiji analizirali z rentgensko praškovno analizo, pri čemer je bilo ocenjeno, da je dobljeni spekter najbolj podoben spektru tega minerala. Kasneje smo mineral analizirali z atomsko spektroskopijo (ICP) in ugotovili, da ne vsebuje niti sledu kadmija. Kasnejši analizi z EMA in rentgenom (glej tudi "Zgodbo o otavitu") sta to samo še potrdili.



Slika 26: Na limonitni podlagi so priraščeni beli kristali kalcita v obliki tristranih prizm. Iz njih orientirano izraščajo igličasti kristali kutnohorita. Taki primerki prihajajo iz rudnika Sasa v vzhodni Makedoniji. Primerek velikosti 20 x 15 cm izhaja iz zbirke I. Derganc.

Picture 26: White triangular calcite prisms are attached to a gossan matrix. Kutnohorite crystals grow from them. These specimens come from the Sasa mine in east Macedonia. Specimen dimensions 20 x 15 cm, I. Derganc collection.



Slika 27: Iz 34 mm dolgega kristala stephanita izraščajo žičnati kristali srebra. Redka kombinacija obeh mineralov iz rudnika Sasa je posledica kemijske pretvorbe stephanita v srebro. Različni barvni odtenki so posledica oksidacije srebra. Primerek slikan kot stereopar. Zbirka M. Žorž.

Picture 27: Silver wire crystals grow out of a corroded stephanite crystal. The extremely rare combination of these two minerals from the Sasa mine is an outcome of the chemical transformation from stephanite to silver. Different colour tones result from silver oxidation. Specimen photographed as stereopair. M. Žorž specimen.

Slika 28: Na naslednji strani: Srebro na stephanitu – detalj primerka s slike 27.
Picture 28: Next page: Silver on stephanite – detail of specimen from the picture 27.

Pyrrhotite Fe_{1-x}S

Well developed crystals are rare. Typical is their flat hexagonal form, conditioned by wide pinacoid faces. It appears together with galena and sphalerite. Crystals do not exceed 5 mm in diameter.

Quartz SiO_2

Some centimetres long prismatic crystals are present on almost every specimen. They round up nicely the mineral paragenesis. They belong to the Bambauer-type typical of the ore deposits. Tectonic influence left some deformed and faden crystals, otherwise uncommon for these deposits.

Zgodba o otavitu The Otavite Story

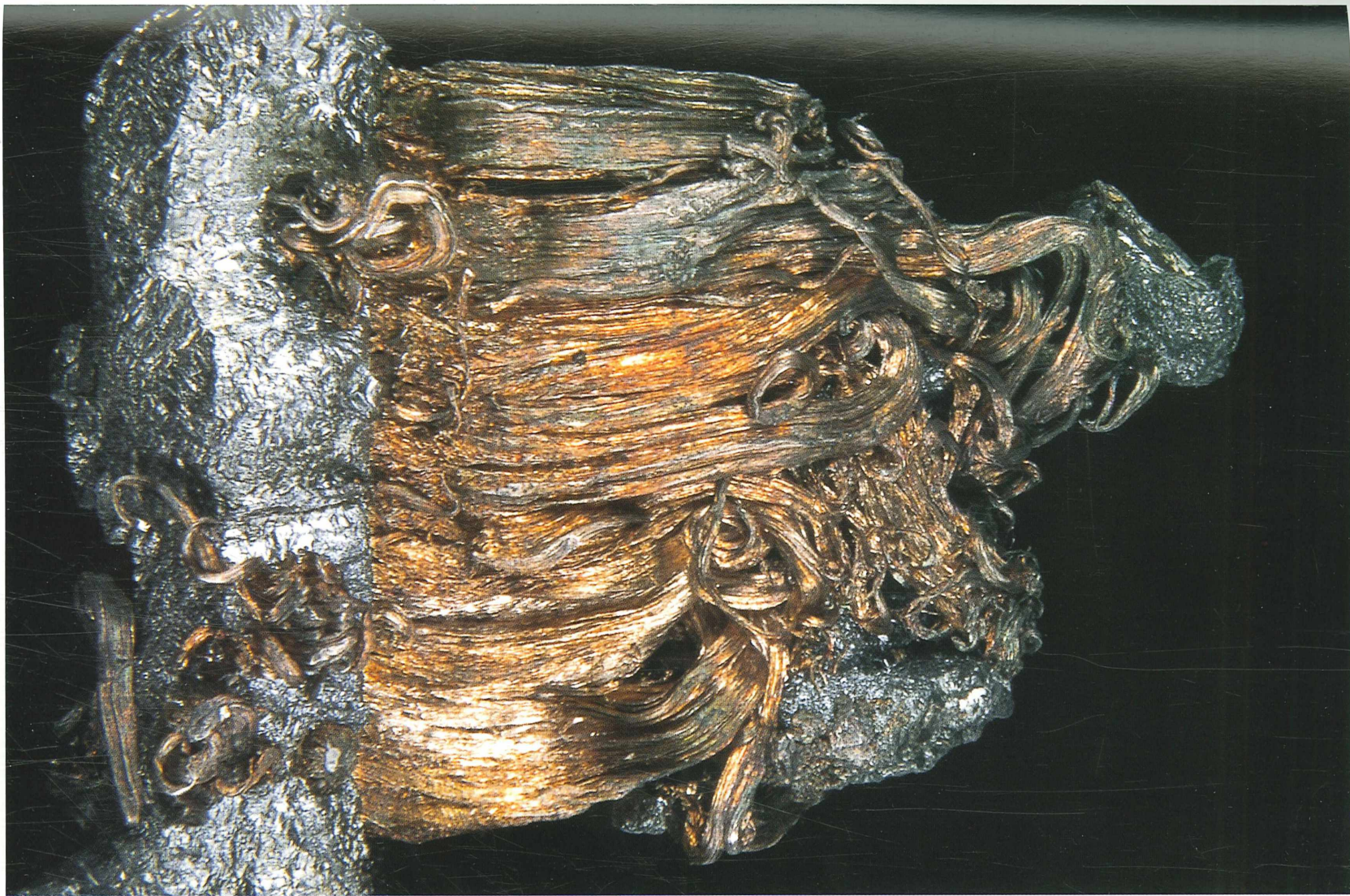
Tadej Dolenec¹ & Todor Serafimovski²

¹Naravoslovnotehniška fakulteta Univerze v Ljubljani, Oddelek za geologijo, Aškerčeva 12, 1000 Ljubljana, Slovenija

²Rudarsko – geološki fakultet, Štip, Makedonija

Some years ago we had a chance to see otavite from the Sasa mine in Macedonia. This event was followed by some investigations which raised doubt as to the genuineness of the said mineral. New specimens were collected and analysed. The specimens originally determined as otavite proved to represent kutnahorite and manganocalcite with different Ca/Mn ratios, respectively. The minerals as mentioned appear in radially spectered aggregates and flat crystals in open cracks, together with silex and johannsenite. The veins run through cipoline marbles in the close vicinity of ore bodies or in the unsubstituted parts of ore bodies. Isotopic investigations showed that these minerals had been formed from low temperature hydrothermal solutions of magmatic origin. The mineral paragenesis includes the minerals oligonite and rodohrosite.

Pred nekaj leti smo dobili vzorec minerala iz makedonskega rudnika Sasa. Po mnenju najditeljev naj bi bil to mineral otavit. Že rezultati prvih raziskav niso potrdili njihovih domnev. Zato smo ponovno izbrali vzorce in jih analizirali. Rezultati so bili spet negativni. Vzorci, ki so bili prvotno določeni kot otavit, so dejansko kutnahorit oziroma manganokalcit z različnim atomskim razmerjem Ca/Mn. Mineral nastopa v radialno žarkovitih agregatih in ploščatih kristalih v odprtih razpokah skupaj s kremenom in johansenitom. Žile sekajo cipolinske marmore v neposredni bližini rudnih teles ali v prvotnih delih rudnih teles, kjer ni prišlo do nadomeščanja. Izotopske raziskave so pokazale, da se je omenjeni mineral izločal iz nizkotemperaturnih hidrotermalnih raztopin magmatskega izvora. Mineralno paragenezo dopolnjujeta minerala oligonit in rodohrozit.



Mirjan Žorž, Miha Jeršek & Gute Mladenovski: Nekatera nahajališča mineralov v Makedoniji in njihova parageneza / Some Mineral Locations in Macedonia and Their Paragenesis



Slika 29: Kroglasto oblikovani kristali kalcita so prekriti s plastjo kristalov kutnohorita. Primerek iz rudnika Sasa meri 7 x 3 cm in je iz zbirke I. Derganc.

Picture 29: Spherically shaped calcite crystals are covered with a kutnohorite crystal layer. The Sasa mine specimen measures 7 x 3 cm, I. Derganc collection.

Bustamit $(\text{Ca}, \text{Mn}^{2+})_3(\text{SiO}_3)_3$ in johannsenit $\text{CaMn}^{2+}(\text{SiO}_3)_2$

To sta minerala, značilna za skarnski nastanek na stiku magne z apnencem. Navadno ni dovolj prostora, da bi se razvili idiomorfni kristali, zato ju najdemo v obliki agregatov, sestavljenih iz medsebojno preraščenih rozetastih kristalov. Kristalni agregati so rjave barve.

Drugi minerali

V tem rudišču so določili 110 različnih mineralov, zato vseh ne bi navajali. Večinoma niso v lepo oblikovanih kristalih. Tisti, ki smo jih opisali sestavljajo paragenezo pri glavnini najdenih primerkov.

Stephanite Ag_3SbS_4

This is the most frequent mineral of all present silver minerals. It appears also in well formed crystals reaching several centimetres in length. Crystals have an intensive metallic lustre. Stephanite crystals were subject to conditions that lead to their transformation into native silver. This effect can be noted in the form of corroded stephanite crystals as well as in the form of silver wires growing out of such stephanite crystals.

Silver Ag

Native silver is present in the form of wires that can be some millimetres thick and several centimetres long. It can be found in matted aggregates in vugs as well as in loose wires on the matrix. Its colour depends on the thickness of the sulphide layer covering the silver crystals. It varies from a silvery over to a golden hue. The most interesting among them are matrix specimens with silver grooving out of stephanite crystals.

Kutnohorite $\text{Ca}(\text{Mn}^{2+}, \text{Mg}, \text{Fe}^{2+})(\text{CO}_3)_2$

Large and well formed kutnohorite crystals represent something of a curiosity. Here they are known mostly under the name of manganocalcite. The crystals are of snow-white colour, sometimes with a pink hue, appearing in the form of divergent sheaf-like aggregates that still maintain their trigonal symmetry. They sometimes overgrow the calcite crystals, which proves their late formation. It was long thought that the cadmium member of carbonate was present. The material was analysed in Sofia by X-ray dust analysis. The spectrum obtained was identified as otavite, due to the fact that it was presumably most similar to its X-ray spectrum. We conducted another analysis with atomic spectroscopy technique (ICP) in Ljubljana and found that the material did not contain any detectable trace of cadmium. A later X-ray analyses (see "The Otavite Story") confirmed it.

Bustamite $(\text{Ca}, \text{Mn}^{2+})_3(\text{SiO}_3)_3$ and johannsenite $\text{CaMn}^{2+}(\text{SiO}_3)_2$

These are two typical skarn minerals formed through the contact of magma and limestone. There are no veins where they could crystallise in idiomorph crystals. This is why they are always found in form of radial intergrown brown-coloured aggregates.

Other minerals

More than 110 different minerals have been identified on his location. It is not our intention to name them all as most are not in form of nice crystals. Those that were described form in most cases, the paragenesis on the specimens found.

This ore deposit is situated in the eastern part of the Kratovo-Zletovo volcanic region. This part of Macedonia slightly resembles the well-known part of Arizona so often shown in Westerns. Story has it that the name of the town Kratovo derives exactly from its position on the bottom of an extinguished volcanic crater. Dobrevo is several kilometres equidistant from Kratovo, Probištip and Zletovo.

Geological setting

The mine surroundings are composed of volcanic rocks i.e. andesites, dacites, tuffs and similar. The ore body is connected to the dacitic ignimbrites that are most frequent here. They are strongly tectonically and hydrothermally transformed. Enclaves of gneisses and schists can be found within their composition.

The ore body is connected with tectonic structures that follow several directions. The ore bodies have a vein form followed with the impregnation of several other ore minerals.

Mineral paragenesis

This can be divided into several varieties. Let us mention metasomatic, high- and medium-temperature sulphidic, medium- to low-temperature sulphidic, low-temperature oxide-carbonatic and supergene mineral paragenesis. The main ore minerals are sphalerite and galena.

Galena PbS

This mine is known for its large quantities of the crystallised galena. Crystals can have a dimension of more than 10 centimetres on the edges. They are mostly in the form of cubes and cubooctahedrons and are of a typical steel-grey colour. Some large veins were found completely covered with galena crystals. They were offered for sale several years ago at the Tržič mineral exhibition.

Sphalerite ZnS

Some centimetres large crystals are of black colour, but brown translucent crystals appear sporadically as well. They can be differentiated from those coming from Sasa by their slightly more complex crystal morphology. They are also spinell-twinning, which gives them step-wise complex morphology.

Barite BaSO₄

This mineral was observed in this mine in several differently shaped crystals. Their dimension can exceed 10 cm on their edges. The most known are the so-called open-book aggregates. The crystals are associated in forms that in fact resemble an open book. The most beautiful and sought-after crystals were orange white-edged crystals.

Rudnik Dobrevo leži v vzhodnem delu kratovsko-zletovskega vulkanskega področja. Ta del Makedonije malo spominja na znano pokrajino v Arizoni, ki jo dostikrat prikazujejo v vesternih. Mesto Kratovo naj bi po nekaterih trditvah dobilo tako ime zato, ker leži v kraterju ugaslega ognjenika. Dobrevo je nekaj kilometrov oddaljeno od Kratova, Probištipa in Zletova.

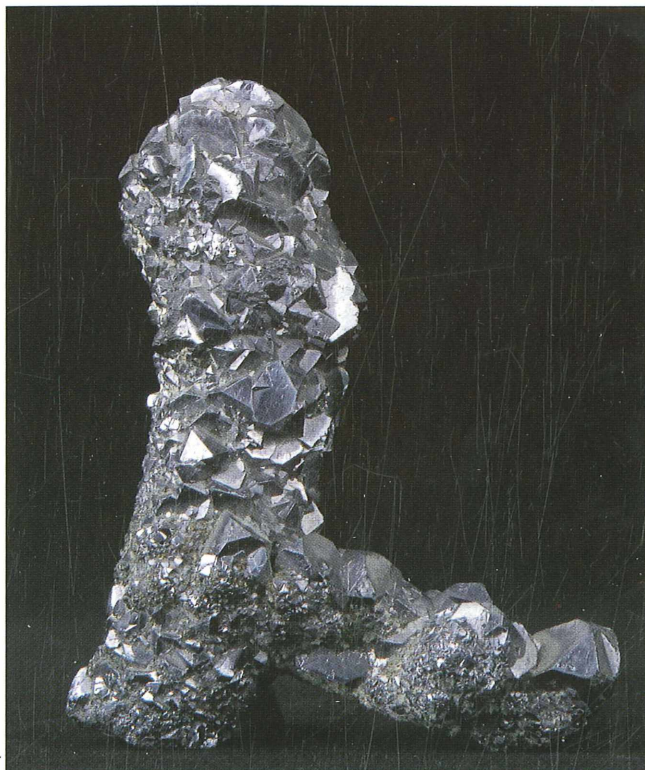
Geološki podatki

V okolici rudnika so vulkanske kamnine andezit, dacit, tufi in druge. Orudjenje samo je vezano na dacitske ignimbrite, ki so tu najpogostejši. So močno tektonsko in hidrotermalno preoblikovani. V njih najdemo tudi enklave gnajsov in skrilavcev.

Orudjenje je povezano s tektonskimi strukturami, ki potekajo v določenih smereh. Rudna telesa imajo obliko žil, ki jih spremlja impregnacija rudnih mineralov.

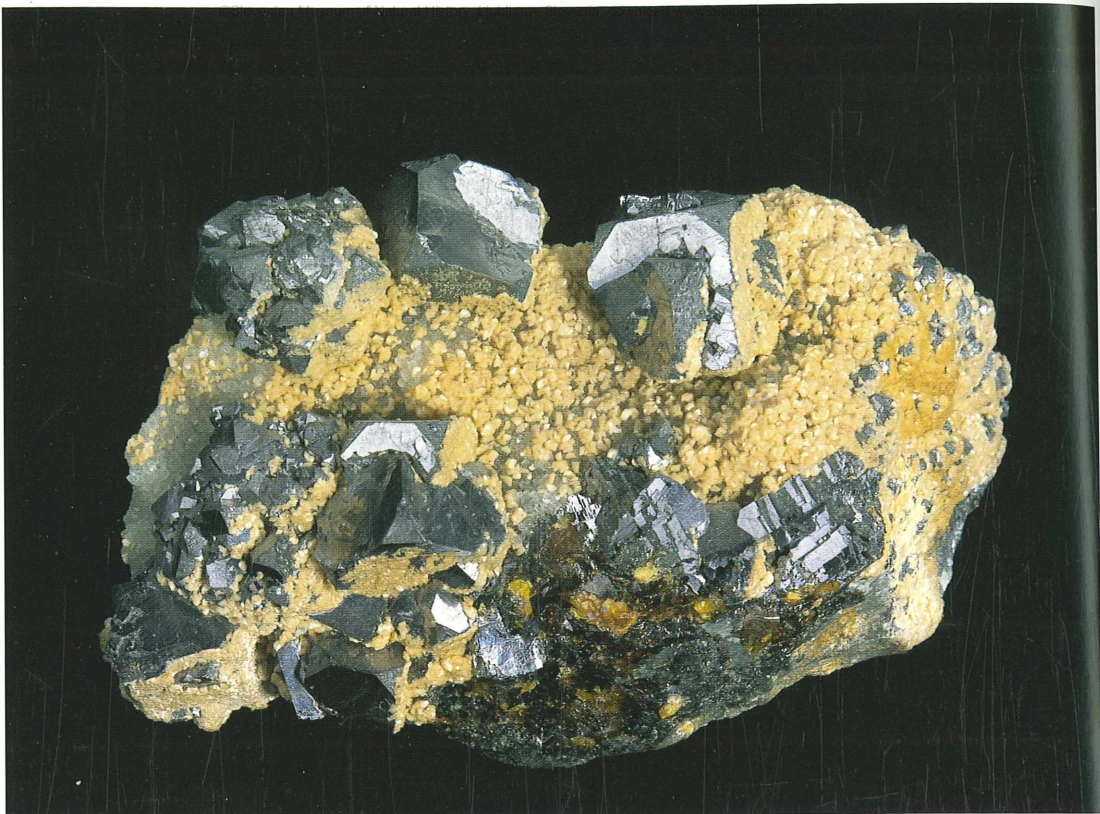
Mineralna parageneza

Mineralizacijo delimo v nekaj vrst paragenez. Omenimo naj kontaktno metasomatsko, visoko in srednjetermaturno sulfidno, srednje- do nizkotemperaturno sulfidno, nizkotemperaturno oksidno-karbonatno in supergeno paragenezo. Glavna rudna minerala sta sfalerit in galenit.



Slika 30: Primerek zanimive oblike je sestavljen iz samih kristalov galenita. Najden je bil v rudniku Dobrevo. Zbirka I. Derganc; velikost 7 x 6 cm.

Picture 30: Galena cubooctahedrons form the interesting shape of this specimen. It was found in the Dobrevo mine. Dimensions: 7 x 6 cm, I. Derganc collection.



Slika 31: Kubooktaedrski kristali galenita so obraščeni z drobnimi lečastimi kristali siderita. Podlago sestavlja tudi sfalerit. Take kombinacije so značilne za rudnik Dobrevo. Zbirka I. Derganc, velikost 12 x 7 cm.

Picture 31: Galena cubo-octahedrons are surrounded by small lens-shaped siderite crystals. Sphalerite is a part of the matrix. Such combinations are typical for the Dobrevo mine. Specimen 12 x 7 cm from I. Derganc collection.

Slika 32: Na naslednji strani: Najlepše oblikovani kristali barita iz rudnika Dobrevo so bili taki, kot ta primerek na sliki. Kristal v obliki knjižnega skupka je priraščen na baritni podlagi. Velikost 14 x 8 cm, zbirka NTF.

Picture 32: Next page: The best barite crystals from the Dobrevo mine were as this one. The open-book-shaped crystal aggregate is attached to a barite matrix. NTF collection, dimensions: 14 x 8 cm.

Galenit PbS

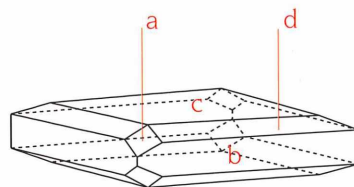
To nahajališče je znano po velikih količinah kristaliziranega galenita. Kristali imajo lahko decimetrske dimenzije. Večinoma so v obliki kock in kubooktaedrov jeklenosive barve. Pogosto so našli velike razpoke, katerih stene so bile v celoti prekrите s kristali galenita. Pred leti so jih v velikih količinah ponujali v Tržiču. Špnelni dvojčki po {111} so pogosti.

Sfalerit ZnS

Nekaj centimetrov veliki kristali so večinoma črne barve. Pojavljajo se tudi rjavkasti prosojni kristali. Od tistih v Sasi se malenkostno razlikujejo, ker so ploskovno nekoliko bogatejši. Kristali sfalerita so večinoma polisintetsko dvojčičeni po špnelnem zakonu, kar jim daje značilno stopničasto in kompleksno morfologijo.

Barit BaSO₄

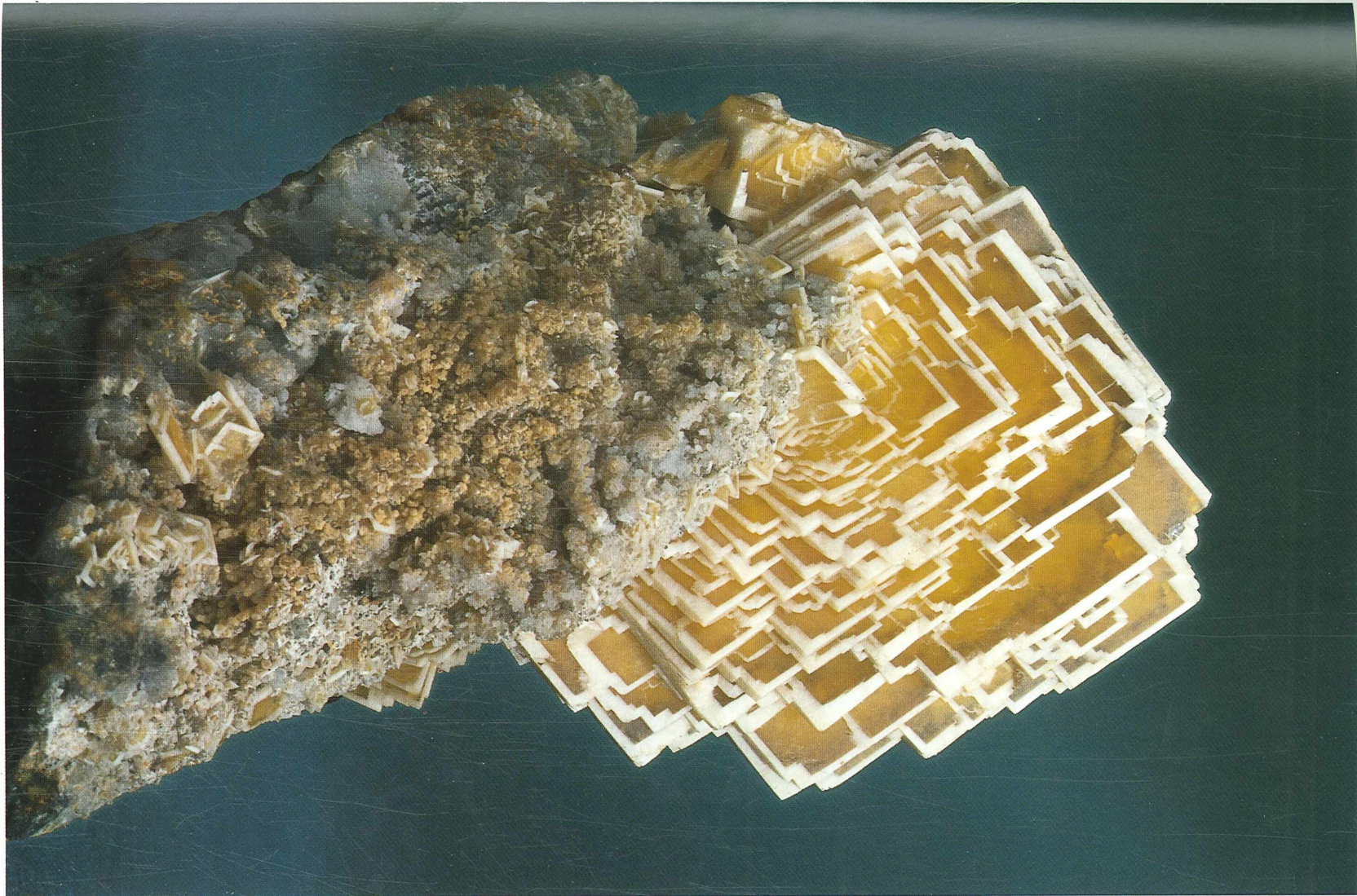
Barit se v tem rudniku pojavlja v različno oblikovanih kristalih, od katerih pa so najbolj znani t.i. knjižni skupki. Pri teh so kristali združeni v agregate, ki spominjajo na



Risba – Drawing 21: Barit - Barite, Dobrevo. $a\{101\}$, $b\{210\}$, $c\{001\}$, $d\{214\}$.

Quartz SiO₂

It is abundant in the paragenesis in the form of prismatic crystals of the Bambauer-type. It appears frequently in short prismatic habit, and especially as the coating on other sulphide minerals. Its colour variety amethyst is found rarely. The colour is tender with some intensive exceptions on the crystal terminations.





Slika 33: Gruča lepo oblikovanih kristalov kremena - ametista na karbonatni podlagi. Primerek iz rudnika Dobrevo meri 15 x 10 cm in izhaja iz zbirke I. Derganc.

Picture 33: A nicely formed amethyst crystal group grows from a carbonate matrix. The specimen from the Dobrevo mine measures 15 x 10 cm. I. Derganc collection.



Slika 34: Prizmatški kristali kremena na sfaleritni podlagi. Lepo oblikovan primerek iz rudnika Dobrevo je iz zbirke I. Derganc. Velikost: 8 x 8 cm.

Picture 34: Prismatic quartz crystals on a sphalerite matrix. This extraordinary specimen comes from the Dobrevo mine. Dimensions: 8 x 8 cm, I. Derganc collection.

Siderite - FeCO_3 is the most common in the form of lens-shaped rhombohedrons. Calcite - CaCO_3 can be found in several centimetre long sheaf-like aggregates resembling closely the kutnahorite from Sasa. However, it is more common in the form of flat, white-coloured rhombohedrons.

Other minerals

Golden-coloured chalcopryrite, magnetite, jacobsonite, hematite and hausmannite are present as well.

odprto knjigo. Še posebej lepi so bili tisti, ki so imeli oranžno jedro in belo obarvane obrobne dele. Kristali barita, veliki tja do 10 cm, niso bili posebej redki.

Kremen SiO_2

Kremena je v paragenezi obilo v prizmatskih kristalih tipa bambauer. Dostikrat se pojavlja tudi v kratkoprizmatskih kristalih, še posebej kot oprh po kristaliziranih sulfidnih mineralih. Lepi so rahlo obarvani ametisti. Nekoliko izraziteje vijolično obarvane so le terminacije njihovih kristalov.

Karbonati

Od vseh je najbolj pogost siderit - FeCO_3 , ki nastopa v položnih romboedrskih kristalih lečaste oblike. Kalcit - CaCO_3 se lahko pojavlja v zanimivih, več centimetrov velikih snopastih agregatih, ki zelo spominjajo na kutnahorit iz Sase. Pogostejši je v obliki diskastih romboedrskih kristalov bele barve.

Drugi minerali

Omenimo še halkopirit v kristalih zlate barve, magnetit, jacobsonit, hematit in hausmannit.

Slika 35: Snopasto ukrivljeni kristali kalcita na podlagi predstavljajo svojevrstno posebnost v rudniku Dobrovo. Večji kristal meri 65 mm v dolžino. Zbirka M. Žorž.

Picture 35: Sheaf-curved calcite crystals on matrix represent a unique feature at the Dobrovo mine. The larger crystal measures 65 mm in length. M. Žorž collection.



Slika 36: Enostavni sedlasto ukrivljeni romboedrski kristali siderita. Primerek iz Dobrova je velik 10 x 8 cm in izhaja iz zbirke NTF.

Picture 36: Simple saddle-shaped siderite rhombohedrons from the Dobrovo mine. The specimen is 10 by 8 cm large and comes from NTF collection.



Približno 50 km dolg gorski masiv se razteza južno od Prilepa in vzhodno od Bitole. Najvišji vrhovi dosega jo nadmorsko višino preko 1400 m. Zanimiva je visoka planota Mariovo, ki leži med Selečko in Dren planino ter Kozjakom. Pokrajina je v glavnem še neokrnjena. Mariovo je znano po zelo lepim narodnih nošah. Zaradi svoje lege in višine ima planota ostro podnebje s suhimi in vročimi poletji ter mrzlimi zimami. Voda je tu redka dobrina, dasiravno v bližini teče Crna reka.

Geološki podatki

Selečka planina predstavlja geološko zelo zanimiv del makedonskega ozemlja. Na njej srečamo predvsem metamorfne kamnine, ki so predstavljene z gnajsi in različnimi skrilavci. Od magmatskih kamnin najdemo granite. V omenjenih kamninah je veliko pegmatitnih teles in žil. Posledica tega so zanimive mineralizacije oziroma mineralne parageneze.

Ozemlje so v preteklih letih precej dobro raziskali zaradi iskanja mineralnih surovin. Odkrili so nahajališča sljude, kremena in diatomejske zemlje. Raziskovali so tudi možnosti izkoriščanja distena in glinencev.

Težko je v nekaj vrsticah opisati celotno območje Selečke planine, zato se bomo omejili le na nekaj nahajališč, v katerih lahko najdemo lepo kristalizirane minerale.

Planina = mountain means "high mountain" in all south-Slavic languages. In this case Selečka planina is a 50 km long mountain massif stretching south from Prilep and east from Bitola. The highest summits reach 1400 m above sea level. Very interesting is the high plateau called Mariovo, hidden behind the summits of Selečka planina, Dren planina and Kozjek. Nature is still almost intact here. The Mariovo region is known for its beautiful national costumes. Due to its position and height it has a very sharp climate characterised by dry and hot summers and cold winters. Water is scarce here in spite of the Crna reka river.

Geological setting

Selečka planina represents, from a geological point of view, a very interesting part of the Macedonian territory. One comes across metamorphic rocks represented by gneisses and different schists. Igneous rocks are present in the form of granites. Many pegmatitic bodies and dikes are present in the mentioned rocks. The outcome is seen as several interesting mineralizations and mineral paragenesis.

Selečka planina was thoroughly researched in the past because of the interest in mineral resources. Deposits of quartz, albite, kyanite, mica and diatomite were found and evaluated.

It is difficult to describe the complete Selečka planina region in a few short words. We will therefore limit ourselves to some most interesting locations distinguished by their well-crystallised minerals.



Slika 37: Almandin z lepo razvitimi ploskvami rombskega dodekaedra iz okolice vasi Bonče na Selečki planini. Velikost 9 mm v premeru. Zbirka M. Žorž.

Picture 37: Almandine from the vicinity of the village of Bonče on Selečka planina has well developed dodecahedron faces. Crystal has 9 mm in diameter. M. Žorž collection.

On the southern margins of Mariovo, on the saddle of this distinctive mountain, lies a mine once active in albite mining. Quartz veins appeared in the albite with prismatic quartz crystals over 10 cm long.

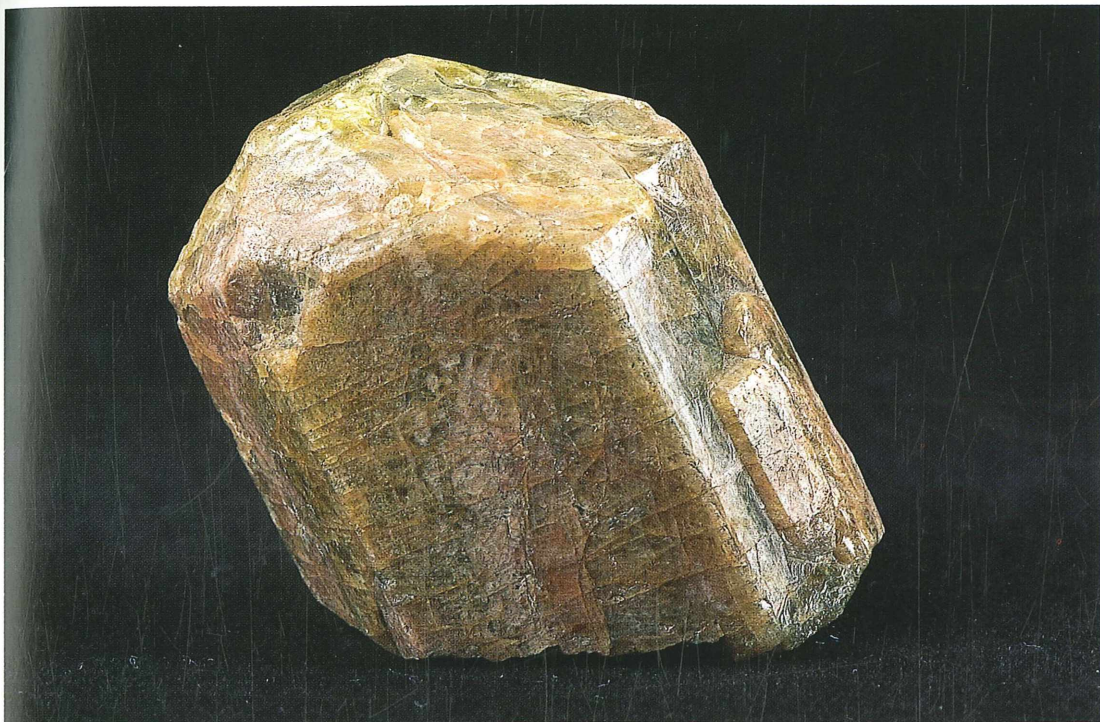
Apatite $\text{Ca}_5(\text{PO}_4)_3(\text{F,OH,Cl})$

Apatite was found together with quartz in the veins in large and morphologically well-developed crystals. The largest found were 12 cm in diameter, but most did not exceed 5 cm. The most developed is pinacoid $\text{c}\{0001\}$ dictating the flat habit of the crystals. The translucent crystals are white and exceptionally violet in colour.

Na južnem obrobju Mariova je na sedlu značilne vzpetine rudnik, v katerem so včasih kopali kakovosten albit. Poleg albita so se pojavljale žile kremena, v njih so naleteli na prizmatske kristale kremena velike do 10 cm.

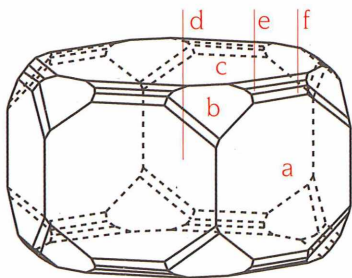
Apatit $\text{Ca}_5(\text{PO}_4)_3(\text{F,OH,Cl})$

Skupaj s kristali kremena se je v teh žilah pojavljal tudi apatit v zelo velikih in lepo razvitih kristalih. Največji najdeni je imel 12 cm v premeru, večinoma pa niso presegali 5 cm. Najbolj razvite so ploskve pinakoida $\text{c}\{0001\}$, zato so kristali iz tega nahajališča ploščatega habitusa. Kristali so bele, nekateri pa lepe vijolične barve.



Slika 38: Apatit na fotografiji ima izrazite ploskve prizme, kar je v tem nahajališču redko. Kristal je visok 5 cm. Zbirka: Prirodonaučen muzej na Makedoniji.

Picture 38: Apatite on picture has well formed prisms. This is quite rare from this location. The crystal is 5 cm high. Prirodonaučen muzej na Makedoniji collection.



Risba – Drawing 22: Apatit - Apatite, Beluče. Modificirano po Barić (1976). Modified after Barić (1974). $\mathbf{a}\{10\bar{1}0\}$, $\mathbf{b}\{11\bar{2}0\}$, $\mathbf{c}\{0001\}$, $\mathbf{d}\{21\bar{3}1\}$, $\mathbf{e}\{10\bar{1}0\}$, $\mathbf{f}\{20\bar{2}1\}$.

To je značilna makedonska vasica, ki leži na zahodnih obronkih Selečke planine. Njeno okolico sestavljajo visokometamorfne kamnine sljudnatih skrilavcev. Značilno zanje je, da so močno prekrstljene. V njih se pojavljajo idiomorfno razviti kristali stavrolita, cianita in granata.

Cianit Al_2SiO_5

Ob prepelevanju sljudnih skrilavcev prihajajo na površje sivkasti kristali cianita (distena po Grafenauerju *et al.*, 1972), v katerih so vključeni še kristali granata. Kristali so do 15 cm dolgi. Redkeje najdemo kristale značilno ciansko modre barve, ki pa so vedno vraščeni v masivnem belem kremenju. Na manjši vzpetini nad vasjo je več kremenovih žil, v katerih najdemo modre protasto preraščene kristale cianita brez terminalnih ploskev, ki dosežejo do 20 cm v dolžino.

Slika 39: Preraščeni kristali cianita v kremenju. Primerek, velik 16 x 7 cm, izhaja iz okolice vasi Bonče na Selečki planini. Zbirka G. Kobler.

Picture 39: Intergrown kyanite crystals in quartz. The specimen (16 x 7 cm) was found at village Bonče on Selečka planina. G. Kobler collection.

This typical Macedonian village of Bonče lies on the slope of Selečka planina. Its surroundings are composed of highly metamorphosed micaschists. As a typical feature of such rocks one sees millions of idiomorphic garnet, kyanite and staurolite crystals embedded in them and slowly falling out due to weathering process gradually gnawing at these rocks.

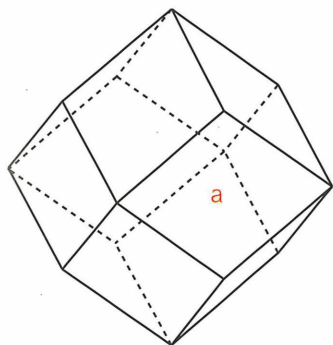
Kyanite Al_2SiO_5

Weathered-out kyanite crystals can be seen on the surfaces of the exposed rocks. They are of grey colour and full of enclosed garnet crystals. Largest can be 15 cm long. Vividly blue coloured kyanite crystals can be found rarely only in the massive white quartz veins. There are several quartz veins on the small elevation near the village where blue intergrown terminationless kyanite crystals can be found. Some of them are more than 20 cm long.

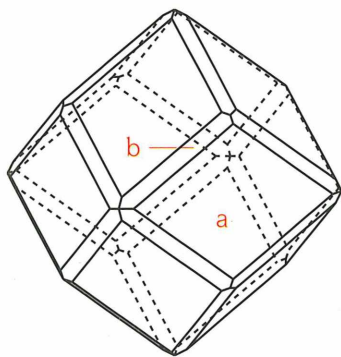


Brown crystals of this mineral can occasionally be found together with kyanite. The largest reach several centimetres in length and some millimetres in diameter. (232) twins are rare. Empty frame $\square$ in the chemical formula denotes a vacancy in the structure.

Rjavi kristali tega minerala se pojavljajo skupaj s kristali cianita, vendar precej redko. Največji dosežejo dolžino do nekaj centimetrov in nekaj milimetrov v premeru. Zelo redko naletimo na dvojčke po (232), ki imajo obliko andrejevega križa. Prazen kvadratik $\square$ v kemijski formuli tega minerala je standardna oznaka, ki ponazarja praznino v strukturi.



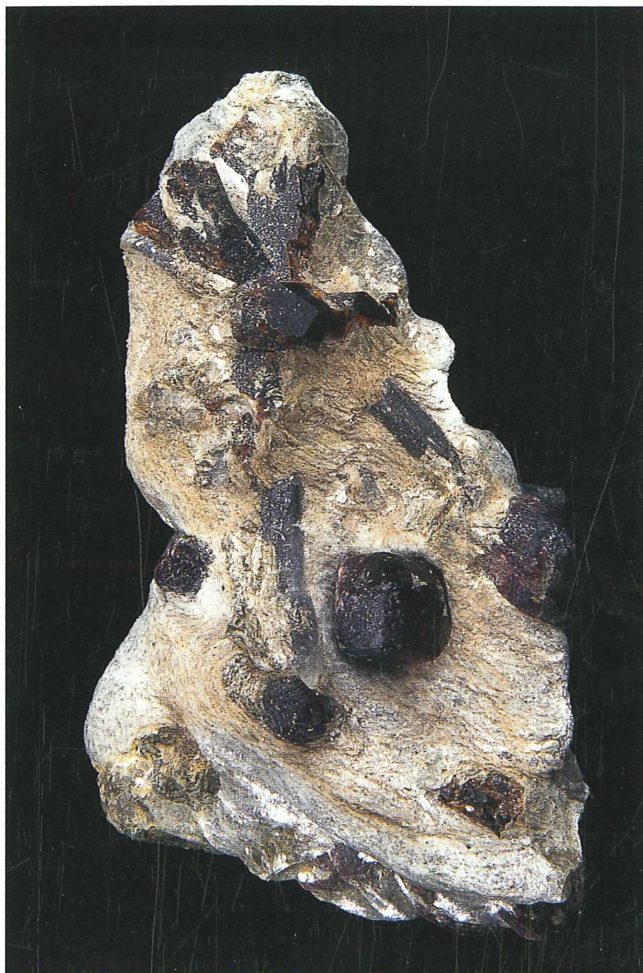
Risba – Drawing 23: Almandin - Almandine, Bonče. $a\{110\}$.



Risba – Drawing 24: Almandin - Almandine, Bonče. $a\{110\}$, $b\{120\}$.

Garnet - almandine $\text{Fe}^{2+}_3\text{Al}_2\text{Si}_3\text{O}_{12}$

Countless garnet crystals are present elsewhere around. They are quite small, with rare exceptions over 1 cm in diameter. Those in the upper schists levels are weathered, whereas those from deeper layers still quite well preserved. The village people used to cut grinding stones out of schists full of small garnets. From time to time the garnets rolled out of the stone and found their way into the flour. The "happy" finder eating the bread baked from such flour noted it as a sharp sound and pain in the teeth. The people called them "sharpeners". They surely knew why.



Slika 40: V okolici vasi Bonče je veliko sljudnih skrilavcev, v katerih je na milijone kristalov granata, distena in stavrolita. Le redko naletimo na vse tri minerale tako blizu skupaj. Primerek iz zbirke M. Kardelj meri 65 x 35 mm.

Picture 40: The vicinity of Bonče is composed of micaschists with millions of garnet, kyanite and staurolite crystals embedded. They are rarely found together on a small portion of rock. Specimen from M. Kardelj measures 65 x 35 mm.

Granat - almandin $\text{Fe}^{2+}_3\text{Al}_2\text{Si}_3\text{O}_{12}$

Kristalov almandina v sljudnih skrilavcih je nešteto. Dobesedno hodimo po njih. Največji dosežejo do 1 cm v premeru. V vrhnjih plasteh skrilavcev so precej prepereli, medtem ko so globlje v kamnini še ohranjeni. Tamkajšnji prebivalci so iz teh kamnin klesali mlinске kamne. Iz njih so se pri mletju luščili kristali granata in tako zašli v moko. Domačini so take "najdbe" v kruhu iz te moke imenovali ostrilci. So že vedeli, zakaj.

Nahajališče je na zahodnem robu Slečke planine, nad vasjo Kanatlarci. Nekdaj so tam pridobivali glinence. Nahajališče je zanimivo zaradi pojavljanja nekaterih mineralov v zelo velikih kristalih.

Mikroklin KAlSi_3O_8

Mineral se redko pojavlja v obliki značilno oblikovanih kristalov bele barve. Zanimiv je njegov zeleno obarvani različek - amazonit, ki sicer ni v idiomorfni kristalih, brez težav pa ga najdemo v razkolkih zelene barve.



Slika 41: Razkolki zeleno obarvanega mikrokлина - amazonita so uporabni za okrasne namene. Velikost razkolka 10 x 8 cm. Zbirka: Prirodonaučen muzej na Makedonija.

Picture 41: Fragments of green coloured microcline - amazonite could be used in jewelry. Fragment dimensions: 10 x 8 cm. Prirodonaučen muzej na Makedonija collection.

Slika 42: Na naslednji strani: Obesek z brušenim amazonitom iz Čaništa na Selečka planini. Brus M. Jeršek; oblikovanje in izdelava N. Šturm. Velikost kamna 15 x 11 mm.

Picture 42: Next page: Pendulum with cut amazonite crystal from Čanište on Selečka planina. Design and manufacture by N. Šturm, cut M. Jeršek. Stone dimensions: 15 x 11 mm.

Phlogopit $\text{K}(\text{Mg}, \text{Fe}^{2+})_3\text{Si}_3\text{AlO}_{10}(\text{F}, \text{OH})_2$

Ta mineral iz skupine sljud se tukaj pojavlja kot nekaj centimetrov debela plast na stiku kremena in glinencev. Kristali rjave barve dosega večmetrske velikosti in se brez težav lomijo in koljejo v manjše plošče.

Epidot $\text{Ca}_2(\text{Fe}^{3+}, \text{Al})_3(\text{Si}_2\text{O}_7)(\text{SiO}_4)(\text{O}, \text{OH})_2$

Kdo ne bi bil presenečen ob podatku, da lahko kristali epidota dosežejo metrsko dolžino. Ravno to se v tem nahajališču dogaja. Kristali seveda niso tako lepi in prozorni kot v bližnjem Šohlehovem kladencu, a vendar idiomorfno izoblikovani v več kot meter dolgih prizmatskih kristalih rjave barve. Kristali so v celoti vraščeni v glinencu, zato jih iz njega ni mogoče dobiti, ne da bi jih poškodovali. Odkrušiti je mogoče le kakšen del celotnega kristala.

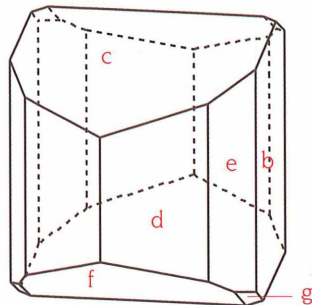
Cirkon ZrSiO_4

Največja mineraloška redkost v tem nahajališču so kristali cirkona. Pojavijo se zelo redko na stiku med phlogopitom in kremenom. Kristali so lahko nekaj centimetrov veliki in rjavordeče barve. Zaradi tektonskih procesov so deformirani in napokani.

The location is on the western edge of Selečka planina above the village of Kanatlarci. Feldspars were mined here in the past. The deposit is interesting because of several minerals appearing here in extraordinary dimensions.

Microcline KAlSi_3O_8

The mineral is rarely in the form of typically white crystals. The most interesting is the appearance of a green variety - amazonite. It is, otherwise, not present in crystals, yet there is an abundance of cleavage fragments.



Risba - Drawing 25: Mikroklin - Microcline, Čanište. $b\{010\}$, $c\{001\}$, $d\{110\}$, $e\{130\}$, $f\{101\}$, $g\{111\}$.

Phlogopite $\text{K}(\text{Mg}, \text{Fe}^{2+})_3\text{Si}_3\text{AlO}_{10}(\text{F}, \text{OH})_2$

This mineral from the mica group is present here as a several centimetres thick layer on the contact between quartz and feldspars. The brown-coloured crystals are several metres long and wide and can easily be broken into small pieces or plates.

Epidote $\text{Ca}_2(\text{Fe}^{3+}, \text{Al})_3(\text{Si}_2\text{O}_7)(\text{SiO}_4)(\text{O}, \text{OH})_2$

Who would not turn the head when hearing about one metre long epidote crystals? This exactly is happening at this location. The crystals, of course, are not so nice and transparent as at nearby Šohlehov kladenec but they are idiomorphically developed in more than one metre long prismatic brown coloured crystals. The crystals are entirely embedded in the feldspar rock. It is, for that reason, impossible to remove them from the rock without damaging them. Only their fragments can be obtained. It is better to leave them inside for the sake of other visitors and their importance as examples of the possible crystal dimensions of the species.

Zircon ZrSiO_4

The ultimate mineralogical rarity here is zircon. It can be found only exceptionally at the contact between phlogopite and quartz. Some centimetres long crystals are of brown-red colour. Strong tectonic forces caused their deformation and crushing.



Na planoti Mariovo leži vas Dunje, obdana z vrhovi, kot v nekakšnem kotlu. Nedaleč od nje izvira majhen studenec, ki mu pravijo domačini Šohlehov kladenec (kladenec = studenec). V bližini tega izvira so pegmatitno-hidrotermalna nahajališča, ki so v obrobni delih granitnih masivov, povečini v gnajsih. Med drugo svetovno vojno so Nemci iskali sljudo, ki so je takrat uporabljali kot izolator v elektronkah. Pri tem so naleteli na žile v glinencih, v katerih so se razvili lepi kristali različnih mineralov. Po 2. Svetovni vojni so žilo raziskovali večinoma znanstveniki in zbiralci. Parageneza v tem nahajališču je raznolika, saj vsebuje več različnih skupin mineralov.

Epidot $\text{Ca}_2(\text{Fe}^{3+}, \text{Al})_3(\text{Si}_2\text{O}_7)(\text{SiO}_3)(\text{O}, \text{OH})_2$

Nahajališče tako lepo razvitih, čistih in velikih kristalov epidota je tudi v svetovnem merilu malo. Ti tukaj se brez težav lahko primerjajo s priznanimi najlepšimi iz nahajališča Knappenwand v Avstriji. Kristali so zaradi izrazitega pleohroizma zelene do rjave barve. Nekateri so popolnoma prozorni. Največji dosežejo dolžine do 15 cm. Kristali imajo značilno prizmatsko obliko in so raztegnjeni v smeri osi b. Morfološko so zelo zanimivi, saj so kombinacija številnih kristalografskih oblik, zato imajo veliko ploskev, še posebej na lepo razvitih terminacijah. Veliko je dvojčkov po (100). Zaradi živahnih tektonskih procesov so se kristali lomili s sten in se kasneje na prelomih zacelili. Na večjih kristalih je priraščenih veliko manjših, ki so popadali nanje.

Titanit CaTiSiO_5

Medenorumenih kristalov titanita je zlasti veliko amfibolni podlagi. Večinoma so majhni. Redko se najde kakšen večji, ki pa je lahko zelo čist. Kot zanimivost in posledica tektonike se pojavljajo tudi nitasti kristali. Morfološko so nekoliko podobni tistim iz Alincev, so pa ploskovno bogatejši, predvsem zato, ker so manjši in čistejši.

Albit periklin $\text{NaAlSi}_3\text{O}_8$

Periklin je različek albita, zdvojen po t. i. periklinskem zakonu vzdolž (010). Posledica zdvojenja so svojevrstno oblikovani kristali, ki predstavljajo posebnost, saj so značilni za alpske razpoke. Ti, ki so bili najdeni tukaj, so lepo razviti in do 10 cm veliki. Kristali so porcelanasto bele barve. Na nekaterih so priraščeni kristali epidota in amfibola.

Adular KAlSi_3O_8

Dodatno znamenje alpskega značaja tega nahajališča je prisotnosti adularja. Ob podrobnejšem pregledu kristalov periklina lahko opazimo drobne kristale adularja, ki jih orientirano preraščajo. Mlečnobeli kristali adularja niso večji od dveh milimetrov in imajo zelo enostavno morfologijo, ki jo definirata v glavnem kristalografski obliki {001} in {110}.

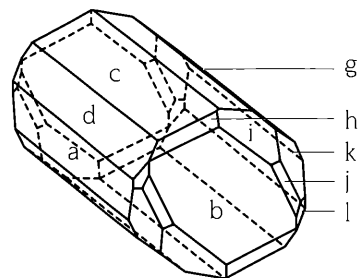
Slika 43: Na naslednji strani: Kristali epidota so priraščeni na podlagi iz mikroklin in periklina. Posamezni kristali imajo lepo razvite terminacije. Primerek iz Šohlehovega kladenca meri 75 x 38 mm in izhaja iz zbirke G. Kobler.

Picture 43: Next page: Idiomorph epidote crystals with well-formed terminations on microcline and pericline matrix from Šohlehov kladenec. 75 x 38 mm specimen from G. Kobler collection.

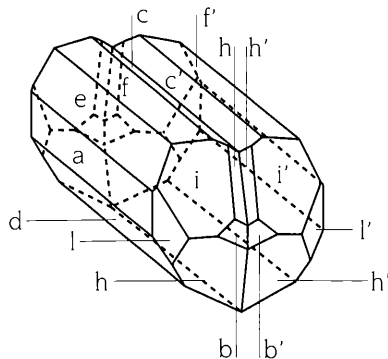
There is a village of Dunje lying on the Mariovo plateau. It is surrounded by summits as if it were in a cauldron. Not far away from it the small spring Šohlehov kladenec emerges. In its vicinity pegmatitic-hydrothermal locations are to be found in the margin parts of granitic massifs, but mostly in gneisses. The Germans searched for micas used for isolators in electronic tubes during World War II and found several dikes in feldspar rocks with various well-formed minerals. The location has since been investigated by scientists and mineral collectors. The mineral paragenesis at this location is quite interesting and composed of several mineral groups.

Epidote $\text{Ca}_2(\text{Fe}^{3+}, \text{Al})_3(\text{Si}_2\text{O}_7)(\text{SiO}_3)(\text{O}, \text{OH})_2$

Locations with epidote crystals of this quality are rare. The crystals from this locality can be compared to those from Knappenwand in



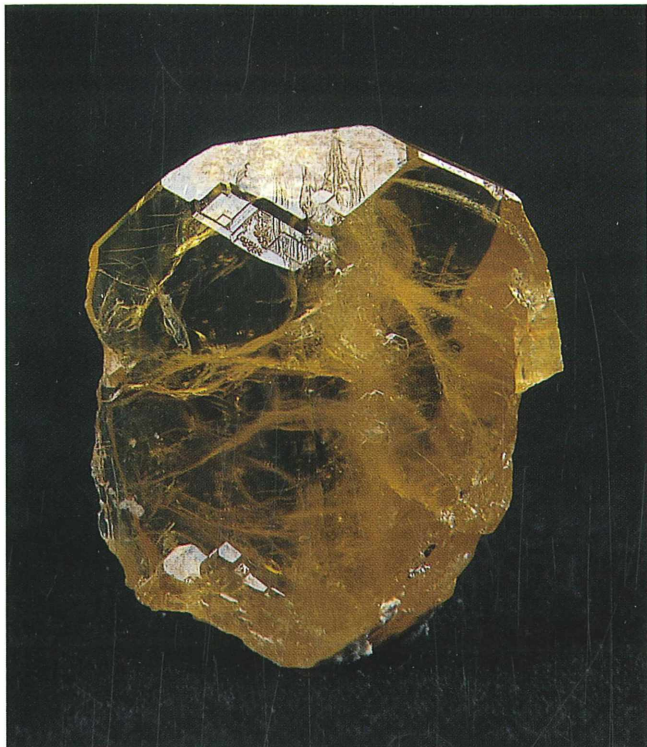
Risba – Drawing 26: Epidot - Epidote, Šohlehov kladenec. Neklinografska projekcija, modificirano po Zebcu (1984). Nonclinographic projection, modified after Zebec (1984). $a\{100\}$, $b\{010\}$, $c\{001\}$, $d\{101\}$, $e\{201\}$, $f\{102\}$, $g\{101\}$, $h\{011\}$, $i\{111\}$, $j\{221\}$, $k\{211\}$, $l\{210\}$



Risba – Drawing 27: Epidot, dvojček po (100) - Epidote (100) twin, Šohlehov kladenec. Neklinografska projekcija, modificirano po Zebcu (1984). Nonclinographic projection, modified after Zebec (1984). $a\{100\}$, $b\{010\}$, $c\{001\}$, $d\{101\}$, $e\{201\}$, $f\{102\}$, $g\{101\}$, $h\{011\}$, $i\{111\}$, $j\{221\}$, $k\{211\}$, $l\{210\}$



Mirjan Žorž, Miha Jeršek & Gute Mladenovski: Nekatera nahajališča mineralov v Makedoniji in njihova paragenеза / Some Mineral Locations in Macedonia and Their Paragenesis



Slika 44: Kristal titanita iz nahajališča Šohlehov kladenec v bližini vasi Dunje na Selečki planini. Posebnost tega kristala je, da ima v svoji notranjosti mlečno nit, ki je odraz tektonskih dogajanj med njegovo rastjo. Kristal iz zbirke M. Žorž meri 21 x 20 mm.

Picture 44: Single titanite crystal from Šohlehov kladenec near Dunje on Selecka planina. It is unique for its faden morphology. The hazy faden structure as the consequence of the tectonic movements during its growth can be seen in its interior. Crystal from M. Žorž collection measures 21 x 20 mm.

Pirit FeS_2

Pirita je tu precej. Nastopa v limonitiziranih kristalih različnih dimenzij, ki pa ne presegajo velikosti dveh centimetrov. Kristali so omejeni s ploskvami kocke in pentagonskega dodekaedra in so značilno progasti.

Stilbit $\text{NaCa}_2\text{Al}_5\text{Si}_3\text{O}_{36} \times 14\text{H}_2\text{O}$

Mineral iz skupine zeolitov se pojavlja v rozetastih oziroma snopastih agregatih rumenkastobelih kristalov. To je mineral, ki kristalizira med zadnjimi pri nizkih temperaturah, zato je priraščen na vseh ostalih mineralih. Največji kristali zrastejo do 2 cm v dolžino.

Kremen SiO_2

Kremina v teh žilah ni veliko. Pojavlja se v obliki posameznih močno korodiranih kristalov, ki pa so se v zadnji fazi zacelili. Zaradi tega najdemo na teh kristalih kristalografske oblike, ki jih na kremenovih kristalih sicer nikoli ne srečamo. Kristali so izredno čisti in se lepo svetijo.

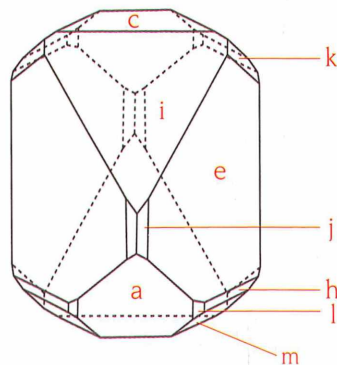
Drugi minerali

V paragenezi se pojavljajo še muskovit, amfibol, mikroklin, apatit, klorit, in heulandit.

Austria. They are green to brown in colour due to their intensive pleochroism. Some are completely transparent. The largest reach 15 cm in length. The crystals are prismatic in the direction of their b-axes. They are interesting from the morphological point of view due to their numerous present crystallographic forms. Their terminations are especially form-rich and well developed. Twins along (100) are very common. Intense tectonics caused their breaking and crumbling and, therefore, the positioning of crystal fragments on the larger epidote crystals as well as on the crystals of other minerals present at that time in the veins.

Titanite CaTiSiO_5

Honey-yellow crystals are abundant on the amphibole matrix. They are mostly small, but some large, finely crystallised and transparent crystals have been found. Faden crystals are present as a result of the widening veins caused by tectonic movements. They are morphologically similar to those from Alinci but are richer in forms because of their slower growth.



Risba – Drawing 28: Titanit - Titanite, Šohlehov kladenec. Neklinografska projekcija - nonclinographic projection. $a\{100\}$, $c\{001\}$, $e\{111\}$, $h\{110\}$, $i\{102\}$, $j\{13.9.13\}$, $k\{122\}$, $l\{210\}$, $m\{111\}$.

Albite - Pericline $\text{NaAlSi}_3\text{O}_8$

Pericline is an albite variety that is always twinned according to the pericline law, i.e. along (010). The outcome of twinning is expressed in specially formed crystals typical of the Alpine-type veins. Those found here are opaque and up to 10 cm long. The epidote and amphibole crystals are sometimes attached.

Adularia KAlSi_3O_8

Additional sign of the alpine character of this vein is the presence of adularia. Small adularia crystals are grown on pericline crystals. White to opaque crystals are not larger than 2 millimetres. They have a simple morphology comprising mostly of crystallographic forms $\{001\}$ and $\{110\}$.



Pyrite FeS_2

Numerous pyrite crystals are present here. Their outer layers are oxidized into limonite coatings. The crystals not larger than 2 cm on their edges are mostly combinations of cube and pentagon dodecahedrons.

Stilbite $\text{NaCa}_2\text{Al}_5\text{Si}_{13}\text{O}_{36} \times 14\text{H}_2\text{O}$

This mineral from the zeolite-group appears here in the form of acicular or sheaf-shaped aggregates. The largest are 2 cm long. They are of slightly yellow colour. This mineral crystallises among the last ones at the low temperatures. It is hence found attached to crystals of all the other minerals present.

Quartz SiO_2

Quartz is not particularly abundant here. It can be found in heavily corroded floater crystals that were re-healed in the last crystallisation phases. For that reason some extremely rare crystallographic forms, otherwise not present on quartz crystals, can be developed. The crystals are exceptionally clear and transparent with an intense lustre.

Other minerals

Muscovite, amphibole, apatite, chlorite and heulandite are also members of the paragenesis.

Slika 45: Kristal kremenca na sliki ima razvite ploskve, ki so nastale s korozijo in kasnejšim celjenjem v razpoki, v kateri je rasel. Popolnoma prozoren kristal iz nahajališča Šohlehov kladenec meri 32 x 19 mm. Zbirka M. Žorž.

Picture 45: The photographed crystal shows some crystal faces caused by corrosion and consequent re-healing in the vein where it grew. The completely transparent crystal from Šohlehov kladenec measures 32 x 19 mm. M. Žorž collection.

15 km vzhodno od Bitole se nahaja velik površinski kop premoga, ki ga uporabljajo v tamkajšnji termoelektrarni Bitola pri proizvodnji električne energije. Še nekaj kilometrov vzhodneje pa leži vas Orehovo, okoli katere se pojavljajo metamorfni sljudnati skrilavci in debelejšje kremenove žile. V skrilavcih najdemo idiomorfne kristale distena in stavrolita, v kremenovih žilah pa zelo velike kristale rutila. S preperevanjem kamnin se vsi omenjeni minerali luščijo iz njih in nabirajo v prsti. Tako je mogoče po njivah in pašnikih najti zelo lepo ohranjene kristale posameznih mineralov.

Stavrolit $(\text{Fe}^{2+}, \text{Mg}, \text{Zn})_{3-4}\text{Al}_2\text{□}_2\text{Al}_{16}\text{Si}_8\text{O}_{48}\text{H}_{2-4}$

Več centimetrov veliki kristali stavrolita so na pol izprepereli iz sljudnatih skrilavcev. Priznati je treba, da jih je zelo težko odbiti s skal. Mnogo lažje jih je poiskati na njivah in pašnikih. Kristali rjave barve imajo prizmatsko obliko in izoblikovane terminacije. Tudi ti kristali imajo vključene kristale almandina. Dvojčkov tukaj ni najti.

Rutil TiO_2

Malokje je moč najti tako velike in dobro oblikovane kristale rutila. Kristali so značilne jeklenosive barve in dosežejo več kot deset centimetrov v premeru. Samskih kristalov skoraj ni, ker so vsi dvojčeni po (101). Praviloma gre za polisintetske dvojčke, saj se dvojčenje po (101) zaradi štirištevne osi

15 km eastwards of Bitola a large open coal pit is situated. The coal is burned in the nearby power plant Bitola. A few kilometres due east is a small village Orehovo. Its surroundings is characterised by outcrops of micaschists and thick quartz dikes. Idiomorph kyanite and staurolite crystals constitute these rocks, whereas large rutile crystals are placed in the quartz veins. Weathered out crystals accumulate in the soil and can be found scattered in the fields and pastures.

Staurolite $(\text{Fe}^{2+}, \text{Mg}, \text{Zn})_{3-4}\text{Al}_2\text{□}_2\text{Al}_{16}\text{Si}_8\text{O}_{48}\text{H}_{2-4}$

Several centimetres long crystals can be found on the weathered surfaces of the exposed rocks. It is certainly very unlikely to get an intact crystal off the rock. It is much better to look around to find it in the soil. Crystals are prismatic with developed terminations. They also have numerous garnet inclusions.

Rutile TiO_2

It is not common to find as large rutile crystals as here. Some crystals reach up to 10 cm and more in diameter. There are mostly (101) twinned crystals. Most of them are twinned polysynthetically. This mineral has a fourfold crystal axis. The (101) twinning can set on into any of the four directions



Slika 46: Lističasti kristali muskovita v kremenu se pojavljajo v velikih množinah na Selečki planini. Ta primerek je iz okolice Orehova in meri 7 x 3 cm. Zbirka M. Kardelj.

Picture 46: Muscovite crystal leaflets in quartz are present in large quantities on Selečka planina. The specimen from Orehovo measures 7 x 3 cm. M. Kardelj collection.

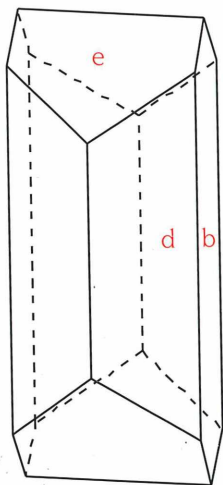


Slika 47: Polisintetski kolenasto-ciklični dvojček rutila v kremenu iz nahajališča Orehovo na Selečki planini. Kristal meri 3 x 4 cm. Dvojčenje po (101) omogoča, da se kristal rutila oblikuje v tako kompleksno razvite kristale. Zbirka M. Žorž.

Picture 47: Polysynthetically- and knee-twinned rutile crystal from Orehovo, Selečka planina. Crystal measures 3 x 4 cm. (101) twinning enables the formation of so complex formed crystals. M. Žorž collection.

around the axis. Complex knee, cyclic and knee-cyclic twins can be formed. Some of them are quite complex. They can best be sought for in the fields and pastures. They can be seen in quartz veins, but it is almost impossible to extract them.

simetrije nadaljuje v katerokoli od štirih smeri. Tako nastanejo kolenasti in ciklični dvojčki. Nekateri kristali so zaradi dvojčenja zelo razgibani. Najlažje jih je najti po njivah in travnikih. Nekoliko redkeje se pojavljajo v kremenovih žilah, iz katerih pa jih je težko dobiti.



Risba – Drawing 29: Stavrolit - Staurolite, Orehovo. $b\{010\}$, $d\{110\}$, $e\{201\}$.

Kakšnih pet kilometrov južno od Prilepa je v strmo pobočje Selečke planine pripet slikovit samostan Prilepec. V njegovi okolici je veliko metamorfnih kamnin, predvsem sljudnatih skrilavcev, ki hitro preperevajo. Iz njih se luščijo posamezni sivkasti kristali cianita, stavrolita in granata. Na nekaterih mestih naletimo na večje žile kremenca, v katerih so prepleteni modri kristali cianita. V kremenu se pojavljajo tudi nekaj centimetrov veliki kristali rutila. Hudourniki odnašajo izpreperele kristale v dolino, kjer se naberejo v naplavinah Lagovske reke. Teh naplavin je še posebno veliko pri vaseh Staro in Novo Lagovo. V njih najdemo izredno veliko izpreperelih kristalov cianita, od katerih nekateri dosežejo tudi do 15 cm v dolžino. V kristalih cianita so vraščeni manjši kristali granata (almandin). Rutil in stavrolit sta redkejša.

Some 5 km southbound from Prilep is the picturesque monastery of Prilepec fastened to a steep slope of the Selečka planina. Around there are many metamorphic rocks, mostly micaschists that are intensively weathered. Myriads of kyanite, staurolite and garnet crystals are weathered out. There are some places with white quartz bands in which blue kyanite intergrown crystals can be spotted. Several centimetres long crystals of rutile are not rare either. Torrents carry the weathered out crystals into the valley below, leaving them as alluvial deposits of the Lagovska reka around the villages of Staro and Novo Lagovo.



Slika 48: Iz matične kamnine preperevajo kristali cianita, v katerih so vraščeni kristali almandina. Kristale najdemo v naplavinah Lagovske reke pod Selečko planino. 8 cm velik kristal je iz zbirke M. Kardelj.

Picture 48: Kyanite crystals with almandine garnet inclusions weather out from the mother rock. They are found in the alluvial ground of the Lagovska reka under Selečka planina. 8 cm tall crystal from M. Kardelj collection.

The city of Berovo is in the easternmost part of Macedonia. It is positioned under Maleševske planine. 12 km due northeast are the villages of Mačevo, Mitrašinci and Budinarci.

Geological setting

The prevailing rocks in the surroundings of these villages are micaschists, gneisses and granites. Wide zones of the completely caolinized granites and quartz veins in gneisses, granites and schists can be encountered. The mineral paragenesis, typical for the alpine-type veins can be found here. The most frequent mineral is quartz accompanied by several other members of this paragenesis. Quartz was strategic raw material in the 1950' sought because of its piezoelectric properties. The Yugoslav army conducted the search by using a special ploughing technique. Whenever the plough struck a quartz vein it grated, announcing in this way the beginning of quartz digging at that site. A cask or a basket full of quartz crystals can still be found in the barns around.

Quartz SiO₂

There is plenty of quartz on the surface, though mostly white and massive. In ploughed and dug places one can find quartz crystals washed out. Intact veins, on the contrary, are difficult to find. Quartz crystals are normally slightly smoky but sometimes dark and transparent. The surfaces are mostly

Berovo leži v najvzhodnejšem delu Makedonije pod Maleševskimi planinami. Kakšnih 12 km severovzhodno ležijo vasi Mačevo, Mitrašinci in Budinarci.

Geološki podatki

Prevladujoče kamnine v okolici omenjenih vasi so sljudnati skrilavci, gnajsi in graniti. V teh kamninah naletimo na široke cone popolnoma kaolinitiziranih granitov ter kremenove razpoke v granitih, gnajsih in skrilavcih. V njih se pojavlja mineralna parageneza, značilna za razpoke alpskega tipa. Najpogostejši mineral teh razpok je kremen, ki je bil strateška surovina v petdesetih letih, ko so ga iskali zaradi njegovih piezoelektričnih lastnosti. Takrat ga je potrebovala predvsem vojska, ki je raziskave tudi vodila. Večino hribov v okolici omenjenih vasi so v ta namen dobesedno preorali s plugi. Ko je plug naletel na kremenovo žilo, je seveda zaškrtalo, kar je bil znak za začetek kopanja. Pri okolišnjih kmetih se še dandanašnji najde kakšna košara ali sod, do vrha napolnjena s kristali kremenca iz tistih časov.

Kremen SiO₂

Kremenca je na površini veliko, večinoma belega in masivnega. Na preoranih in prekopanih delih brez težav

Slika 49: Nitasti kremen iz okolice Budinarcev. Kristal je potegnjjen v smeri osi a, zato je sploščen. V notranjosti je vidna mlečna struktura v obliki niti. Na zgornjem delu je kristal rahlo kloritiziran. Dimenzije kristala 42 x 26 mm. Zbirka M. Žorž.

Picture 49: Faden quartz crystal from vicinity of Budinarci. The hazy milky thread in its interior is clearly seen. Its upper part is slightly covered with chlorite. Crystal dimensions 42 x 26 mm, collection M. Žorž.





najdemo večje in manjše kristale. Na erodiranih delih se pogosto svetlikajo kot vključki v prsti. Težje je najti še nedotaknjene žile, v katerih so skupaj z ostalimi minerali. Kristali so rahlo dimasti do izrazito čadaste barve in prozorni. Ploskve so motne in kloritizirane. Nekoliko redkejši so kristali z gladkimi in svetlečimi ploskvami. Največji so do 20 cm veliki in do 10 cm debeli. Kristali so tipa friedlaender in vedno dauphinejsko dvojčičeni. Največje presenečenje je pojav zvitih kristalov - vijačnikov, ki se pojavljajo samo v alpskih razpokah. Tiste, ki smo jih našli, prištevamo večinoma v stari - odprti tip vijačnikov. Tektonika je poskrbela tudi za nastanek nitastih kristalov, ki tu niso posebno redki.

Slika 50: Kristal čadavca iz okolice vasi Budinarci je visok skoraj 8 cm. Zbirka G. Kobler.

Picture 50: Smoky quartz from the surroundings of the village of Budinarci is almost 8 cm tall. Collection G. Kobler.

dull due to the chlorite that fell on in the last crystallisation stages. Shiny crystals are therefore rather rare. The largest are up to 20 cm long and can be 10 cm thick. The crystals are of the Friedlaender type and always Dauphine twinned. The most surprising was the finding of a twisted



(gwindel) quartz, which is a typical sign of the alpine paragenesis. These specimens as found can be ascribed to so-called old-open-type of gwindel quartz. The tectonics caused the formation of faden quartz crystals that are common here.

Pyrite FeS_2

Several centimetres large crystals with limonite coatings are occasionally found.

Anatase TiO_2

A typical attendant of the alpine veins is anatase. It was found here in the form of minute blue-coloured crystals with an intense diamond lustre.

Slika 51: Kremenovi vijačniki so doma v Alpah, zato je njihova najdba v okolici Budinarcev pred nekaj leti pomenila pravo mineraloško senzacijo. Značilno za vijačnike je, da so raztegnjeni vzdolž osi a, okoli katere so istočasno zasukani. Na sliki se dobro vidi ukrivljenost kristala, ki ga uvrščamo med takojmenovane leve vijačnike starega odprtega tipa. Zbirka I. Derganc; velikost kristala 68 x 56 mm.

Picture 51: The home of twisted quartz crystals (gwindels) is in the Alps. Their finding in the vicinity of Budinarci produced quite a sensation. Typical of gwindels is their elongation along their a-axis and twisting around it at the same time. The crystal flexion of the left crystal of the old-closed-type can clearly be noted in the picture. Gwindel dimensions: 68 x 56 mm. Collection I. Derganc.

Pirit FeS_2

Pirit se pojavlja redko v nekaj centimetrov velikih kockastih kristalih. Površina je že močno limonitizirana.

Anataz TiO_2

Značilen spremljevalec alpskih razpok se tukaj pojavlja v milimetrskih kristalih, ki imajo močan sijaj in nevsakdanjo modrikasto barvo.

Geografska lega z geološkimi podatki

Od Delčeva pelje cesta proti Bolgariji. Nekaj kilometrov vzhodno od vasi Zvegor, tik pred samo državno mejo, je ob cesti dobro viden izdanek kremenovega latita, v katerem je nešteto idiomorfnih kristalov sanidina.

Sanidin $KAlSi_3O_8$

Sanidin je visokotemperaturna monoklinska oblika kalijevega glinenca. Tukaj se pojavlja v največ 5 cm velikih kristalih. Nekateri so porcelansko beli, drugi pa rdečkasti. Poleg samskih in naključno preraščenih kristalov se v večjem številu pojavljajo karlovarski dvojčki, ki so zraščeni po (010). Veliko manj je manebaških dvojčkov, zraščenih po (001). Kristali so modelno oblikovani in imajo razvitih precej kristalografskih oblik. Zaradi hitrega kemijskega preperevanja osnovne kamnine se luščijo iz nje, vendar tudi sami hitro preperevajo.

Geographical position with geological setting

From Delčevo, a small town in the east of Macedonia, a road leads towards the Bulgarian border. Some kilometres eastbound of the village Zvegor, close to the state border, there is an outcrop of quartz-latite full of idiomorph sanidine crystals.

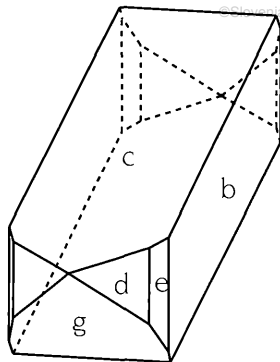
Sanidine $KAlSi_3O_8$

Sanidine is a high temperature form of potassium feldspar. Here it appears in idiomorph crystals not longer than 5 centimetres. Most of them are white and opaque, but some can be reddish as well. Crystals are in the form of singles, twins and random intergrowths of singles and twins. Karlsbad twins are most frequent, whereas those twinned according the Manebach law are a rarity. Crystals are idiomorph and quite rich in crystallographic forms. The relatively fast chemical weathering of the mother rock results in a large quantity of weathered out crystals that can easily be found under the wall.



Slika 52: Idiomorfno razviti kristali sanidina iz Zvegorja v vzhodni Makedoniji. Na posnetku so od leve proti desni: levi in desni karlovarski dvojček ter samski kristal. Kristali so približno 2 cm veliki. Zbirka M. Kardelj.

Picture 52: Idiomorph sanidine crystals from Zvegor in Eastern Macedonia. From left to right: left and right Karlsbad twinned crystals and single crystal. Each crystal is approximately 2 cm long. Collection M. Kardelj.



Risba – Drawing 30: Sanidin - Sanidine, Zvegor.
 $b\{010\}$, $c\{001\}$, $d\{110\}$, $e\{130\}$, $g\{201\}$

Thier Parag.

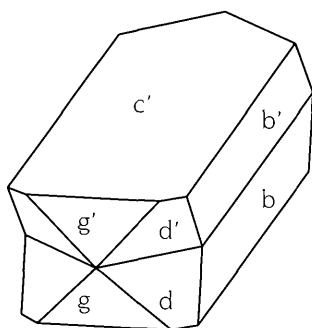
Mineral Locations in Macedonia

njihova paragenza

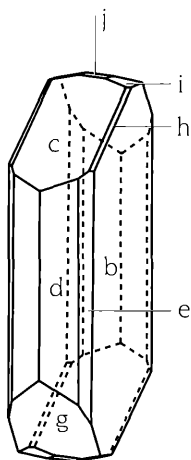
Makedoniji

slji Nekatera najbajaljšča mineralov

Mirjam Žorž, Milica Jeršek & Gita Mladen



Risba – Drawing 31 Manebaški dvojček sanidina
 po (100) - Sanidine Manebach twin along (100),
 Zvegor. $b\{010\}$, $c\{001\}$, $d\{110\}$, $g\{201\}$



Risba – Drawing 32: Sanidin, neklinografska
 projekcija - Sanidine, nonclinographic projection,
 Zvegor. $b\{010\}$, $c\{001\}$, $d\{110\}$, $e\{130\}$,
 $g\{201\}$, $h\{021\}$, $i\{213\}$, $j\{203\}$

Pikermijska favna Makedonije Pikermian Fauna of Macedonia

Gute Mladenovski¹ & Katarina Krivic²

¹ Prirodonaučen muzej na Makedonija, Bulevar Ilinden 86, 95000 Skopje 55, Makedonija

² Prirodoslovni muzej Slovenije, Prešernova 20, 1000 Ljubljana, Slovenija

V Makedoniji so številna bogata nahajališča fosilov, med katerimi je najznačilnejša pikermijska favna. To so fosilni ostanki predstavnikov različnih živalskih skupin izpred 8 - 10 milijonov let. V sedimentih pliocenske starosti so ohranjeni ostanki mastodontov, nosorogov, hijen, žiraf, levov, sabljastih tigrov, hiparionov, gazel, antilop in drugih. Najštevilčnejše so zastopani hiparioni - troprsti konji, zaradi česar se pikermijska favna imenuje tudi hiparionska favna.

Najpomembnejša, zelo bogata najdišča raznovrstnih fosilnih ostankov so Veles, Valandovo, Negoti in Kavadarci, posamezni primerki pa so bili najdeni tudi v okolici Skopja, Delčeva, Berova in Bitole.

V obdobju spodnjega pliocena so bila na območju današnje Makedonije številna jezera. V njihovi bližini so živele skupine omenjenih živali. Po svojem videzu in habitatu (življenjskem prostoru) so bile podobne današnjemu afriškemu tipu živalstva (sloni, žirafe, tigri, nosorogi, hijene in podobno). Na podlagi znanih podatkov sklepamo, da so prevladovala stepske razmere.

V najdiščih so serije sedimentov z zelo številnimi fosilnimi ostanki, kar govori o naglem poginu večjega števila živali. Najverjetneje naj bi ga povzročili veliki gozdni požari, ki so zajeli stepe. Živali so se ognju verjetno umikale v bližnja jezera, kjer so se utopile.

Literatura – References

ČIRIĆ, A., 1957: Pikermiska fauna iz okoline Titovog Velesa. – Glasnik Prirodnačkog muzeja Srpske zemlje, Ser. A, knj. 8, 1- 82, Beograd.

FORSTEN, A., R. GAREVSKI, 1989: Hipparions /Mammalia, Perisodactyla/ from Macedonia /Yugoslavia. – Geol. Maced., T. 3, Nr. 2, 159 – 206, Štip.

Macedonia is known for its rich finding sites of fossils. The most characteristic among them being those of pikermian fauna. These are fossil remains of the representatives of different animal groups from about 8 to 10 million years ago. Preserved in the Pliocene sediments are remains of mastodonts, rhinoceros, jackals, giraffes, lions, tigers - sabre-toothed tigers, hipparions, gazzeles, antilopes and others. As hipparions, i. e. horses having three digits, are represented in the largest number, the Pikermian fauna is often referred to as hipparion fauna.

The most important and richest finding sites of diverse fossils are at Veles, Valandovo, Negoti and Kavadarci, while single specimens were found also in the vicinity of Skopje, Delčevo, Berovo and Bitola.

In the period of the Lower Pliocene Macedonia was covered by numerous lakes around which lived the afore mentioned animal groups. By their appearance and habitat they strongly resembled the current African type of fauna (elephants, giraffes, tigers, monkeys, rhinoceros, hyenas etc.) as deduced from the data available, the prevailing living conditions were of the steppe type.

The finding sites reveal blocks and series of sediments with numerous fossil remains, which points to a rapid death of a larger number of animals. It was most probably occasioned by great forest fires breaking out in the steppes. The animals seem to have been fleeing the fire by retreating toward the lakes where they were drowned.



Slika 53: Zgornji sekalci. *Hipparion gracile* Christol. Spodnji pliocen. Veles. Zbirka Oddelka za geologijo NTF.
Picture 53: Upper incisors. *Hipparion gracile* Christol. Lower Pliocene. Veles. Collection NTF.



Slika 54: Del lobanje -part of skull. *Hipparion gracile* Christol. Spodnji pliocen. Veles. Zbirka Oddelka za geologijo NTF.
 Picture 54: Part of skull. *Hipparion gracile* Christol. Lower Pliocene. Veles. Collection NTF.



Slika 55: Fragment spodnje leve čeljustnice. *Hipparion gracile* Christol. Spodnji pliocen. Veles. Zbirka Oddelka za geologijo NTF.
 Picture 55: Part of lower left jaw. *Hipparion gracile* Christol. Lower Pliocene. Veles. Collection NTF.

BARIĆ, L. 1935: Disthen (Cyanit) von Prilepec im Selečka-Gebirge. Mineraloško-Petrografski muzej, Zagreb: 57-92.

BARIĆ, L. 1964: Mineralgänge von Crni kamen bei dem Dorf Alinci in Mazedonien. Mineraloško-Petrografski muzej, Zagreb: 23-30.

BARIĆ, L. 1969: Dolomitmarmor in der Umgebung der Stadt Prilep und die in ihm vorkommenden Minerale. Tschermak Mineralogische und Petrographische Mitteilungen, **13**: 233-249.

BARIĆ, L., 1972/73: Über die neuen und angeblich neuen Minerale im jugoslawischen Gebiet. Glasnik Zemaljskog muzeja, Sarajevo, XI/XII: 5-32.

BARIĆ, L., 1976: Apatit iz pegmatitne žile Beluče kod sela Dunje u Makedoniji. Glasnik prirodnjačkog muzeja, Beograd, knjiga **31**: 5-7

BARIĆ, L., 1979: Diaspor, ein ungewöhnlich grosser Kristall aus dem Dolomit-Steinbruch Sivec weit von Prilep in Mazedonien, Jugoslawien. Lapis, Vol **4**, No. 11 - 25.

BARIĆ, L., 1981: Allchar, Seltene Thalliumminerale aus Jugoslawien. Lapis, Vol **6**, No. 13: 15-17

BLACKBURN, W. H., W. H. DENNEN, 1997: Encyclopedia of Mineral Names. Mineralogical Association of Canada: 359 pp.

JERŠEK, M., B. MIRTIC, 1997: Diasporescencia prilepskih rubinov - nov optični pojav v svetu dragih kamnov. Geološki zbornik, **13**: 67-72.

JERŠEK, M., MIRTIC B., 1999: Corundum of Prilep Dolomitic Marble. Scopolia 41 (v tisku - in press).

TIBLJAŠ, D., V. ZEBEC, V. BERMANEC, 1987: Zeolite occurrence in the vein mineral paragenesis near Dunje, Macedonia. Geološki vjesnik, Zagreb: 81-87

ZEBEC, V., 1984: Epidot von Smilevski dol bei Dunje im Selečka - Gebirge (Mazedonien). Univerzitet Kiril i Metodij, Skopje: 63-103.

ŽORŽ, M., VIDRIH R., MIKUŽ V., KOBLEK G., MUŠIČ B., 1988/89: Minerali iz Alincev v Makedoniji. Proteus, **51** 326-330.

ŽORŽ, M., R. VIDRIH, V. MIKUŽ, G. KOBLEK, 1990/91: Minerali prilepskega marmorja. Proteus, **53**: 243-251

ŽORŽ, M., 1992: Nitasti kremen. Proteus, **54**: 291-301

ŽORŽ, M., 1993: Pyroelectrically caused twisting of quartz crystals. Geologija, **36**: 211-222.

Zahvala

Acknowledgments

The participants of the project »Hidden Treasures of Macedonia« are grateful to numerous public institutions and friends who have helped us with our work.

The basis of this project was prepared by the Slovenian Museum of Natural History and the Macedonian Museum of Natural History. We owe our sincere thanks to the heads of both institutions Matija Gogala and Tatjana Boškovi for their support.

The project »Hidden Treasures of Macedonia« was sponsored by the Ministry of Culture of the Republic of Slovenia, Ministry of Culture of the Republic of Macedonia, Ministry of Science and Technology of the Republic of Slovenia, Ministry of Science of the Republic of Macedonia and Ministry of Environmental Affairs of the Republic of Macedonia. Let us also express our gratitude to His Excellency Dimitar Mirčev, Ambassador of the Republic of Macedonia in Slovenia for his active support.

Grateful acknowledgment is made to numerous institutions and private collectors for lending us specimens from their valuable collections for the exhibition and taking of photographs. Sincere thanks to the Geoinstitut of Skopje, Department of Geology of the Faculty of Natural Sciences and Engineering, especially to Breda Mirtič and Uroš Herlec, and to Marin Aleksandrov, Izidor Derganc, Marjan Dolenc, Zvonko Gruevski, Ana Hinterlechner - Ravnik, Marjetka Kardelj, Gregor Kobler, Vojko Pavčič, and Nataša Šturm.

Photographs of mineral specimens are very important to their exhibition. For all efforts in this respect we give thanks to Ciril Mlinar, Miran Udovč and Dragan Arrigler.

Last but not least, we extend our thanks to all those who offered us understanding and support with the formation of this work. Allow us to name the Janez Gregori editor of the Scopolia with the editorial board and designer Dušan Kramberger.

Vsi, ki smo sodelovali pri projektu "Skrita bogastva Makedonije" se zahvaljujemo številnim prijateljem in javnim ustanovam, ki so nam na različne načine pomagali pri našem delu. Osnutek projekta sta pripravila Prirodoslovni muzej Slovenije in Prirodonaučen muzej na Makedonija. Zato se za vso podporo zahvaljujemo njunima direktorjema akad. prof. dr. Matiji Gogali in Tatjani Boškovi, dipl. biol.

Projekt "Skrita bogastva Makedonije" so omogočili Ministrstvo za kulturo Republike Slovenije, Ministrstvo za znanost in tehnologijo Republike Slovenije, Ministrstvo za kultura Republike Makedonije, Ministrstvo za nauka Republike Makedonije in Ministrstvo za životna sredina Republike Makedonije. Za aktivno podporo se zahvaljujemo njegovi ekscelenci Dimitru Mirčevu, veleposlaniku Republike Makedonije v Sloveniji.

Zahvaljujemo se številnim zavodom in institucijam ter zasebnim zbiralcem, ki so posodili iz svojih zbirk minerale za fotografiranje in razstavo. Zahvaljujemo se Geoinstitutu iz Skopja, Oddelku za geologijo Naravoslovnotehniške fakultete v Ljubljani, še posebno Bredi Mirtič in Urošu Herlecu, ter Marinu Aleksandrovu, Izidorju Dergancu, Marjanu Dolencu, Zvonku Gruevskemu, Ani Hinterlechner - Ravnik, Marjetki Kardelj, Gregorju Koblerju, Vojku Pavčiču in Nataši Šturm.

Fotografije mineralov so pomemben del predstavitve mineralov. Zato se za prizadevanje in fotografiranje zahvaljujemo Cirilu Mlinarju, Miranu Udovču in Draganu Arriglerju.

Ne nazadnje se zahvaljujemo tudi vsem ostalim, ki so pokazali vse razumevanje pri nastanku tega dela. To so med drugimi urednik Scopolie Janez Gregori z uredniškim odborom ter oblikovalec Dušan Kramberger.

Avtorji

Authors

Izdajatelj Prirodoslovni muzej Slovenije, Ljubljana
Published by Slovenian Museum of Natural History, Ljubljana

Zanj Matija Gogala
Editor responsible

Avtorji prispevkov Mirjan Žorž, Miha Jeršek, Gute Mladenovski, Radomir Ilić,
Texts by Katarina Krivic, Tadej Dolenc, Todor Serafimovski

Fotografije Ciril Mlinar, Dragan Arrigler (21 in naslovna fotografija), Miran
Photography Udovč (3 in 17), Mirjan Žorž (27, 28 in 37)

Risbe Mirjan Žorž
Drawings

Oblikovanje Dušan Kramberger
Design

Tisk Tiskarna Tone Tomšič, Ljubljana
Printed by

Naklada 1000 izvodov
No. of copies

Izdano Ljubljana, 1999
Published

SCOPOLIA
SUPPLEMENTUM 2

Glasilo Prirodoslovnega muzeja Slovenije. Izdaja Prirodoslovni muzej Slovenije, sofinancirata Ministrstvo RS za kulturo in Ministrstvo RS za znanost in tehnologijo. Uredniški odbor: Breda ČINČ-JUHANT, Janez GREGORI (urednik), Huw I. GRIFFITS (GB), Boris KRYŠTUFEK, Lojze MARINČEK, Ignac SIVEC, Kazimir TARMAN, Nikola TVRTKOVIĆ (HR) in Tone WRABER. Lektorici: Cvetana TAVZES (za slovenščino) in Helena SMOLEJ (za angleščino). Recenzentki: za mineraloški del izr. prof. dr. Breda MIRTIC, za paleontološki del izr. prof. dr. Vida POHAR. Naslov uredništva in uprave: Prirodoslovni muzej Slovenije, 1000 Ljubljana, Prešernova 20. Izideta najmanj dve številki letno. Naklada SUPPLEMENTUM 2 1000 izvodov. Tekoči račun pri NLB št. 50100-603-40115. Tisk Tiskarna Tone Tomšič d. d., Ljubljana.

Journal of the Slovenian Museum of Natural History, Ljubljana. Edited by the Slovenian Museum of Natural History, subsidised by the Ministry of Culture and Ministry of Science and Technology. Editorial stuff: Breda ČINČ-JUHANT, Janez GREGORI (Editor), Huw I. GRIFFITS (GB), Boris KRYŠTUFEK, Lojze MARINČEK, Ignac SIVEC, Kazimir TARMAN, Nikola TVRTKOVIĆ (HR) and Tone WRABER. Readers: Cvetana TAVZES (for Slovene) and Helena SMOLEJ (for English). Reviewers: izr. prof. dr. Breda MIRTIC (mineralogical part), izr. prof. dr. Vida POHAR (paleontological part). Address of the Editorial Office and Administration: Slovenian Museum of Natural History, SI-1000 Ljubljana, Prešernova 20. The Journal appears at least twice a year. 1000 copies of issue SUPPLEMENTUM 2. Current account at NLB No 50100-603-40115. Printed by Tiskarna Tone Tomšič d.d., Ljubljana.



PRIRODOSLOVNI MUZEJ SLOVENIJE
MUSEUM HISTORIAE NATURALIS SLOVENIAE