New Minerals from Lavrion Mining District, Greece

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(translated from the original "Weitere Naufunde aus Lavrion", Griechenland, Mineralien Welt, 05/2018)

Branko Rieck et al, New Minerals from Lavrion Mining District, Greece, 2018

Already shortly after the finalization of the last comprehensive description of new discoveries from the Lavrion Mining District (KOLITSCH et al. 2014) new finds were made. In parts they could be named in the article mentioned above, most however were made after the publication. It is therefore now time to open a new chapter in the description of this world-famous deposit.

In the meantime, new minerals for Lavrion were found especially in polished sections and presented in a short paper for a conference (KOLITSCH et al. 2015). These and many more will be described here. In addition, an uncommon paragenesis of Uranium-bearing minerals was found in the Paleokamariza Mine #18 (SIMON & KAPELLAS 2017, RIECK 2017). And finally, there are **four completely new mineral species** from Lavrion currently being studied by scientists.

All new discoveries presented here were analyzed by diffraction of X-ray on powders (PXRD) or single crystals (SXRD) and/or by semiquantitative SEM-EDS analysis.

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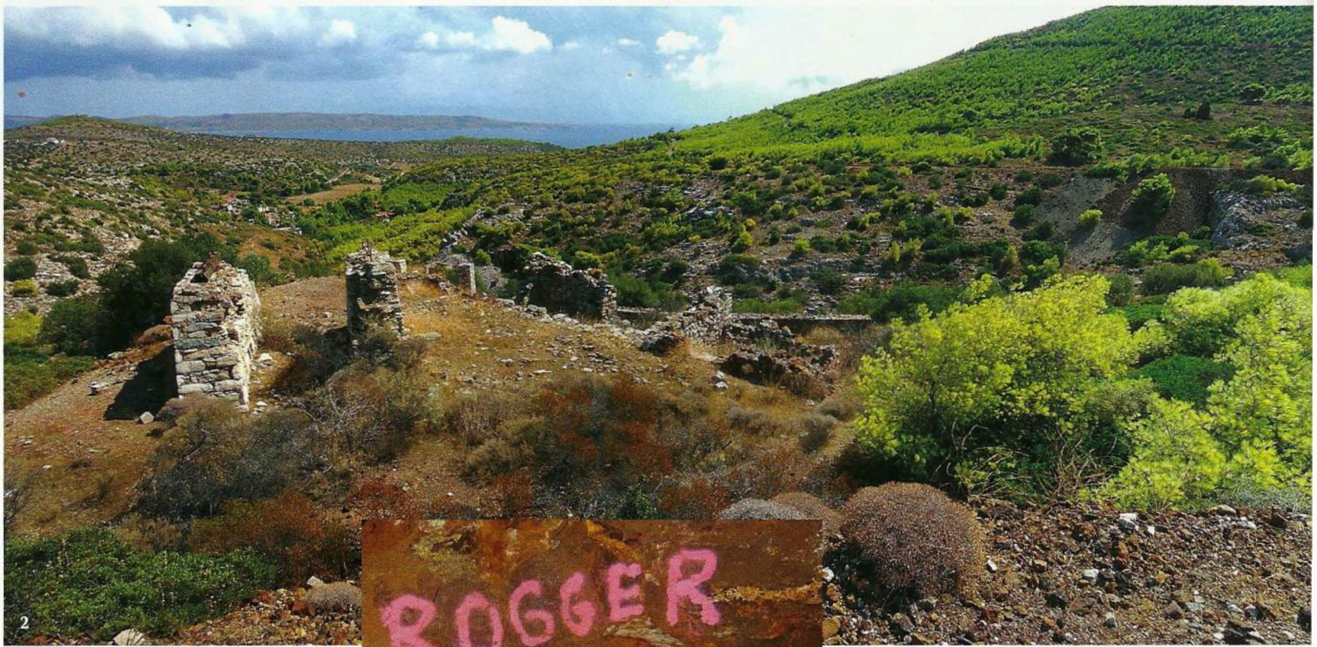

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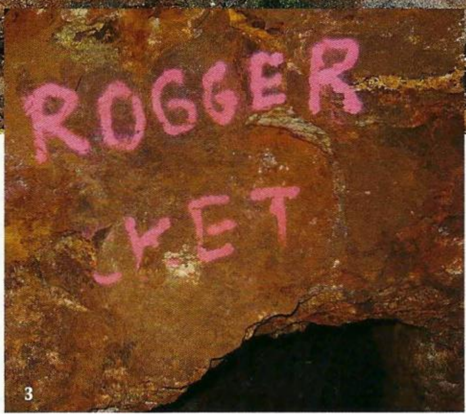
Additionally, quantitative Electron Probe and Raman Spectrometry analysis were carried out where it was deemed necessary.



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Aeschynite-(Y), $(Y,Ln,Ca,Th)(Ti,Nb)_2(O,OH)_6$

At a location discovered by the famous Greek collector Stathis Lazaridis (Lazaridisite) in the Plaka Mine #80 that is well-known for its beautiful anatase crystals in thin “alpinotype” veins also the mineral Aeschynite-(Y) could be identified. It appears thin, lathlike, dark brown crystals with a resinous luster. They reach about half a millimeter in length. The single crystal used for identification with SXRD was also analyzed with SEM-EDS and INAA to confirm the Yttrium-dominant variety. The paragenesis is the same as for anatase with small quartz crystals, synchysite-(Ce), senaite and calcite.

Aldridgeite, $(Cd,Ca)(Cu,Zn)_4(SO_4)_2(OH)_6{\cdot}3H_2O$

The Esperanza mine in the Kaminiza area is well-known for its rich paragenesis of Cadmium-bearing minerals and being the type locality for no less than four Cadmium-minerals. Some analytical data from previous work has shown that serpierite from the Esperanza mine sometimes contains a distinctive Cadmium content. A find from April 2014 contained Cd-bearing christelite, very nice niedermayrite and for the first time for Lavrion also a member of the serpierite group of minerals where the Calcium content is lower than the Cadmium content and therefore the mineral in question is aldridgeite. The light blue crystals are up to 0.1 mm long and look more like aurichalcite in color and shape. Further minerals accompanying aldridgeite are blue-green, Copper-bearing gordaite and atacamite.

Allanite-(Ce), $\{CaCe\}\{Al_2Fe^{2+}\}(Si_2O_7)(SiO_4)O(OH)$

From a granodioritic dyke in the Hilarion area GALANOS (2009) shortly describes allanite-(Ce) from thin sections. The authors could identify this mineral in polished sections from skarn-samples from Adami #2 mine and from a contact seam between an acid plutonite and marble at a locality at the second level of the Hilarion adit as small grains exhibiting zonal growth (KOLITSCH et al., 2015). At the locality in Hilarion mine allanite-(Ce) that shows a transition to REE-rich or REE-bearing epidote is a secondary product of the hydrothermal alteration of monazite-(Ce).

Alpersite, $(Mg,Cu)[SO_4]\cdot 7H_2O$

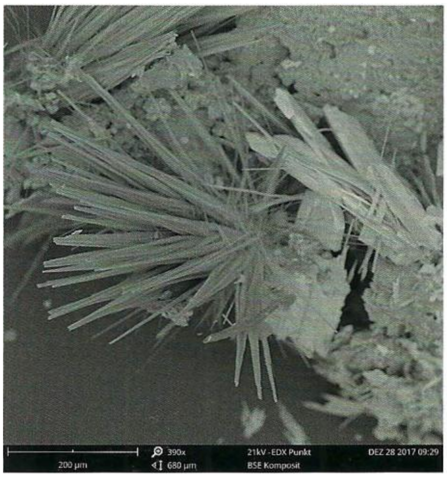
It is well possible to find alpersite in the Esperanza mine, but it is near impossible to conserve it for an extended period of time. From experience we can say that alpersite decomposes within hours to copper-bearing pentahydrite if you try to remove it without any precautions from the mine environment. If it is enclosed and sealed in an air-tight container directly at the place of discovery, at least two months after it was still possible to find remains of alpersite with PXRD. Long-time conservation is probably only possible by enclosing the specimen in synthetic resin directly after removal from the host rock. The authors will try this out at the next visit to the locality.

Alpersite is found as grainy, light blue coating on matrix that also hosts “rams’ horn” epsomite up to 10 cm in size. It looks remarkably like the aubertite-magnesioaubertite solid solutions found at the Plaka Sulfate Locality. Individual grains reach half a millimeter in size.

Altaite, PbTe

In an ore sample from Adami #2 Mine in the Plaka area the first fully confirmed discovery of a Tellurium-bearing mineral could be made. LELEU (1973) describes – without adding details – tetradymite (Bi_2Te_2S) from a skarn in Plaka, but after his description no further finds of this parageneses were made. As the original samples have gone missing, a modern verification is no longer possible.

The altaite-bearing sample originates from a very tough calcsilicate-skarn that is mineralized with pyrrhotite, little chalcopyrite and galena. The main constituents of the matrix are epidote, grossular-rich garnet, with minor clinozoisite, quartz, titanite and calcite. As an accessory mineral zircon is found within garnet as very pure and near idiomorphous crystals up to 50 µm. Altaite forms very small (max. 25 µm, usually 1-2 µm) xenomorphous grains, mostly as inclusions in pyrrhotite (KOLITSCH et al., 2015).



Alumohydrocalcite, $CaAl_2(CO_3)_2(OH)_4{\cdot}4H_2O$

In spring 2017 the first author received a present of a piece of azurite and "picropharmacolite" on a schistose matrix from the 3rd Level of the Hilarion area from Vasilis Stergiou. The matrix and the paragenesis however rendered the ID of "picropharmacolite" highly unlikely. A PXRD-analysis revealed the true identity of alumohydrocalcite which was also confirmed with an additional EDX analysis. The chemistry shows no other elements present than the main constituents.

On the available specimen alumohydrocalcite forms spray of needles up to 0.5 mm that rest on crusts of chalcoalumite together with azurite.

Alunite, $KAl_3(SO_4)_2(OH)_6$

Alunite is a rather common mineral in Lavrion, however it was so far not mentioned. Only the work on a 15 years old find from the 4th Level of the Christiana Mine brought some attention to this mineral.

Alunite is a weathering product of potassium feldspars that are common in the acid and intermediate plutonites in the Lavrion area. It forms white powdery aggregates that are commonly thoroughly intergrown with clay minerals. Many of the so-called "Gibbsite" specimens contain alunite. In this form the individual grains that may even show crystal faces can only be identified in a SEM. All the more remarkable are therefore the crystals from the above-mentioned find: here alunite forms crystals up to 2 mm forming intergrown aggregates covering several square centimeters on well-formed gypsum crystals. Mostly these aggregates are light blueish or a light beige.

Amarantite, $Fe^{3+}_2(SO_4)_2O\cdot 7H_2O$

In a so far rather unnoticed area within the 4th Level of the Hilarion area a highly interesting sulfate-paragenesis was discovered in fall 2013. There are quite a few similarities with the sulfate localities in Plaka and Sounion, however also marked differences may also be observed. This leads to a slightly different mineralization and consequently new discoveries for Lavrion. On a single piece, picked up at the floor of the adit, amarantite forms radial aggregates in a matrix of gypsum, melanterite and kröhnkite. The color, an intense orange-brown and the cleavage are distinctive. At the

end of the amarantite-fibers quite often copiapite can be found, as well as fibroferrite, hohmannite and metahohmannite.

Ammoniojarosite, $(NH_4)Fe^{3+}_3(SO_4)_2(OH)_6$

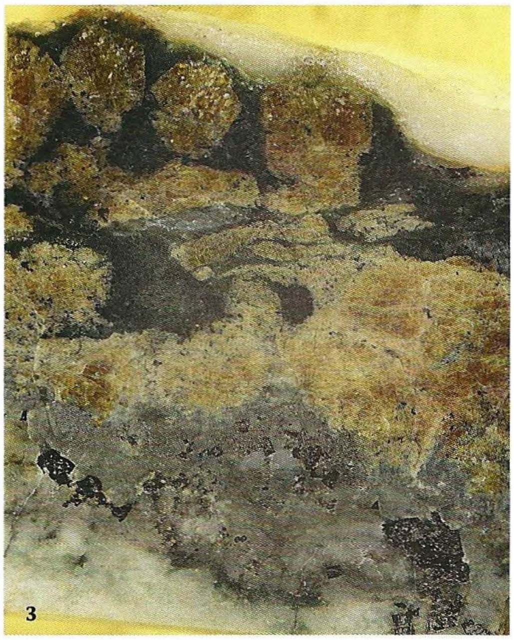
The authors of the original publication of katerinopoulosite (CHUKANOV et al. 2018) describe in the paragenesis of the latter also ammoniojarosite. From samples taken in spring 2017 by the authors this could be confirmed. It must however be pointed out, that ammoniojarosite is an exceedingly rare mineral in this paragenesis. Only in a small cavity dubbed "rathole" by collectors (because of an abandoned nest of a dormouse found inside) analytically confirmed discoveries of this mineral could be made (the vast majority of jarosite in this area is plain jarosite and to a small percentage natrojarosite). For analysis an ICP-OES was used and the result is $[(NH_4)_{0,75}Na_{0,14}K_{0,10}Mg_{0,02}]_{\Sigma=1,01}Fe_{3,01}(SO_4)_2(OH)_6$ which is in good agreement with analytical results by other authors. Ammoniojarosite forms yellow to light brown

aggregates on natrojarosite. It is accompanied by katerinopoulosite, ktenasite, atacamite and a further as yet undefined ammonium-bearing phase.

Andersonite, $Na_2Ca(UO_2)(CO_3)_3 \cdot 6H_2O$

The andersonite from Lavrion cannot be compared with the one found at the sedimentary uranium deposits is the American southwest. In the Paleokamariza Nr. 18 Mine it forms thin, smudgy crusts that quite commonly shine through the overgrown, transparent gypsum coloring the latter yellow-green.

Underground andersonite is a welcome indicator of the above-mentioned uranium mineralization as it shows an intense light green fluorescence in both shortwave and longwave UV light. Therefore, the cheap LW-UV-LED pocket lamps available on the internet for a few Euros are sufficient to determine the centers of the uranium mineralization. Also, the fluorescence serves to distinguish andersonite from very similar looking clay minerals also appearing at this locality.



Andradite, $Ca_3Fe^{3+}_2(SiO_4)_3$

Grossular, the Aluminum-analogue of andradite, is well-known from the contact-metamorphic rocks of Lavrion, e.g. in the calcsilicate hornfels of the Plaka (BALTATZIS, 1981). The obviously much rarer andradite is mentioned by GALANOS (2009) as a short notice in the description of a contact-metamorphic formation between a granodioritic dyke and marble in the Hilarion area. This dyke was also sampled by us. In polished sections of the reaction seams we could identify rough grains of slightly manganese and aluminum-bearing andradite in rhombohedra up to 2 mm in size. The grains are often massively fractured. Rarely a zonal variation of the chemical composition could be observed. If present, there is a noticeable aluminum enrichment in a thin outer seam (Fe:Al = 0,59:0,41). The paragenesis of almandine comprises calcite, quartz, pyrrhotite with an outer seam of pyrite, ferro-actinolite, actinolite, epidote, scheelite and magnetite. Near the garnets also chamosite, fluorapatite, and very rarely the accessory minerals allanite-(Ce), monazite-(Ce), bastnäsite-(Ce), synchysite-(Ce), xenotime-(Y) und zircon.

Also, we could identify andradite in a skarn in the Adami 2 adit (KOLITSCH et al., 2015). The extensive paragenesis comprises here grossular, epidote, clinozoisite, allanite-(Ce), titanite, diopside, hedenbergite, chamosite, Potassium feldspar minerals, anorthite, calcite and quartz, as well as accessory zircon and traces of sulfides and tellurides.

Anilite, Cu_7S_4

The ink-blue and up to millimeter large platelets of anilite were first considered to be covellite until it was noticed that the crystals were not hexagonal but rather pseudo-

tetragonal (with an octagonal outline). They were found in an area known to collectors as “Rogger Pocket” at the 3rd Level of the Hilarion area which is well-known for its interesting formations. Anilite is accompanied by quartz, scorodite, parascorodite, kaatialaite and anglesite.

Auriacusite, $Fe^{3+}Cu^{2+}(AsO_4)O$

A literally nice surprise is the occurrence of the mineral auriacusite from the olivenite group of minerals. The specimen originates from the 3rd Level of the Christiana Mine. Grown between jarosite crystals are golden yellow sprays of crystals. Strictly speaking

this is not a new discovery because the specimen was collected in 1998. However, the identity of auriacusite was established only recently. Unfortunately, a re-visit of the area made it clear, that from this point there will be no more specimens. Busy “collectors” have thoroughly cleaned out any remaining pieces.

Bastnäsite-(Ce), $Ce(CO_3)F$

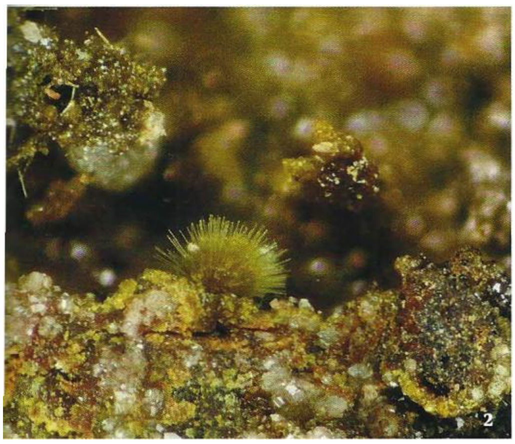
In a polished section of the contact seam between an acid magmatic dyke and marble at a location at the 2^{nd} Level of the Hilarion area bastnäsite-(Ce) was found intergrown with synchysite-(Ce). So far only bastnäsite-(La) as known from Lavrion which was formed in a secondary environment (Gröbner und Kolitsch, 2002).

Bayleyite, $Mg_2(UO_2)(CO_3)_3{\cdot}18H_2O$

The previously mentioned andersonite and bayleyite share many similarities. Its existence was only noticed because of the markedly weaker reaction in LW UV light. In all other aspects it cannot visually be distinguished from andersonite. Its provenance is – like most other uranium minerals – the recently discovered uranium-paragenesis in Pakeokamariza Mine #18.

Beidellite, $(Na,Ca_{0.5})_{0.3}Al_2((Si,Al)_4O_{10})(OH)_2 \cdot nH_2O$

Beidellite is a mineral of the smectite group. In Christiana Mine it has – for a smectite mineral – a close to perfect stoichiometric composition with iron beneath detection limit for SEM-EDX. It forms white balls on massive marble. Collectors beware: these balls disintegrate completely to submicroscopic platelets in an eventual cleaning in the ultrasonic cleaner.



Bendadaite, $Fe^{2+}Fe^{3+}_2(AsO_4)_2(OH)_2 \cdot 4H_2O$

Yellow to light greenish bundles of tiny needle-like crystals on an admixture of pyrite, arsenopyrite and galena were found together with coatings of beudantite, cerussite, pharmacosiderite and scorodite. Idividual needles have an rectangular cross-section which serves to distinguish it from beudantite and jarosite, both of which sometimes occur also in needle-like habit. The find is from a small zone at the third Level of Christiana Mine, where a still rich lead-mineralization can be found. Additionally, carminite, anglesite and mimetite were also found there.

A second occurrence with a most attractive piece is from the collection of Kostas Tzanis, Agios Konstantinos, which he found a long time ago on a dump near the Esperanza mine and which is known to host material coming from Christiana Mine. On this piece dark green (sometimes with an olive tint) to dark yellow-green (a color similar to arthurite) rounded to hemispheric aggregates with a radial structure and a maximum dimension of 3 mm are grown. At high magnification the crystals appear striated length-wise glassy, transparent and prismatic. The terminal faces are roof-shaped. In places where the hemispheres are broken it becomes visible that only the outer zone is greenish while the core is reddish brown. The core sections are – according to SXRD and EDX analyses – a Zn-rich bendadaite, while the greenish parts are Fe-bearing ojuelaite. The paragenesis consists of K- and Al-rich natropharmacosiderite, pharmacosiderite (Na- and Al-rich) and scorodite.

Bilinite, $Fe^{2+}Fe^{3+}_2(SO_4)_4\cdot 22H_2O$

At the type locality of hilarionite at the 3rd Level of the Hilarion area nondescript, beige crusts of radial aggregates were found next to copiapite, metavoltine and fibroferrite. The were found to be bilinite which is very unstable under normal ambient conditions. It usually disintegrates to individual fibers within a few weeks.

Bonattite, $CuSO_4\cdot 3H_2O$

At a locality at the 3rd level of the Hilarion area that was given the nick-name "parnauite-place" because of the fantastic finds of this mineral there another surprise became evident when the sulfates covering an entire wall of the diggings were analyzed. While mostly chalcanthite, epsomite and brochantite, with minor antlerite were found the color of some areas did not match that of chalcanthite. This lighter colored material (all combined about a square meter) did not show "rams' horn" formations and turned out to be bonattite. Further observations will clear whether this is a seasonal change between chalcanthite and bonattite or not.

Brannerite, $(U^{4+},REE,Th,Ca)(Ti,Fe^{3+},Nb)_2(O,OH)_6$

A routine analysis with SEM-EDS of a polished section of a sulfide-rich ore from "Rogger Pocket" at the 3rd level of the Hilarion area surprisingly revealed a grain (ca. 5 µm) of brannerite grown within arsenopyrite (KOLITSCH et al., 2015). This constitutes the first discovery of a primary uranium-bearing mineral at Lavrion. The analyzed grain is quite pure having only slight Fe- and Ca-contents. So next to uraninite described later in this text, uranium-bearing zircon and xenotime-(Y) also brannerite may be considered as the source of uranium for the secondary uranium minerals found in Lavrion.

Caracolite, $Na_2(Pb_2Na)(SO_4)_3Cl$

The paragenesis of rare sulfate minerals at the 4^{th} Level of the Hilarion area also includes colorless, platy and pseudohexagonal crystals of caracolite. It is accompanied by bluegreen kröhnkite, changoite and natrojarosite. Slight nooks at the "hexagonal" prism faces help with the identification and show the drillings quite like those of aragonite.

Carlhintzeite, $Ca_2[AlF_6]F{\cdot}H_2O$

Colorless crystals grown on black botryoidal iron oxides and resembling adamite (that does not occur in this paragenesis!) were identified as the rare calcium-aluminum-fluoride carlhintzeite. The specimens hail from the same place in the Adami 2 adit that yielded quite nice pieces of lepidocrocite. Lepidocrocite is also a quite common mineral accompanying carlhintzeite, next to other iron oxides and oxihydrates.

Cattierite, CoS_2

Both in the Plaka #145 adit and the Sclives mine a paragenesis of cobalt-bearing minerals is found with erythrite as indicating mineral. The matrix contains cobaltite (see further down) as a common accessory mineral which is responsible for the formation of the erythrite. In this pieces pyrrhotite is also commonly found and in one of these tiny inclusions (up to 15 µm) of cattierite were found (KOLITSCH et al., 2015). It is noteworthy that the cattierite grains reflect the nickel-content of the surrounding pyrrhotite: the Pyrrhotite at the rim of the grains is noticable richer in nickel (up to Fe:Ni = 2:1) and the cattierite grains in this zone also contain more (Co:Ni = 3:1), while at the nickel poor cores of the pyrrhotite the proportion is Co:Ni = 20:1 in cattierite.

Celestine, $SrSO_4$

Celestine is – rather surprisingly – a first discovery for Lavrion. It forms crystals ranging from dark brown, to orange, yellow to colorless and a size of up to 2 mm. They are partially included or grown on top of gypsum in the now famous paragenesis of uranium-bearing minerals in the Paleokamariza #18 Mine proving them to be a late formation within the sequence. The crystals are thin platy to stocky. All types have in common that the crystal faces are mirror bright and often a goodly number of vicinal faces are exhibited.

Ceruleite, $Cu_2Al_7(AsO_4)_4(OH)_{13}\cdot 11,5H_2O$

At the 3rd Level of the Hilarion area in a short side working a zone of very nice secondary minerals was found. Especially cyanotrichite and spangolite were mined there for years by Greek collectors. In a lateral zone, arsenate-rich minerals were found, among others beautiful pharmacosiderite. Light blue fracture fillings in quartz with radial structure were initially considered to be cyanotrichite but turned out to be ceruleite with means of PXRD and SEM-EDX. Note that only such fracture fillings in quartz were ceruleite, while the same in gypsum or gossan matrix uniformly were found to be cyanotrichite.

Chamosite, $(Fe^{2+},Mg)_5Al(AlSi_3O_{10})(OH)_8$

In the literature the iron-dominant member of the chlorite group of minerals has not been mentioned so far. It was identified in several specimens from different paragenetic sequences. Among the analyzed pieces were pyrrhotite-bearing skarn from Adami 2 adit, a contact seam between an acid intrusive and marble from the 2nd Level of the Hilarion area and a polished sample of a chalcopyrite-galena-sphalerite ore from the -1 Level of Plaka #80 mine. Unpublished data from prior finds include magnetite-bearing specimens from Mount Mavrou Lithari in the Sounion area and as the cores from baileychlore-aggregates.

Changoite, $Na_2Zn(SO_4)_2\cdot 4H_2O$

Colorless, rounded stocky crystals up to 2 mm from the kröhnkite paragenesis were identified as the zinc-analog of blödite. It is quite rare in this paragenesis and can easily be mistaken for ill-developed caracolite. On the specimens at hand it seems to be the latest mineral to form as it includes samples of all other minerals found there.

Christelite, $Zn_3Cu_2(SO_4)_2(OH)_6\cdot 4H_2O$

Christelite is found in two places in Lavrion. It was first discovered in 2014 in a cadmium-bearing variety in the Esperanza Mine. It occurs as light blue grains from a few hundredths of a millimeter to exceptional half millimeter diameter. They show no crystallographic terminations.

Much nicer are the pieces found in the Sounion #19 Mine. In a place not far from the annabergite locality an area was discovered where smithsonite, serpierite, schulenbergite, ktenasite and brochantite could be found. Just like in the Jean Baptiste Mine in the Kamariza area the smithsonite is sometimes replaced by copper-zinc-sulfates forming pseudomorphs. Some of these were identified as christelite. It is light blue and thus easily distinguishable from the darker blue serpierite which is an often-found companion mineral. The pseudomorphs reach up to a centimeter in size.

Chukhrovite-(Ca), $Ca_{4.5}Al_2(SO_4)F_{13}\cdot12H_2O$

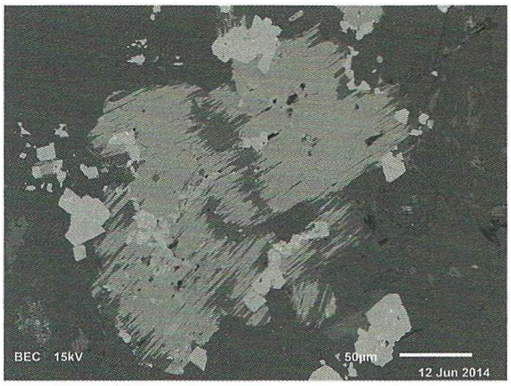
For a long time, the area "Christian 132" is known for the occurrence of the calcium-aluminum-fluoride gearksutite. A sampling of the location in autumn 2013 yielded some more minerals of this general chemical composition: Chukhrovite-(Ca), creedite, prosopite and yaroslavite.

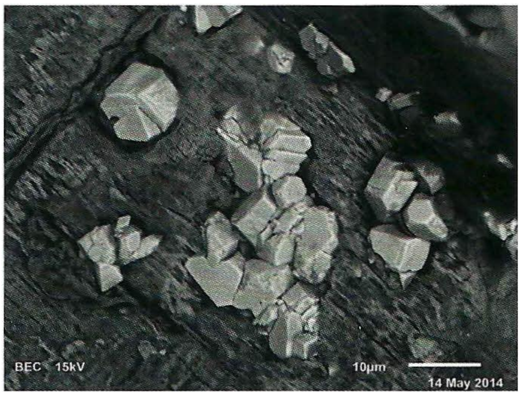
Chukhrovite-(Ca) forms colorless cubes that are often, but not always modified by octahedra faces. This makes chukhrovite-(Ca) from this locality somewhat special, because in most other localities it forms only octahedra. On broken crystals it is easy to distinguish it from similar looking fluorite by its missing octahedral cleavage.

Chukhrovite-(Ca) is always grown on quartz crystals and accompanied by sheaves of white mimetite.

Cobaltite, CoAsS

In many polished sections of ore minerals from both the Adami 2 adit, the Plaka #145 adit and the Sclives mine comprising pyrrhotite-bearing skarn and matrix pieces from the erythrite samples cobaltite was identified quite often in grains up to 0,2 mm. Typically the form idiomorphic crystals (KOLITSCH et al., 2015). Thus, the hitherto

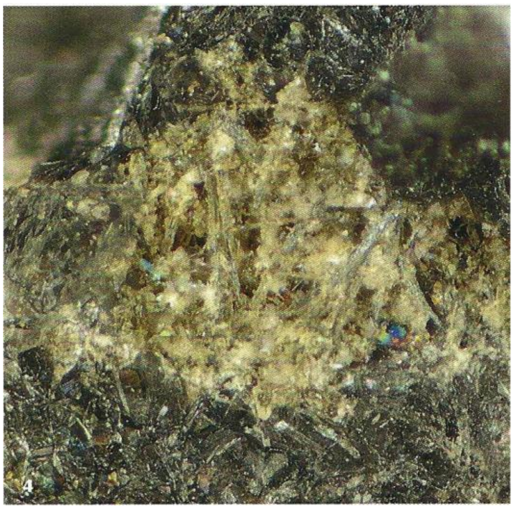




unknown source of cobalt for the secondary minerals erythrite, cobaltkoritnigite and smolyaninovite could be identified.

Cobaltkoritnigite, $(Co,Mg,Zn)(HAsO_4)\cdot H_2O$

Cobaltkoritnigite is a mineral that – due to the enhanced analytical methods and their broader availability – is found in many places where erythrite had previously been described from. The Plaka #145 mine is no exception. Cobaltkoritnigite forms pointy, elongated after the c-axis, lathlike to needle-like crystals that are usually radially aggregated. The color is not only dependent from the thickness of the crystals but also from the magnesium-content. Color is no suitable means of differentiation between the similar-looking minerals cobaltkoritnigite, erythrite and magnesiokoritnigite. One way of distinguishing between erythrite and cobaltkoritnigite is the shape of the crystals (where visible), however the distinction between cobaltkoritnigite and magnesiokoritnigite can only be done by advanced means of analysis.



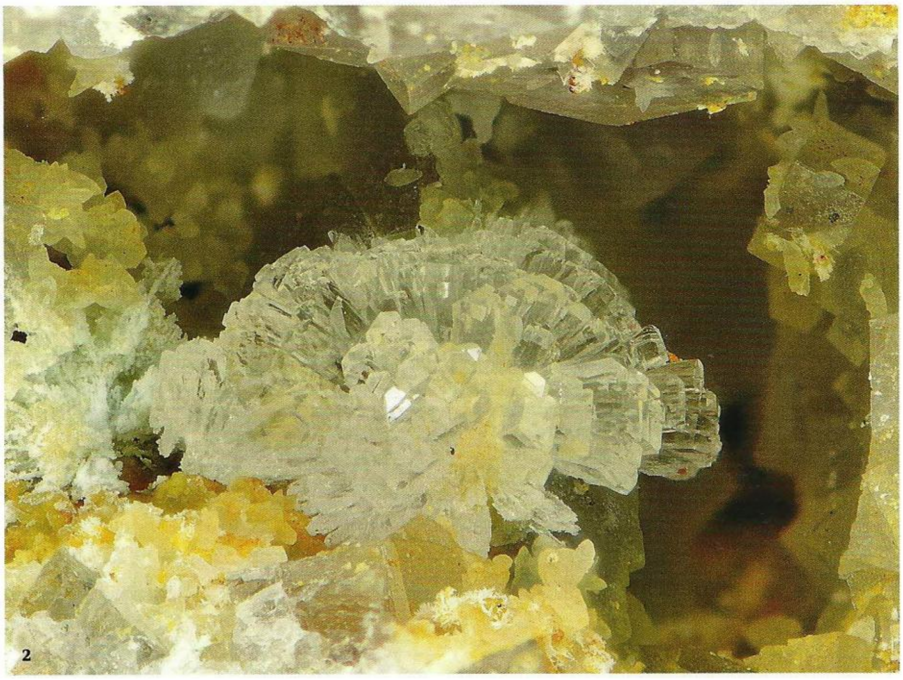
Coquandite, $Sb_{6+x}O_{8+x}(SO_4)(OH)_x(H_2O)_{1-x}$ (x = 0.3)

Stibnite not always (but most commonly) alters to stibiconite. At a locality now commonly referred to as “Vasili’s Arsenic place” among collectors in the Plaka #145 Mine sometimes aggregates of stibnite were found coated with mirror-bright (and thereby distinguishable from stibiconite) lathlike crystals of coquandite. The crystals are pliable like gypsum which it resembles in SEM imagery.


1

Corkite, $PbFe_3(PO_4)(SO_4)(OH)_6$

In the quartz-rich rock of the vauquelinite-locality in the Exi mine in Sounion (not to be confused with the much more common localities for fornacite in the Exi mine) there are vugs with light brown to greenish yellow platy to steep pyramidal crystals of corkite that were often taken for jarosite. The proportions of iron to copper (Fe:Cu = 5:1 bis 7:1) and the sulfate content point to a solid solution with beaverite-(Cu). In direct paragenesis only iron oxides and hydroxides, as well as quartz crystals are found.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Creedite, $Ca_3SO_4Al_2F_8(OH)_2 \cdot 2H_2O$

The occurrence of creedite has been known for a long time from pseudomorphs of gibbsite after creedite that contain remnants of creedite

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in its core. A new discovery of exceptionally well crystalized is now reported here. The prismatic crystals are colorless or milky white and were initially considered to be aragonite. The reason for this misidentification is the habit with “straight” terminal faces which is uncommon for this mineral. After the initial discovery in the Christiana 132 are the locality was revisited in spring 2014 and then also the typical terminations were found on some of the crystals. The individual crystals are usually aggregated to small groups or “suns”. They reach 12 mm in length with one exceptional specimen containing crystals up to 22 mm. Sometimes the crystals are in the process of dissolution which renders them dull white. Also found were crystals with an overgrowth of a second generation. The most common accompanying minerals are smithsonite, mimetite quartz, fluorite, gypsum and the other Calcium-Aluminum-Fluorides reported her.

Dussertite, $BaFe^{3+}_3(AsO_4)_2(OH)_5$

At the locality already described which yielded the ceruleite specimens there were some cavities found that were plastered with a beige coating. With the aid of a SEM trigonal (pseudohexagonal) platelets are discernable. These crystals have a maximum diameter of 30 µm. The mineral looks like arseniosiderite and is the only mineral in the cavities. Like the specimens from the type locality dussertite from Lavrion is almost pure and hardly contains any trace elements. Dussertite seems to have exhausted the supply of barium, as the pharmacosiderite in nearby vugs does not contain any noticeable barium.

Edwardsite, $Cu_3Cd_2(SO_4)_2(OH)_6 \cdot 4H_2O$

In the paragenesis of niedermayrite occasionally light blue sheaves of crystals occur. The chemical composition of this mineral has been known for a long time, but only a new discovery from spring 2015 allowed the unambiguous identification as edwardsite. Meanwhile it has been identified from all localities where niedermayrite has been found in the Lavrion mining district (Esperanza mine, Hilarion mine, Villia #111 mine, Sounion #19 mine). The discovery in the Esperanza mine from spring 2015 is interesting insofar as edwardsite is the only oxidic at this site.

Famatinite, Cu_3SbS_4

The occurrence of famatinite was reported by the first author already in 1999 albeit in a short notice without further description. Previously it has been known only as rounded grains included in chalcopyrite-tetrahedrite ore. Its pink tint is distinctive.

In the Esperanza mine a vein was discovered which contains mainly massive bournonite. Included are also grains of famatinite up to 20 mm. Chemically it is a solid solution with luzonite with a Sb : As = 7 : 1. Above, it also contains up to 0,36% cadmium which makes it an important source for the cadmium-bearing minerals niedermayrite, lazaridisite and voudourisite which are locally abundant.

Ferricopiapite, $Fe_5(SO_4)_6O(OH)\cdot 20H_2O$

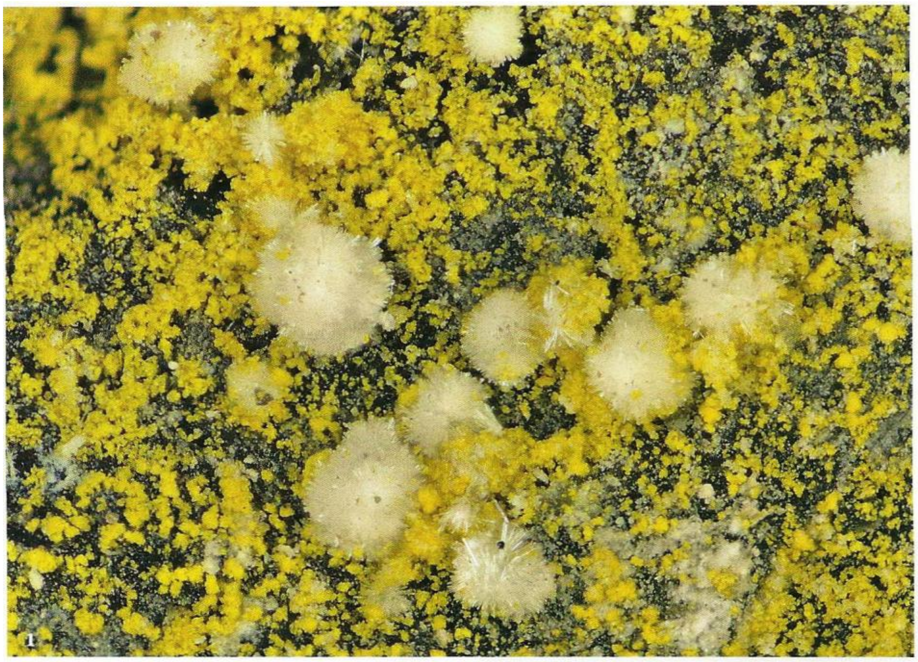
In numerous locations in Lavrion accumulations of iron sulfates occur as decomposition products of pyrite-bearing rocks. Especially those in the Plaka area are well-known for their richness in different and also rare species. The Greek collector Kostas Kapellas and his son Christos have found another such locality in the Sounion area at the southern tip of the peninsula. It is not as rich as the localities in Plaka, but it is most interesting nevertheless. First it contained römerite crystals up to 10 mm length which is enormous for the mineral and rich fibroferrite aggregates up to 40 cm, and secondly it is responsible for yet another new discovery from Lavrion: ferricopiapite. Up to 20 cm large aggregates consisting of individual crystals up to 0,3 mm were analyzed by Professor C.L. Lengauer with PXRD at the University of Vienna.

Ferrimolybdite, $Fe_2(MoO_4)_3 \cdot nH_2O$

Ferrimolybdite is a common secondary mineral occurring from the weathering of molybdenite. It is therefore no surprise that it is also found at the Plaka Porphyry deposit where molybdenite is locally abundant. It forms the typical yellow, radiating fracture fillings in quartz. Apart from remnants of molybdenite, only limonite and pyrite are found with ferrimolybdite.

Ferrinatrite, $Na_3Fe(SO_4)_3 \cdot 3H_2O$

At the 4th Level of the Hilarion area on the way to the world-famous mixite locality one passes through an area of dark grey and very crumbly schist. This part of the mine is supported by a massive concrete shoring system or it would have collapsed a long time ago. The decomposition of the host rock is caused by the sulfide minerals that weather to secondary sulfates under the influence of large amount of ground moisture (the gallery is nearly at sea-level!). The weathering goes hand in hand with an increase of volume which effectively destroys the schist matrix rendering such places highly dangerous. The sea-water seeping in is a rich source of sodium leading to the formation of sodium-bearing secondary minerals. At one place a large area has been covered with beautiful sideronatrite/metasideronatrite an in other areas crusts of metavoltine and glassy sprays up to ½ mm of ferrinatrite formed. These can easily be confused with gypsum of the same habit.



Ferrinatrite was also found in the Sounion #19 mine at the place of first discovery of sideronatrite for Lavrion, as well as other places in the Kamariza area, the Esperanza mine and the Dipseliza mines. Careful attention will probably lead to more discoveries of this mineral yet.

Ferro-Actinolite, $\square\{Ca_2\}\{Fe^{2+}_5\}(Si_8O_{22})(OH)_2$

In a rock sample from outside the near the parking place at the Plaka Sulfate Locality I surprisingly ferro-actinolite was discovered (KOLITSCH et al., 2015). The sample itself is a piece of fine-grained, grey green skarn with macroscopically visible iron sulfide and galena especially in thin calcite veins. A detailed SEM-EDS analysis of a polished sectionshows, that ferro-actinolite is locally abundant and generally forms more or less idiomorphic crystals. It is found in calcite, quartz, limonite, or the ore minerals. The crystals show a slight zonal growth with Fe : Mg between 1,95 and 1,20. The analyses show that apart from the main constituents there are always at least traces of Mn and partly also Al, Na and Cl. The main constituents of the rock sample are much epidote, calcite and chamosite. Subordinate components are diopside, hedenbergite and quartz. Ferro-Actinolite – as well as actinolite – are also constituents of the rock from the old granodiorite mine in Plaka with Fe:Mg:Mn = 8:4:1.

Fluorapatite, $Ca_5(PO_4)_3F$

Fluorapatite has been known as a primary mineral in the ores from Lavrion for a long time (Skarpelis, 2007) and was identified by us surprisingly often in various polished sections. Specimen that would raise the interest of collectors however have been unknown so far. On a sample collected by the second author in the Exi mine and that were initially discarded as visually identified aragonite there are colorless to white spherical aggregates that were identified by means of SEM-EDX as secondary (!) fluorapatite. The spheres consist of sharp, radially oriented hexagonal crystals, grown on well-formed jarosite. Rarely individual crystals may be observed. Based on the measured ratio of Ca : P, which are slightly off for pure fluorapatite it seems that a small component of carbonate is present.

Freieslebenite, $AgPbSbS_3$

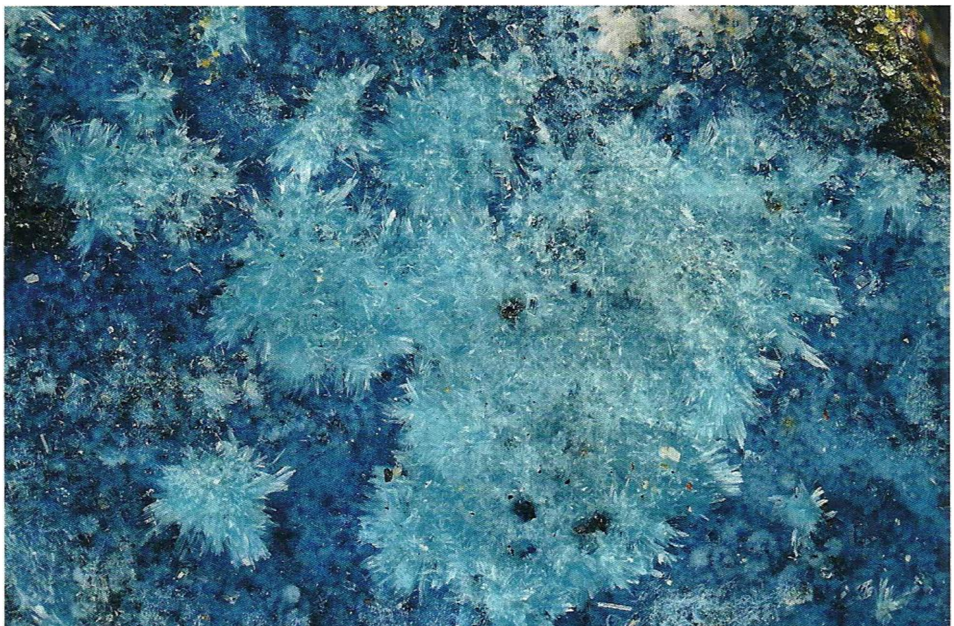
The Plaka #80 mine is known for the occurrence of silver-bearing minerals in relatively low temperature hydrothermal veins. One sample from one such vein rich in galena and sphalerite and symmetrical in respect to the salband from the locality that became famous among Lavrion collectors for the occurrence of wire-silver was analyzed on a polished section crosscutting the vein with SEM-EDS. In the matrix of carbonates intergrowths of galena, pyrargyrite and freieslebenite could be observed, the latter forming tiny grains usually smaller than 10 µm (KOLITSCH et al., 2015). Locally the arsenic content was found to be higher that the antimony content so that marrite is also present (see later in this text).

Geminite, $Cu(HAsO_4) \cdot H_2O$

This copper mineral was found to be a component of blue-green, amorphous seeming crusts from the paragenesis of arsenocrandallite in the Cristiana 132 mine. The rather unattractive and uncharacteristic aggregates were unambiguously identified by PXRD but have only statistical meaning for the locality.

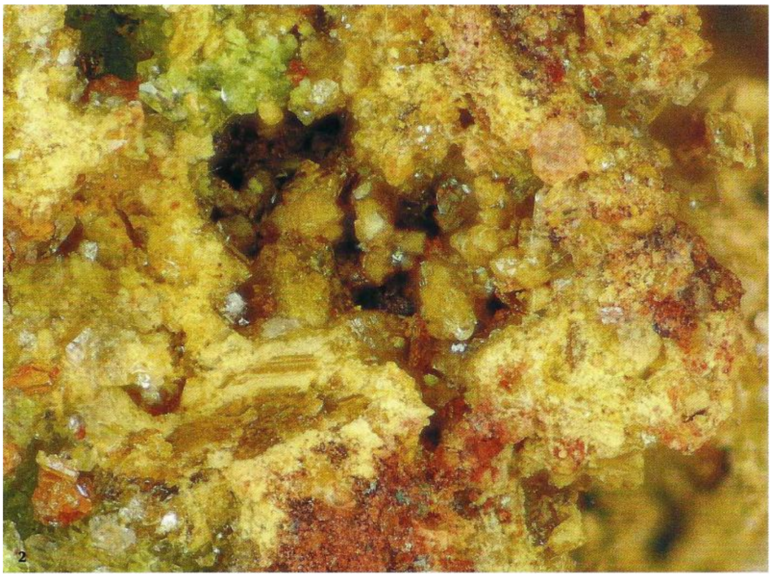
Grandviewite, $Cu_3Al_9(SO_4)_2(OH)_{29}$

On an intermediate level between the 3rd and 4th Level of the Hilarion area a small ore-chute that has pyrite, galena, sphalerite and rich chalcopyrite. On fracture seams in this material cyanotrichite occurs in rich and beautiful albeit small crystals. Occasionally on these druses, light blue sheaves of lath-like crystals are found that are noticeable by their lighter color than that of cyanotrichite. These crystals were identified as grandviewite – only the third locality worldwide.



Graulichite-(Ce), $CeFe^{3+}_3(AsO_4)_2(OH)_6$

Not far from the well-known locality for rich chenevixite-specimens at the 2nd Level of the Jean Baptiste mine some very rich and species-defining specimens of beudantite were found. These are light green to brown and usually thin tabular. Therefor the rounded and orange crystals of graulichite-(Ce) are quite easily distinguishable. Element distribution could be discerned as the means of 4 samples: A-lattice position = $(Ce_{0.68}\ La_{0.10}\ Nd_{0.09}\ Gd_{0.08}\ Ba_{0.05}\ Sr_{0.02})_{\Sigma 1.02}$ and B-lattice-position = $(Fe_{2.85}\ Al_{0.23})_{\Sigma 3.08}$. Until the time of writing only a small number of specimens have been found.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Haidingerite, $CaHAsO_4 \cdot H_2O$

Among the secondary calcium arsenates of the "arsenic-paragenesis" sometimes clear crystals that resemble gypsum can be found grouped to small aggregates. So far we could identify haidingerite in places in Adami 2 adit, the Plaka #145 mine and the Plaka #80 mine, all in the wider Plaka area.

Hohmannite and Metahohmannite, $Fe^{3+}_2(SO_4)_2O \cdot 8H_2O$ und $Fe^{3+}_2(SO_4)_2O \cdot 4H_2O$

Hohmannite is one of these minerals that can only be found during a certain season of the year. It can be collected – depending on the outside weather – in parts of the Plaka Sulfate Locality II (diggings close to the surface that have open ventilation) usually at the end of March until mid-April. Then – and only then – the ambient temperatures and humidity allow for the formation of hohmannite from the weathering of the iron sulfides included in the host rock. If the samples are taken at the right time and conserved – e.g. with the method after Wolfsried (WOLFSRIED 2016) – then one can enjoy the resinous, dark brown crystals of hohmannite. Failing to do so, hohmannite decomposes inevitably to metahohmannite which is found in Lavrion as fine powder. Sometimes it forms small pyramidal heaps at the Plaka Sulfate Locality II where it trickles down from the ceiling.

Ianthinite, $U^{4+}{}_2(UO_2)_4O_6(OH)_4 \cdot 9H_2O$

All ianthinite-crystals found so far are included in gypsum. They form dark blue-violet needle-like crystals up to 0,3 mm in length. Sometimes the crystals are deep purple at one end and yellow at the other. Obviously, this is some kind of partial pseudomorph of which only ianthinite is identified without doubt. Of course, this mineral hails from the uranium-paragenesis from the Paleokamariza #18 mine.

Kaatialaite, $Fe(H_2AsO_4)_3 \cdot 5H_2O$

Kaatialaite is an indicator of an extremely acid environment. It forms felted masses of colorless to white needles that are found loose in cavities of quartz and scorodite. If these cavities are opened, the masses usually fall out, so matrix specimens are quite rare. The locality where they are found is the fabled "Rogger Pocket" at the 3rd Level of the Hilarion area. Apart from the already mentioned quartz and scorodite the paragenesis consists of parascorodite, sarmientite, zýkaite, anilite und anglesite. The small number of specimens recovered so far indicate that kaatialaite forms only in such cavities that also yield anglesite.

Katerinopoulosite, $(NH_4)_2Zn(SO_4)_2 \cdot 6H_2O$

The most recent of the new minerals described with a type locality in Lavrion is the Tutton's salt and Zinc-analogue to boussingaultite, nickelboussingaultite (which also occurs at the same locality) and mohrite. Recently accepted under IMA-number 2017-004 (CHUKANOV et al. 2017) the original description has now been published (CHUKANOV et al. 2018). The type locality is the Esperanza Mine in the Kaminiza area.

Katerinopoulosite occurs as white, grey or colorless crystals that usually have a "rounded" appearance. They are grown on other sulfates of the paragenesis or included in solid solutions of the melanterite-boothite-zincmelanterite-series (in all analyzed grains the melanterite component dominates). Such pieces are very attractive by their contrast. It may be confused with rapidcreekite which occurs in the same type of paragenesis but whose crystals are always sharp-edged. With little information available up to now it is an unfortunate fact, that on various internet platforms specimens were offered for sale which do indeed come from the type locality, but do not contain any noticeable katerinopoulosite. The individual aggregates are usually no larger than 1-2 mm, but in exceptional cases they form aggregates up to 30 mm in length. In these cases, they resemble the epsomite "ram's horn" aggregates which are quite common at the type locality. These "big" katerinopoulosite are quite often seen covered by a thin layer of nickelboussingaultite. Especially interesting are such pieces where in addition to katerinopoulosite also niedermayrite in thin platy crystals, lazaridisite in very nice, sharp-edged crystals and voudourisite are found on the same specimen.

Kochsándorite, $CaAl_2(CO_3)_2(OH)_4 \cdot H_2O$

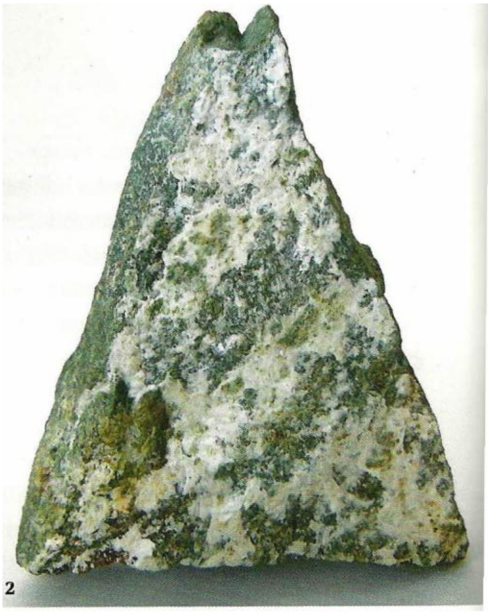
In the area that yielded katerinopoulosite there are many places that are covered by centimeter-thick crusts of chalcanthite – a magnificent view! However, this crust also hides some very interesting minerals. By gentle dissolution of the chalcanthite from matrix specimen remaining after trimming in one case brittle, white crystals appeared grown directly on graphite-bearing schist. These were found to be Kochsándorit by

PXRD. Unfortunately, the crystal quality was not enough for single crystal work. The fibrous aggregates cover areas of several square millimeters.

Kröhnkite, $Na_2Cu(SO_4)_2 \cdot 2H_2O$

Kröhnkite has been known to appear in Lavrion for quite a while, but a detailed description of its properties has been missing so far. At the 4th Level of the Hilarion area – nearly at sea-lever – there are several places with very interesting sulfate minerals. They form from the weathering of the primary sulfide minerals and sometimes this process renders the afflicted headings instable and very dangerous to travel. The closeness to the sea brings a certain sodium-content to the otherwise calcium-dominated environment and thus the appearance of sodium-bearing secondary minerals. One such is kröhnkite. It forms – usually oblong – grains of light blue color without noticeable crystallographic forms. They usually are found on a matrix of yellow iron sulfates (mostly natrojarosite), but rarely directly on sulfide ore. It is accompanied by rare, sodium-bearing secondary minerals like changoite, caracolite and natrojarosite.

Laumontite, $CaAl_2Si_4O_{12} \cdot 4H_2O$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The appearance of a zeolite mineral is – at first glance – not to be expected as this group of minerals is commonly associated with volcanoes. Laumontite is also a mineral that occurs regularly in rocks of a low-grade metamorphism and there is plenty of such rocks in the Lavrion mining area. In the wake of the (high-temperature) metamorphic events surrounding the rise of acid plutonites in the Plaka area, some rocks were affected by a low-temperature, retrograde metamorphism which enabled the formation of laumontite in fracture seams. On a piece of fine-grained, dark grey-green skarn from the Adami 2 adit one side was completely covered by crystals and cleavages with the typical, pearly luster which helps do distinguish it from calcite and which also may be found on fractures in the metamorphic rocks (locally called Plakites).

Leightonite, $K_2Ca_2Cu(SO_4)_4 \cdot 2H_2O$

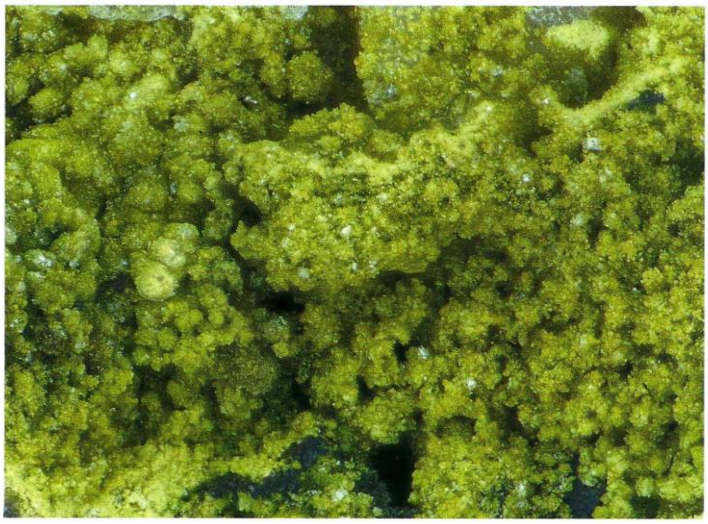
Not the typical form of appearance of leightonite is found in the Esperanza Mine, but rather pseudo-tetragonal, thin platy and very light blue crystals. It is accompanied by antlerite, brochantite, boleite, caracolite, natrochalcite and gypsum. The crystals rarely reach more than 0,1 mm on edge and their thickness almost never exceeds a few 100^th^ of a millimeter. Thus, they are nearly colorless and not comparable to those from the fabled Chilean localities.

Lemanskiite, $NaCaCu_5(AsO_4)_4Cl\cdot5H_2O$

Lemanskiite is the tetragonal dimorph of lavendulan and can only be distinguished from the latter by advanced analytical methods even more complicated by the fact that pulverizing lavendulan for PXRD analysis may trigger the formation of lemanskiite in the sample.

A positive identification of lemanskiite has so far exclusively come from samples from a single locality at the 2nd Level of the Jean Baptiste area. To be exact it is the same place that has also yielded annabergite specimens. At this place a small seam of a brittle, glassy brown matrix contains flat spaces and clefts that contain light blue fans of lemanskiite. Rare accessory minerals are chlorargyrite, olivenite, parnauite and cornwallite. However, usually lemanskiite is the only mineral in the open spaces. To help with the identification the trace content of lead in the minerals. So far, the authors could find traces of lead in lavendulan (solid solution with zdeněkite) in most (but not all) samples. Lemanskiite however has always been lead-free. The senior author has acquired numerous specimens of “lemanskiite” from Lavrion via different internet sources and mineral dealers at the Munich show with the sad result that all samples turned out to be lavendulan and not a single specimen of lemanskiite. The reader is therefore advised to be cautious with such offers.

Lukrahnite, $Ca(Cu,Zn)(Fe^{3+},Zn)(AsO_4)_2\cdot2(H_2O,OH)$



The Greek collector Mr. Michalis Kazamiakis discovered a specimen on a small dump near the Sounion #19 mine that contains pointed and mostly twinned, olive-green crystals of lukrahnite, grown directly on quartz. The ratio of Cu : Fe : Zn = 4 : 4 : 3. Some conichalcite is found as an accessory mineral. Unfortunately, the one specimen has remained a single, isolated find although an extensive search was carried out to find more study material.

Magnesiokoritnigite, $Mg(AsO_3OH)\cdot H_2O$

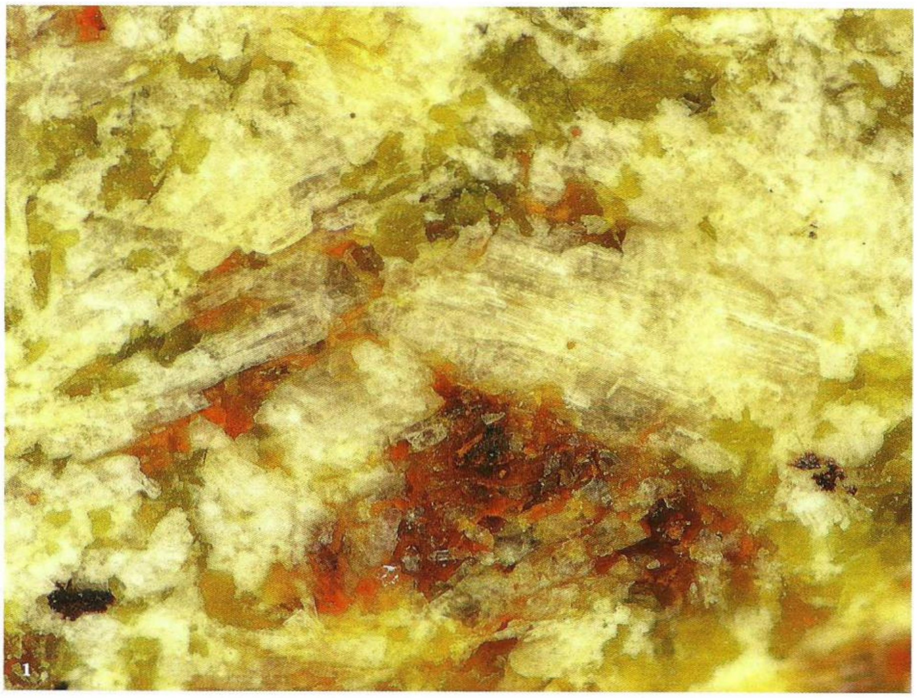
Aside from the cobalt-dominated member of the koritnigite group of minerals the Plaka #145 mine has also yielded magnesiokoritnigite as pale pink, lathlike crystals. The so far richest specimen yielded crystals up to 40 µm in width and 450 µm in length. The differentiation between the cobalt-dominant and the magnesium dominant member can only be done with advanced methods of analysis. Color cannot serve as a method! Also, the similarity to erythrite must be taken into account.

Mansfieldite, $AlAsO_4\cdot 2H_2O$

At the 3rd Level of the Hilarion area is a locality well-known for its lavendulan (this area also yielded the type material for kamarizaite). Little notice went to the "scorodite" at this place because it is indeed unremarkable and found in much better specimen in other places. However, it turns out that said "scorodite" is in some cases actually the aluminum-dominant member mansfieldite with an outer rim that is Fe-rich and a more Al-rich core (Al : Fe = 4 : 1 - 6 : 1). Accessory minerals are needle-like quartz, light blue lavendulan and anglesite.

Marialite, $Na_4Al_3Si_9O_{24}Cl$

The vanadinite crystals from the new discovery in the Plaka #145 mine are grown on a matrix that contain colorless to white, lathlike to fibrous crystals. Analysis showed, that they are members of the scapolite group (marialite-meionite-series) with a composition that puts them clearly in the marialite field (90% marialite).



Marrite, $AgPbAsS_3$

In the above-mentioned polished section containing freieslebenite from the Plaka #80 mine tiny grains of Sb-rich marrite were discovered which is the As-analog to freieslebenite. The simplified empirical formula of the measured grains is $(Ag_{0,81}Cu_{0,19})Pb(As_{0,53}Sb_{0,47})S_3$.

Mcnearite, $NaCa_5(AsO_4)(HAsO_4)_4 \cdot 4H_2O$

Also in the lavendulan-bearing zone at the 3rd Level of the Hilarion area, the mineral mcnearite was discovered. Already in our last article on new discoveries from the Lavrion mining area (KOLITSCH et al. 2014) this mineral was mentioned in the paragenesis of slavkovite but at the time the characterization was not completed, so it was called "unknown Na-Ca-arsenate". With the new finds from 2016 we were now able to pin the identification to mcnearite. It forms, white bladed crystals with a pearly sheen that are loosely aggregated. It is accompanied by scorodite, lavendulan, slavkovite and jarosite.

Minohlite, $(Cu,Zn)_7(SO_4)_2(OH)_{10} \cdot 8H_2O$

There is a number of (pseudo)hexagonal copper-zinc-sulfates that are not easily distinguishable visually. Amongst those are hodgesmithite, schulenbergite, minohlite and namuwite. SXRD-analysis and Raman-spectroscopy (if comparative data is available) can help to identify these minerals.

Quite near the locality that is known as "blue lakes" from which hail devilline specimens that rank amongst the world's best is a small digging that has yielded rare copper-zinc-sulfates. Ramsbeckite, schulenbergite, serpierite, ktenasite and the lead-sulfate linarite have previously been identified from there. Now, also minohlite has been discovered. To separate schulenbergite from minohlite requites very precise XRD-analysis (there is no comparative RAMAN data available), as both form light blue-green six-sided platelets usually aggregated to form small rosettes.

Monazite-(Ce), $Ce(PO_4)$

At the slag locality "Legrena Cove" the Legrena valley finally reaches the sea. Steep cliffs form part of the sea shore. The schist visible there is riddled with "alpinotype" clefts in which the typical minerals for such an environment are found: rutile, anatase, brookite, synchysite-(Ce), pyrite and – as a new discovery for Lavrion – monazite-(Ce). It forms pale pink to light brown stubby crystals mostly

embedded in massive quartz and only rarely as free-standing crystals in cavities. Usually they do not exceed 1 mm.

Monazite-(Ce) was also identified by SEM-EDS from a polished section of a molybdenite-bearing quartz sample from the Plaka Porphyry deposit (KOLITSCH et al., 2015). Here it is a relatively common accessory mineral, usually in 10 µm-sized grains, but rarely as big as 80 µm. It is intergrown with xenotime-(Y) or molybdenite. Also in a polished sample, monazite-(Ce) was discovered from the contact seam of an acid intrusion to marble at the 2nd Level of the Hilarion area.

Montetrisaite, $Cu_6(SO_4)(OH)_{10}\cdot 2H_2O$

The rich and exciting secondary paragenesis in the oxidation zone of the Lavrion orebodies have let the upper levels, where relatively fresh sulfidic ores are found, go unnoticed by collectors for a long time. Highly interesting here is the 1st Level of the Jean Baptiste area. The different chemical aspects of the low temperature fluids travelling through the ore-bearing rocks lead to the formation of different secondary minerals. One such piece that at cursory observation contained langite and malachite is much more exciting: the characteristic striation gave the hint that the lathlike crystals were indeed montetrisaite, which was confirmed by SXRD.

Mottramite, $PbCuVO_4(OH)$

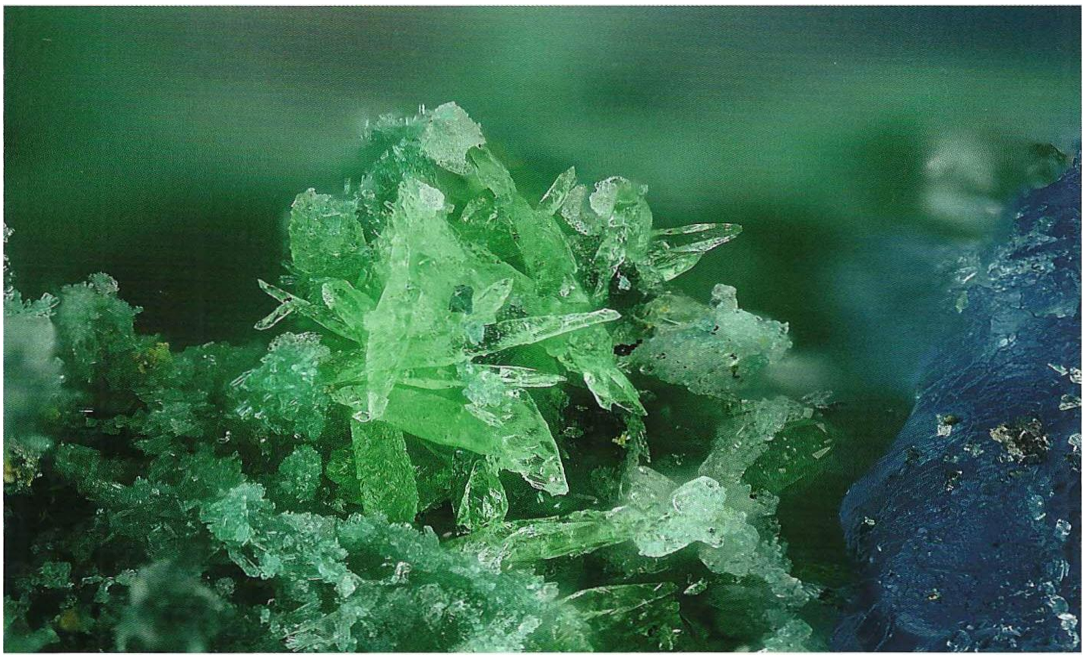
The rather surprising find of vanadinite at the Plaka #145 mine contained another interesting mineral: mottramite. On some of the pieces small, brown resinous crystals with rhomb-shaped outline and a maximum size of 0,5 mm closely resembled the arsendescloizite from the initial discovery of vanadinite in the Plaka #80 mine. SEM-EDX analyses quite clealy showed however, that vanadium dominates at the #145 mine, so the mineral is mottramite. Also, a solid solution with čechite was found in this analysis, as about 20% of the copper atoms are replaced by iron.

Natrochalcite, $NaCu_2(SO_4)_2[(OH)(H_2O)]$

Near the type locality of katerinopoulosite an ore vein consisting mainly of bournonite and famatinite can be seen. It is accompanied by numerous secondary sulfate minerals, most prominently chalcanthite, which forms crystalline crusts several centimeters thick. Upon dissolution of these crusts, a highly interesting paragenesis comes to light: what was initially considered to be brochantite is indeed antlerite and inside some of the antlerite aggregates steeply pyramidal, yellow-green crystals of natrochalcite can be found.

These reach a maximum size of 2 mm and show the characteristic striation.

Branko Rieck et al, New Minerals from Lavrion Mining District, Greece, 2018



Natropharmacosiderite, $(Na,K)Fe^{3+}_4(AsO_4)_3(OH)_4 \cdot 6\text{-}7H_2O$

As an accessory mineral of the above-mentioned bendadaite natropharmacosiderite (K- and Al-rich) forms thin crusts consisting of myriads of individual cubes of yellow to yellow-green color. In this paragenesis natropharmacosiderite is rare, most analysis falling into the field of pharmacosiderite (Na- and Al-rich). It has not been mentioned in the literature of Lavrion so far which is surprising in view of the number of other sodium-bearing species found.

The discovery of natropharmacosiderite initiated a larger survey of the chemical composition of pharmacosiderite-like minerals. It was found that natropharmacosiderite is not as rare as initially thought, while bariopharmacosiderite is even rarer. Samples from the 2nd and 3rd Level of the Hilarion area, the 1st, 2nd and 3rd Level of Christiana area (including the so-called Christiana 132), the 2nd and 3rd Level of Jean Baptiste area and the Adami 2 adit in Plaka were used in this investigation. About a third of the samples were found to be natropharmacosiderite, with cation-ratios ranging from Na:K:Ca = 8:1:1 to 5:1:2. A single sample – the one from Adami 2 adit – turned out to be bariopharmacosiderite, originating close to the well-known cerussite-locality in this adit. Also 3 samples of bariopharmacosiderite that were not taken by the authors but acquired for various dealers/collectors, having only vague locality designations (e.g.: “Kamariza”) were analyzed. None of these had a barium-content even approaching that necessary for a designation of bariopharmacosiderite. The vast majority of specimen had a composition putting them squarely in the field of pharmacosiderite. One sample from the 1st Level of the Christiana area was found to be right on the border between pharmacoalumite and natropharmacoalumite, with individual measurements ranging from pharmacoalumite in the core of the crystals and natropharmacoalumite at the rim. In all other cases the aluminum-content does not play a role in species designation.

Nickelboussingaultite, $(NH_4)_2Ni(SO_4)_2·6H_2O$

At a late stage in the formation of the katerinopoulosite-paragenesis in the Esperanza mine obviously a nickel-bearing solution added to the already complicated mix of ions. Only a couple of meters away is a small ore-shoot containing mainly primary gersdorffite, but also other nickel-bearing sulfides and sulfarsenides. The nickel-mineralization is also indicated by the colorful secondary minerals annabergite, and nickel-bearing varieties of austinite and adamite. The nickel-bearing solutions led to a replacement of zinc in the structure of katerinopoulosite by nickel and the formation of nickelboussingaultite which covers katerinopoulosite-aggregates at the rim, but also forming individual grains.

Nickeltsumcorite, $Pb(Ni,Fe^{3+})_2(AsO_4)_2·(H_2O,OH)_2$

This mineral was first discovered and described from the fabled Km3 locality by Russian mineralogists (PEKOV et al. 2016). Nickeltsumcorite forms crusts of radia elongated crystals that often fill entire cavities. It has a characteristic brown color and is commonly accompanied by annabergite, gaspéite, dolomite, as well as iron- and manganese oxides and hydroxides. It is found most commonly in gersdorffite-rich areas. Nickeltsumcorite forms a series with nickellotharmeyerite that has been known to occur at Lavrion much longer. With higher Ca-content the color changes from brown to yellowish-green.

Nováčekite-II, $Mg(UO_2)_2(AsO_4)_2·9H_2O$

On a specimen from the uranium paragenesis from the Paleokamariza #18 mine small crystals of a uranium-mica in tiny canary-yellow platelets were found. SXRD-analysis showed them to be Nováčekite-II (*Note: since the discovery of Nováčekite-II also other uranium-micas have been found!*). The individual crystals rarely exceed 1 mm in size, but platy aggregates up to 18 mm have been found. Nováčekite-II shows an intense yellow-green reaction in SW and LW UV light.

Omsit, $Ni_2Fe^{3+}(OH)_6[Sb(OH)_6$

In an old find dating back to the 1970s by the deceased collector Karl Fechner from Vienna/Austria, this mineral of the Cualstibite-group - that was only first discovered and described in 2012 - was analyzed in polished sections. The specimen macroscopically shows pseudomorphs of a fibrous, radiating primary mineral (most likely millerite) replaced by a yellow mixture of secondary minerals, enclosed in a fine-grained, reddish-brown matrix of more or less iron-bearing dolomite. The main constituent of this mixture is annabergite, closely associated with a mineral of the roméite group of minerals (most likely hydroxycalcioroméit). Ancillary aggregates of small grains with irregular shapes and as fillings of tiny open spaces and fractures were found to be a chemically relatively pure omsite. Minor trace elements found were only Al, Ca, As, Si and Mg in variable amounts.

Other olive-green crusts found on the nickel ores from Km 3 and the Esperanza mine were found to have a Ni:Fe:Sb-ratio of 2:1:1 and are also most likely omsite.

Ondrušite, $CaCu_4(AsO_4)_2(HAsO_4)_2 \cdot 10H_2O$

Next to Jáchymov in the Czech Republic Lavrion is the second mining district to yield the rare mineral ondrušite. The exact location is the 3rd Level of the Hilarion mine from where lavendulan and kamarizaite have been reported. These two minerals are also the main minerals accompanying ondrušite (next to jarosite). Unfortunately the occurrence is restricted to yellow-green crusts of tiny (10-50 μm) crystals that cover areas of up to several square centimeters.

Parabutlerite, $Fe^{3+}SO_4(OH) \cdot 2H_2O$

Another new mineral for Lavrion and an addition to the ever-growing list of minerals coming from the Sounion Sulfate Locality is parabutlerite. It is included in massive magnesiocopiapite (as opposed to the ferricopiapite which is much, much more common at this locality, comprising more than 99% of the copiapite group minerals). Parabutlerite forms crystalline masses up to 10 mm that may have very nicely terminated crystals in open spaces.

Parádsasvárite, $Zn_2(CO_3)(OH)_2$

This mineral of the rosasite group is nominally copper-free and colorless to white. In reality it nearly always contains trace amounts of copper, which leads to a light blue coloration. Its appearance is – apart from its color – identical to that of rosasite. It has been identified from the Esperanza mine, several places in the Kamariza area and in the Exi mine in Sounion.

Branko Rieck et al, New Minerals from Lavrion Mining District, Greece, 2018

Paragonite, $NaAl_2(AlSi_3O_{10})(OH)_2$

This sodic mica could be identified with SEM-EDS as a rare accessory mineral in polished sections of a fine-grained, banded sphalerite-galena-(±arsenopyrite)-ore-sample from the modern workings in the Clemence area (KOLITSCH et al., 2015). Paragonite forms small, coherent inclusions in bigger muscovite grains.

Paraskorodite, $FeAsO_4 \cdot 2H_2O$

Rather unspectacular is the occurrence of parascorodite at its locality "Rogger Pocket" at the 3rd Level of the Hilarion area. It forms white to beige colored, pulverous aggregates, that form loose aggregations of rounded, barrel-shaped grains as can be seen in the SEM. It is accompanied by (and easily confused with) kaatialaite, sarmientite and zýkaite. Invariable it is found in cavities in massive scorodite/pyrite ore.

Penfieldite, $Pb_2Cl_3(OH)$

The senior author discovered a vein of mostly galena ore with minor sphalerite and chalcopyrite at the Sounion #19 mine that had seen a process of massive alteration through chlorine-bearing solutions. The resulting secondary mineralization resembles that usually found in the Lavrion slags. Minerals like laurionite, paralaurionite, penfieldite, boleite could be found covering fractures in the material. While laurionite and paralaurionite have already been found in localities in the Lavrion mining district (cf. KÖCHLIN, 1887 and KOLITSCH et al., 2014) the identification of penfieldite outside of slags is new. It forms colorless, steep pyramidal or prismatic hexagonal crystals with a very high luster. The basal pinacoid is ofttimes visible. Always the characteristic striation at right angle to the elongation of the crystal can be observed. It is accompanied by other lead-oxyhalogenides, gordaite, kapellasite and linarite.

Pentlandite, $(Fe_xNi_y)_{\Sigma 9}S_8$ $(x + y = 9)$

Part of the erythrite-paragenesis in the Plaka #145 mine is – next to the above-mentioned cobaltite – also pentlandite as subordinate mineral in addition to Ni-bearing pyrrhotite and Ni-bearing pyrite (KOLITSCH et al., 2015). It has been found so far only in polished sections with the aid of a SEM.

Pentahydrite, $MgSO_4 \cdot 5H_2O$

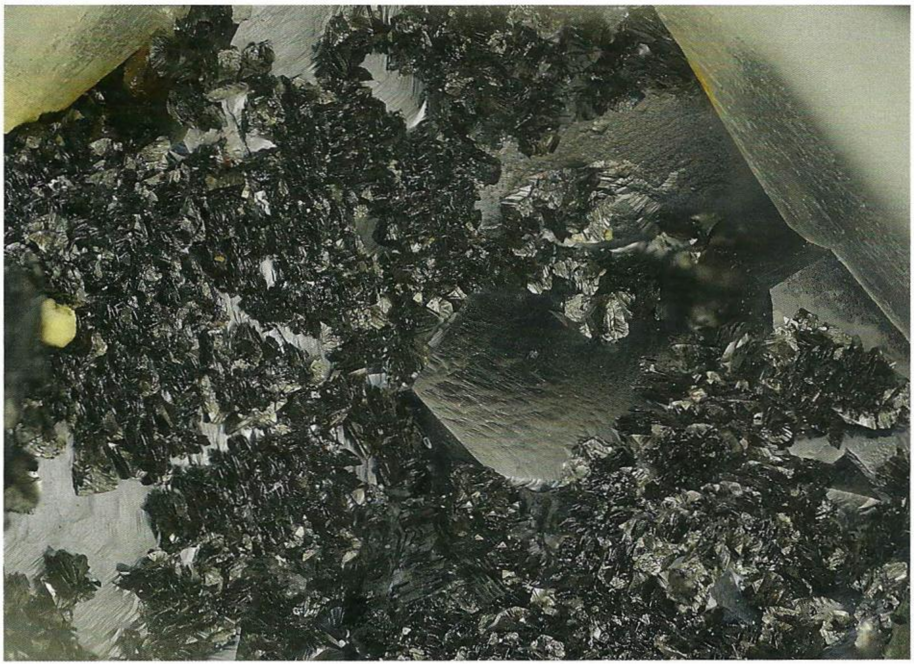
Copper-bearing pentahydrite was found as powdery, white decomposition product of alpersite at the Esperanza mine. It is likely, that it has also formed directly as the result of the weathering of sulfide-bearing ore and dolomite from the host rock.

Piemontite, $Ca_2(Al,Mn^{3+},Fe^{3+})_3(SiO_4)(Si_2O_7)O(OH)$

In the newsletter of the Geological Community of Greece FITROS & KOUTSOPOULOU (2014) report the occurrence of piemontite. The specimen investigated was found by the Greek collector Michalis Kazamiakis on an unnamed dump. Unfortunately, the location is no longer accessible, as it is now on fenced, private land.

Plagionite, $Pb_5Sb_8S_{17}$

In the Plaka #145 mine quite close to the well-known erythrite locality a large vein of fluorite-galena-sphalerite-siderite can be followed over quite a distance. In small cavities well-formed galena crystals were found that had on their faces crusty or tufts and rosettes of very small, lenticular bent and subparallel scaly crystals of steelgray to dark gray color. Partly these crystals are grown epitactically on galena. SXRD and PXRD analyses show with absolute confidence that this is the first discovery of plagionite from Lavrion (KOLITSCH et al. 2015). The closely related and visually not discernible lead-antimony-sulfosalts semseyite and fülöppite are both already known from Lavrion.



Plumboagardit, $(Pb,Ca,Ce)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

The identification of the minerals of the mixite group is quite problematic in Lavrion. There are many reasons for this, but most important are the fact that zonal growth occurs on a regular basis with sometimes three different species present in a single crystal and second, that at any given locality (with few exceptions) usually two ore more different species occur.

In order to truly identify a specimen, the use of advanced methods is required, and the person doing the analysis must understand the limitations of the method employed. In the course of such investigations, sometimes surprises may occur as with a sample from the 1st Level of the Christiana area. Here lead was found to exceed the other possible elements which identifies this sample as plumboagardite. The matrix of this piece consists of quartz that liberally contains inclusions of sulfidic ores, mainly galena, arsenopyrite and chalcopyrite. Next to plumboagardite there is yukonite, carminite, arsentsumebite and conichalcite found in the cavities.

Polydymite, $Ni^{2+}Ni^{3+}_2S_4$

At the Km 3 deposit this nickel-thiospinel was found as thin fracture fillings in galena (GALANOS, 2009). Also, in polished sections from the Plaka #145 mine this mineral was identified as rare accessory mineral (KOLITSCH et al., 2015).

Prosopite, $CaAl_2(F,OH)_8$

In the same paragenesis that yielded the calcium-aluminum-fluoride-sulfate creedite (see above), two further calcium-aluminum-fluorides could be identified: prosopite and yaroslavite.

Prosopite forms monoclinic, glassy and transparent crystals in a fluorite-rich matrix, accompanied by quartz and typical, rice-grain-shaped smithsonite. Accessory minerals include chlorargyrite, gearksutite and mimetite. Some of the prosopite crystals are clouded by white inclusions. These were identified as yaroslavite.

Branko Rieck et al, New Minerals from Lavrion Mining District, Greece, 2018

Rapidcreekite, $Ca_2(SO_4)(CO_3)\cdot 4H_2O$

Gypsum-like but opposed to gypsum very brittle crystals from the paragenesis of katerinopoulosite have been shown by SXRD to be rapidcreekite. It seems to be quite frequent in certain areas of the digging and completely absent in other parts. It resembles not only gypsum, with which it shares a certain kinship, but also the very common aragonite from this locality. Radial groups and single crystals reach 2 mm in length. It is usually grown on a schist matrix, but can be found on most other minerals in this paragenesis.

Redgillite, $Cu_6SO_4(OH)_{10}\cdot H_2O$

An ore sample from the 1st Level of the Jean Baptiste area contained in a few places subordinate amounts of secondary minerals. They were initially considered to be langite and poor malachite. When the "langite" turned out to be montetrisaite, also the malachite was analyzed and found to be the much rarer redgillite, similar to other localities worldwide with such a mineralization. Redgillite forms radial sprays of pale green needle-like crystals. In addition, an interesting paragenesis was discovered in spring 2018 in the Esperanza mine where redgillite is grown directly on marble which in turn is covered by massive chalcanthite. Only after dissolution of the chalcanthite, areas of several square centimeters come to light that are covered with redgillite tufts and posnjakite.

Rhomboklase, $(H_5O_2)Fe^{3+}(SO_4)_2\cdot 2H_2O$

Near the Plaka Sulfate Locality I a small outcrop in a steep cliff was discovered in 2013 that contained excellent voltaite crystals, in paragenesis with plentiful römerite and other iron sulfates. Under the stereomicroscope colorless, thin platy crystals with a diamond-shaped outline were noticed. They are aggregated to finely foliated masses of white to light grey color which are built up of subparallel individual crystals. By means of SXRD they were identified as rhomboclase. They are accompanied ay coquimbite, paracoquimbite, voltaite and szomolnokite (all identified by SXRD).

Rickardite, Cu_7Te_5

In the course of the study of calcsilicate samples from the Adami #2 adit a number of polished sections were made. In some of them rickardite was found in grains between 10 and 40 µm next to the already known altaite. The Cu : Te ratio in this second telluride for Lavrion fits well with the idealized chemical formula, which also precludes the similar weissite.

Sailaufite, $(Ca,Na,\square)_2Mn_3^{3+}O_2(AsO_4)_2CO_3\cdot 3H_2O$

In our last bigger update on Lavrion we reported the occurrence of brandtite, parabrandtite and their respective Fe^{2+}-analogs (KOLITSCH et al., 2014). That same locality has yielded yet another new discovery for Lavrion: sailaufite. The matrix of the specimens consists of coarse-grained calcite which is covered by gypsum. At the border between these two minerals dark red-brown pseudohexagonal platelets are found that resemble a little chalcophanite. The luster however is clearly resinous. Mostly these crystals were covered by late gypsum, but in places where the gypsum lacks, the sailaufite crystals become visible.

Sarmientite, $Fe_2^{3+}(AsO_4)(SO_4)(OH)\cdot 5H_2O$

Sarmientite is one of only four arsenate-sulfates of trivalent iron known to exist: sarmientite, bukovskýite, hilarionite and zýkaite. And all four are found in the Lavrion mining district in places where vadose water slowly decomposes pyrite and arsenopyrite-rich ore. While hilarionite is commonly distinctively green, the other minerals are white, grey or beige. Of these three minerals sarmientite is the one that forms the best crystals which are aggregated to small balls with radial structure. They reach usually no more than 0,1 or 0,2 mm and are accompanied by hilarionite and gypsum. Sarmientite has so far only been observed from a single locality at the 3rd Level of the Christiana area.

Sewardite, $CaFe^{3+}{}_2(AsO_4)_2(OH)_2$

Sewardite is the calcium analog to the widely found carminite. It is extremely rare and to our knowledge only known from two polished sections where it forms xenomorph inclusions (< 0,1 mm) in quartz next to arsenopyrite, aragonite and arseniosiderite. It hails from the lead-poor and iron-rich paragenesis at the 3rd Level of the Hilarion area.

Shannonite, Pb_2OCO_3

Shannonite is a mineral that quite often forms through the process of fire-setting from initial cerussite. It is then – as seen in Lavrion – accompanied by massicot and minium.

As fire-setting played a very minor role in the mining of the Lavrion ore (PUTZER 1948, ROSENTHAL et al. 2013), the distribution of these minerals in Lavrion is poor. Such places are known from the Maria mine, but it is unclear if the fires were actually burnt for fire-setting or to enhance the ventilation. In a few places in the Maria mine it is unclear, if fires have been responsible for the formation of these minerals at all. Shannonite forms porcelaneous masses in a quartz-rich schist, accompanied by lead oxides, fluorite and anglesite.

Siegenite, $CoNi_2S_4$

In the polished section of the above-mentioned ferro-actinolite-bearing skarn from the Plaka area a grain of about 5 µm diameter of iron-rich siegenite with the simplified formula $(Co,Fe)(Ni,Fe,Co)_2S_4$ was found (KOLITSCH et al., 2015). The same polished section contained also the (much more common) violarite.

Also, from Km 3 area siegenite was found in some polished sections. Violarite is also here an accompanying mineral, as is chalcopyrite.

Sklodowskite, $Mg(UO_2)_2(SiO_3OH)_2 \cdot 6H_2O$

The discovery of the uranium-paragenesis at the Paleokamariza #18 Mine was caused by the occurrence of exceptionally well-developed crystals of sklodowskite. The crystals are elongated after [010] and form radiating sprays of free-standing crystals, as well as radial aggregates included in gypsum. Individual crystals reach 20 mm in length.

It is notable, that two forms of crystallization are present: rather stocky or thin and needle-like. The former crystals are usually much smaller (0,5 -2 mm), but they exhibit a number of vicinal faces not commonly seen with this mineral and with an excellent crystallographic termination. Chemical analysis with ICP-OES showed next to the main elements traces of Zn (< 1%), iron (<0,5%) and strontium (<0,5%). The trace elements are distributed either randomly or – more often – as zonal growth both lengthwise and across as shown with SEM-EDX. Highly interesting is the reaction to LW UV light. The literature describes sklodowskite as only weakly reacting with yellow-green fluorescence. At the Paleokamariza #18 mine sklodowskite always shows with an LW UV LED pocket light. On polished samples the chemical zoning as discussed above can also be made visible with this kind of UV illumination. With very pure samples the fluorescence is a light green, with low iron or zinc contents the reaction becomes weaker and – depending on concentration – turns from yellow-green to pure yellow. A combination of zinc and strontium creates an interesting effect: the fluorescence changes from orange to red.

Stolzite, Pb(WO_4)

With SEM-EDS routinely checked polished sections of an ore sample from the -1 Level of the Plaka #80 mine revealed scheelite grains up to 220 µm as inclusions in gangue quartz. Locally also stolzite was found that is in this case without doubt a primary hydrothermal phase (KOLITSCH et al., 2015). It forms small (5 µm) epitactic overgrowths on scheelite and less common inclusions in scheelite. Sometimes eight-sided outlines can be observed that match the tetragonal symmetry of stolzite. The monoclinic dimorph raspite could be excluded by Raman spectroscopy.

Stolzite also occurs as a secondary mineral at the well-known cerussite locality at the Plaka #145 mine. Stolzite here is very rich in molybdenum with a W : Mo ratio of about 5 : 4. The individual crystals generally exhibit skeletal growth and reach a size of 2 mm. It is accompanied by yellow wulfenite and cerussite.

Strashimirite, $Cu_8(AsO_4)_4(OH)_4 \cdot 5H_2O$

Strashimirite was reported from the Lavrion mining district a while ago, but the analysis made at the time by MÖCKEL turned out to be incomplete and plain wrong (GRÖBNER & KOLITSCH, 2002).

While digging for specimens for sale a Greek collector/dealer removed a large volume of material containing lavendulan from the 3rd Level of the Hilarion area. Apart from kamarizaite, jarosite, scorodite and lavendulan there were also some few pieces with cornubite, a mineral quite rare at Lavrion. In some cases, there were lathlike crystals of light blue-green color found together with cornubite which were found to be strashimirite. Unfortunately, only a handful of specimens from this find were analyzed and so it max be expected, that a few more "treasures" hide in collections.

3

Finally, strashimirite was also found at the 2nd Level of the Jean Baptiste area at a small nickel mineralization as fracture fillings between fluorite aggregates. These are very nondescript and easily confused with other, green copper secondary minerals.

Strontianite, $SrSO_4$

In the Plaka #80 mine there are a number of baryte veins visible throughout the workings. In one of them white milky strontianite crystals up to 8 mm were found on a limonitic groundmass within cavities in the surrounding barite. The great similarity of these crystals with aragonite has probably precluded further examination and therefore the discovery of this mineral.

Synchysite -(Ce), $CaCe(CO_3)_2F$

In thin sections of a granodiorite vein in the Hilarion area GALANOS (2009) mentions synchysite-(Ce) briefly. We could prove the occurrence of this calcium-cerium-carbonate in polished sections of a contact seam between an acid dyke and marble at a locality at the 2nd Level of the Hilarion area (KOLITSCH et al., 2015). The REE-source of this mineral, that is also intergrown with bastnäsite-(Ce), is in this case clearly hydrothermally decomposed monacite-(Ce).

Also, a sample of native gold and native bismuth from the "Gold-place" in the Hilarion area yielded synchysite-(Ce) This material is locally rich in lanthanum and the ratio of Ce : La may approach 1 : 1.

Finally, synchysite-(Ce) was found as stubby, pale pink crystals in the "alpinotype" clefts in the cliffs above the slag locality "Legrena Cove", as well as from the same type of host rock from the anatase-locality in the Plaka #80 mine.

Szomolnokite, $FeSO_4 \cdot H_2O$

Colorless, inconspicuous crusts that appear together with voltaite near the Plaka Sulfate Locality I, szomolnokite was found by means of PXRD. The occurrence has only statistical value, as the crusts are usually thinner than 150 µm and exhibit no crystal faces.

Thorite, $ThSiO_4$

In a sulfide-rich sample from the "Rogger Pocket"-locality at the 3rd Level of the Hilarion area surprisingly to tiny (<4 µm) grains of thorite were found in polished sections of the sample together with arsenopyrite. The thorite shows a very low uranium content (KOLITSCH et al., 2015). Two more discoveries of thorite can be reported from Lavrion. First, the already mentioned contact seam of an acid plutonite with marble (2nd Level of the Hilarion area) and also from an molybdenite-bearing polished sample from the Plaka Porphyry deposit. The discovery of thorite is not only a first for Lavrion but is also very interesting from the genetical point of view for the deposit.

Ullmannite, NiSbS

GALANOS (2009) describes ullmannite from the Km 3 deposit as grains that are included and completely surrounded by gersdorffite. We could find this nickel-antimony-sulfide in a number of polished sections from places throughout the mining district. At the Plaka #145 mine a well-known find of annabergite in pale green pustules richly on fuchsite-bearing schist was made in a big cavern. The matrix contained gersdorffite which usually had a small Sb-content and proved to be the source of nickel for the annabergite. In polished sections ullmannite was found, usually with an arsenic content. It appears as seams around gersdorffite grains and was seen also as surrounding millerite.

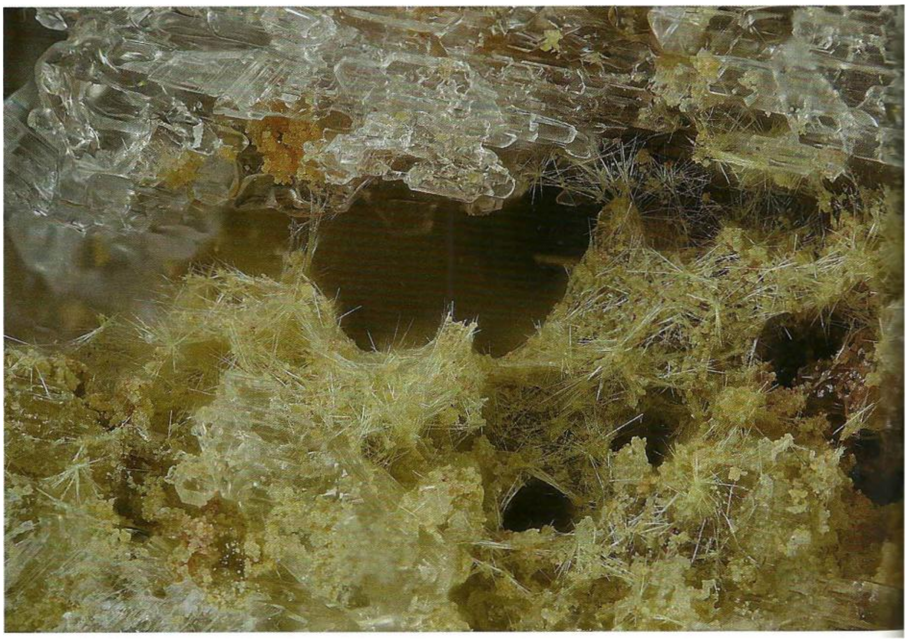
Ullmannite is also found as inclusions in gersdorffite at the two nickel mineralizations in the Jean Baptiste mine.

Uraninite, UO_2

In a polished section from a sample consisting of a fist-sized piece of chalcopyrite that was added to the inventory of the Museum of Natural History in Vienna in 1893 a number of interesting discoveries were made. Next to wittichenite and a so-far unidentified (Cu,Ag)-(Fe?)-Pb-Bi-Sulfide a tiny grain of uraninite was found included in quartz gangue, accompanied with small, rounded fluorapatite grains. Beside the above described brannerite this is the second primary uranium mineral.

Uranophane, $Ca(UO_2)_2(SiO_3OH)_2{\cdot}5H_2O$

Uranophane was discovered by its deviating behavior under LW UV light: as opposed to sklodowskite which always shows at least weak but noticeable fluorescent reaction, uranophane does not react at all. Otherwise it is quite similar to the thin, needlelike sklodowskite. On the few specimens recovered by us, uranophane is clearly younger than sklodowskite. It is also never included in gypsum.



Vaesite, NiS_2

The nickel analogue to pyrite was proven to occur in two localities. GALANOS (2009) describes it from polished sections from the Km 3 deposit as seams around gersdorffite or millerite which in turn are included in galena. The senior author could confirm this exact mode of occurrence from own observations. At the second nickel-mineralization at the 2^{nd} Level of the Jean Baptiste area vaesite appears as micron-sized grains and also as seams around gersdorffite, millerite and pyrite.

Vesuvianite, $(Ca,Na,\square)_{19}(Al,Mg,Fe^{3+})_{13}(\square,B,Al,Fe^{3+})_5(Si_2O_7)_4(SiO_4)_{10}(OH,F,O)_{10}$

It is not astonishing that vesuvianite occurs in the calcsilicate rocks in the metamorphic aureole around the acid magmatic intrusion in the Plaka area. The specimens however are quite inconspicuous and hail from the first vanadinite locality in the Plaka #80 mine. It is grainy, light green in the hand specimen and crystal faces are rarely seen. In small calcite-filled cavities there was enough space for well-formed crystals which can be made visible by removing the calcite with a mild acid.

Violarite, $FeNi_2S_4$

In the polished section of the above-mentioned ferro-actinolite-bearing skarn from the Plaka area grains of about 20-30 µm diameter of violarite were found (KOLITSCH et al., 2015). The grains are iron-rich with iron replacing Ni and always have a noticeable Co content. Individual grains are homogenous or near homogenous. The violarite grains usually reside next to chalcopyrite in this sample.

Fe-bearing violarite was also found as rare accessory mineral in cobaltite-bearing polished sections from the well-known erythrite-locality in the Plaka #145 mine and from the Km 3 deposit together with siegenite.

Wollastonite, $CaSiO_3$

In thin sections of a granodiorite vein in the Hilarion area GALANOS (2009) describes wollastonite briefly as a silicate phase formed by contact metamorphism. A find from outside the Plaka granodiorite mine contained a contact seam between granodiorite and marble. The contact plane contained macroscopically discernable wollastonite. It forms white, lathlike crystals that are randomly aggregated. It is accompanied by grainy grossular. The granodiorite part of this specimen also contained rather high zircon and rutile contents.

Xenotime, YPO_4

In two polished sections from molybdenite-bearing quartz from the Plaka Porphyry deposit xenotime-(Y) was identified by means of SEM-EDS as intergrowths with the much more common monazite-(Ce) (KOLITSCH et al., 2015). The xenotime forms grains up to 115 µm.

Yaroslavite, $Ca_3Al_2F_{10}(OH)_2 \cdot H_2O$

Some prosopite crystals from the Cristiana 132 mine are clouded by inclusions of a white mineral that is aggregated to radial balls of fibrous crystals. This was identified by PXRD (with prosopite as a convenient internal standard) and EMPA as the rare Calcium-aluminum-fluoride yaroslavite that has so far only been reported from its type locality in Siberia. Outside of prosopite it has as yet not been identified.

Yukonite, $Ca_3Fe^{3+}(AsO_4)_2(OH)_3 \cdot 5H_2O$

Yukonite is one of the minerals that has to be identified with advanced means of identification. It is so close to the appearance and properties of arseniosiderite which is very common in the Lavrion mining district that it is indistinguishable from the latter.

A small chamber at an intermediate level between 1st and 2nd Level of the Christiana mine that is known for fantastic carminite specimens has yielded the material for the first description of yukonite from Lavrion. The matrix consists of massive, extremely tough quartz that is shot through with idiomorphic arsenopyrite crystals that ar din different stages of decomposition. In cavities of this material colorful and often quite rare secondary arsenate minerals have formed. The arsenopyrite is – if not fresh – mostly altered to amorphous Fe±Ca-arsenates of varying chemical composition. Occasionally however, the arsenopyrite crystals are pseudomorphed to well crystallized yukonite. In this case it is easily distinguished by its golden sheen and thin bladed aggregates.

Zavaritskite, BiOF

A polished section of the typical gold- and bismuth-bearing mineralization at the 2nd Level of the Jean Baptiste mine, the famous "ασπρα χωματα" locality showed macroscopically dense, dark grey seams around rounded grains of native bismuth. These seams are zoned with the inner area being a complex mixture of zavaritskite and bismite and the outer ring of bismutite (typically with small Ca-contents). Additionally, a surprising diversity of secondary minerals was observed in this sample: rooseveltite and preisingerite (very common), atelestite (very rare), bismoclite (locally abundant), beyerite and kettnerite (both rare) and adamite. Finally, this sample contained also a beudantite group mineral that is from bismuth-rich to unambiguously bismuth-dominated (which would be the arsenate analogue to zairite and a new mineral). Primary ores are native gold (var. electrum), native bismuth and slightly Sb-bearing bismuthinite. Thus, the paragenesis is very similar to the one described by SOLOMOS et al. (2004) and the one of the type-material for "arsenobismite" which was discredited in 1999.

Zdeněkite, $NaPbCu_5(AsO_4)_4Cl{\cdot}5H_2O$

The two minerals mahnertite and zdeněkite that occur together are only discernible by advanced methods of analysis. As opposed to mahnertite, zdeněkite contains lead in its structure. In an ore lens at the 3rd Level of the Hilarion adit which consists of pyrite, arsenopyrite, chalcopyrite, galena and the common decomposition products melanterite and chalcanthite small thin platy, light blue crystals were discovered in small cavities. PXRD and SEM-EDS analysis confirmed the presence of a slightly Ca-bearing zdeněkite.

Zýkaite, $Fe_4^{3+}(AsO_4)_3(SO_4)(OH)\cdot15H_2O$

Zýkaite was discovered as component of light grey, inconspicuous crusts on arsenopyrite-pyrite-ores in schists from a number of localities throughout the mining district. It is generally accompanied by amorphous iron arsenates, rarely also by hilarionite.

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Acknowledgments

The authors wish to thank Karl Heinz Fabritz (Sankt Pölten/Austria), Fritz Schreiber (Schwechat/Austria), Kostas Kapellas (Agios Konstantinos), Heracles Katsaros (Lavrion), Michalis Kazamiakis (Athens), Kostas Tzanis (Agios Konstantinos), Tom Neuber (CH), Ivan Prachař (Prague/CR), Harry Sniaschek (Lindau/Germany), Vasilis Stergiou (Agios Konstantinos) and Alkis Tsolakos (Athens) for material for study and analysis. The second author is much obliged to the Institute of Mineralogy and Crystallography of the University of Vienna under the current head Prof. Dr. Roland Miletich for the possibility for mineralogical research. Dipl.-Geol. Manuela Zeug from the same institute has kindly helped with the Raman-spectroscopy of stolzite.

For the excellent digital photography we thank Dr. Harald Schillhammer, Museum of Natural History in Vienna, and Stephan Wolfsried (Waiblingen/Germany).

The authors wish to dedicate this article to the memory of **Alkis Tsolakos**, who died on 2.2.2018 after a long and serious desease.

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