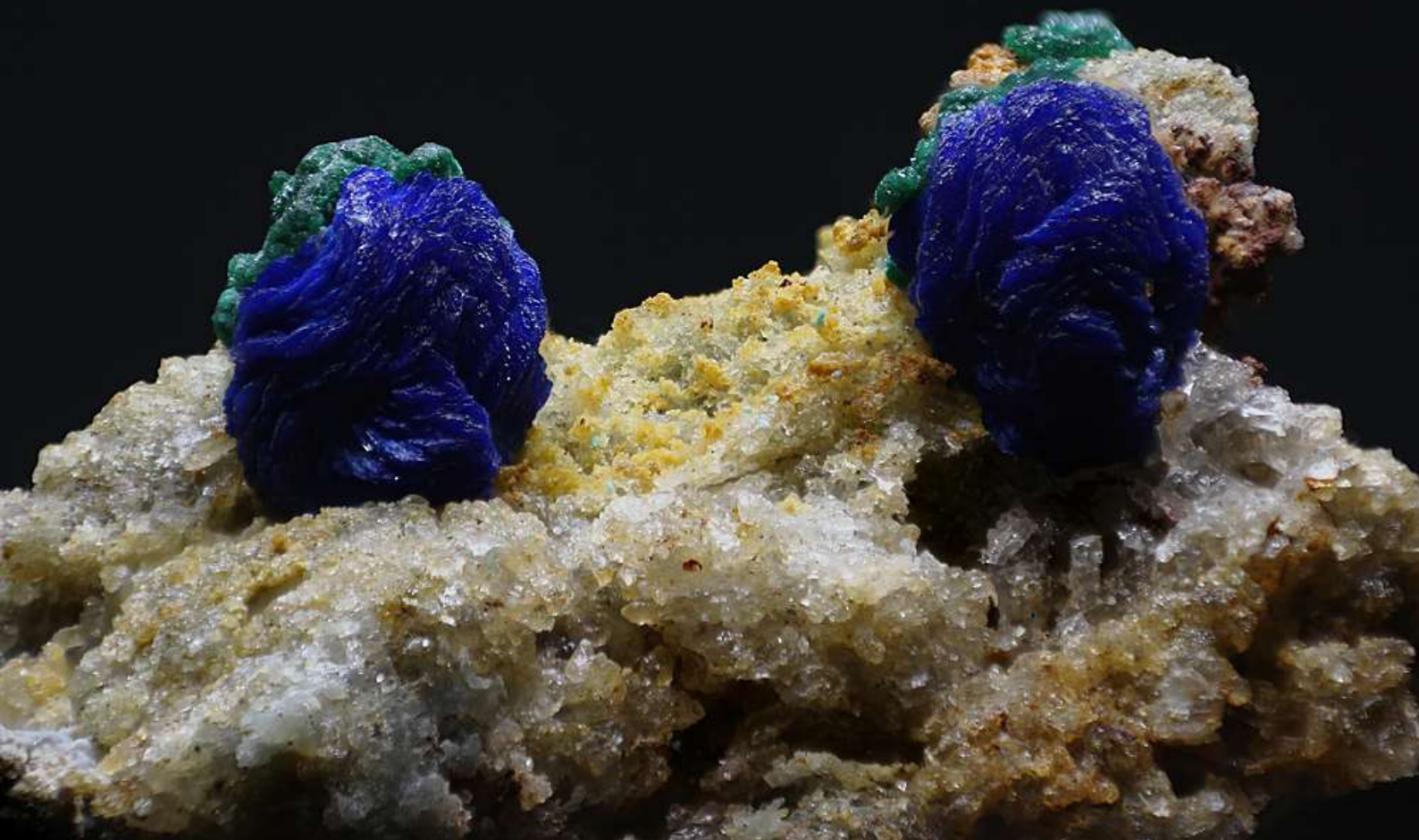


Australia and New Zealand Micromineral News



Issue 10 – January 2015

Editor: Steve Sorrell – steve@crocoite.com



Cover photo:

Malachite replacing Azurite
Burra, South Australia

19 images stacked using Zerene Stacker

Taken with Canon 600D with reversed 18-55mm lens

Photo width 15mm across

Photo and Specimen: Steve Sorrell

In This Issue

Introduction

Great to see the New South Wales collaborative effort on an article (Woodlawn). And this publication will have at least another seven articles to publish in the crystallography series. But please. Don't sit back. Contribute! Is it not too much to ask for even a one paragraph note (or query)?

Contributions – We Still Need Your Input!

Articles should be submitted to the editor in Word format, and any photos should be of a sufficient quality for publication. If you believe that you can provide a suitable article for the next issue, please advise the editor as soon as possible. Planning for the next issue begins as soon as the current one is published! I have one for the next issue just waiting on photographs.

Contacts

If you want to find out what's happening with micromounting or microminerals in your region, get in touch with one of the following:

- ✂ New South Wales: George Laking – bglaking@tech2u.com.au
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- ✂ Victoria: John Haupt – john.haupt@bigpond.com
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Forward Diary

Please send details of micromounting or micromineral upcoming events (up to six months ahead would be good) for inclusion in the next issue of the Australian and New Zealand Micromineral News.

The Arthur Roe Micromounter Symposium is on Friday 13th February (hope that's not a bad omen!). Scheduled talks:

- Micromounts from Selected Spanish Localities, Robert Jenkins
- Copper Arsenates and Other Rare Minerals from the Cap Garonne Mine (France), Georges Favreau
- My Summer 2014 Collecting Trip - A Visit to Micromount Nirvana, Rick Turner

Table of Contents

In This Issue	1
Notes and Queries	2
An addition to the list of Kingsgate minerals	5
The NSW Micromineral Group	7
Micro mineral news from Victoria.....	8
Micro Group Meetings, Western Australia	9
Crystallography for Micromounters: Part I – Introduction and Composition	9
Microminerals found in the Iron Ore deposits of the Pilbara, WA.	14
Minerals from Jindivick, Victoria	18
Minerals of the Woodlawn Mine in the Southern Tablelands of NSW	24
Classifieds	47

Notes and Queries

According to Wikipedia, *Notes and Queries* was first published in 1849 as a weekly periodical edited by W.J. Thoms. It was founded as an academic correspondence magazine, in which scholars and interested amateurs could exchange knowledge on folklore, literature and history. The format consisted of "Notes" (miscellaneous findings of correspondents that they and the editors considered of interest to the readership), and "Queries" (and responses to queries), which formed the bulk of the publication.

Notes

10.01 – Milton Lavers sale. Crystal Classics and Crystal Universe hosted a two day sale of much of the well-known Broken Hill collector, the late Milton Lavers. This was an opportunity for Australian mineral collectors to view and acquire specimens from Milton's collection before it made its way to Tucson, and the international market.

There were high-priced specimens as you would expect, but also bargains to be had. Quite a lot of material that would make very nice micro specimens, many in flats. One example, that of a pyromorphite from the South Mine, is shown below. – Contributed by Steve Sorrell



Pyromorphite, South Mine, Broken Hill, New South Wales. Ex Milton Lavers. Stack of 7 images. 15mm FOV.

10.02 – Reversed camera lens photos. Recently I purchased a reversing ring to try out taking macro mineral photos using my Canon 600D and lens reversed. One of the issues with macro photography of course, is the limited depth of field (DoF). I initially tried with an older Canon FD lens that has the ability to control the aperture on the lens itself, in order to maximize DoF. This unfortunately failed, due to the way that the Canon 600D works. So that's when image stacking comes in. I use Zerene Stacker and am happy with the results so far. I have found that the results are better with the camera mounted on a rail. It makes it easy to get consistent change of focus. The azurite image on the front page, the pyromorphite above, and the boleite below were all taken using this method. – Contributed by Steve Sorrell

Queries

10.03 – A question for all micromineral collectors.

Some collectors of microminerals may have a specimen of native mercury in their collections. Perhaps it is in association with cinnabar but in any case it most usually occurs as small liquid droplets. According to Fleischer's Glossary of Mineral Species (any edition), Mercury in this state is indeed a mineral and the entry is:

Mercury, Hg, a liquid,

Although it is not stated in the Introduction to the Glossary, it is presumed that the information provided for each species applies to ambient temperature and atmospheric pressure. Under those conditions, mercury certainly occurs naturally as a liquid and is well known to be the only liquid mineral.

So here is the question. What happens when, as occurs in some parts of the world, the ambient temperature decreases to below -40°C , the freezing temperature of mercury, and it solidifies to the rhombohedral crystalline state? As such, being a natural crystalline solid with specific chemical composition (Hg), the broad definition of a mineral is satisfied and we should conclude that solid mercury is a mineral. However, as Fleischer contains no reference to solid mercury we must also conclude that upon solidification mercury ceases to be a mineral. Thus, we are presented with a logical dilemma. Comments please.

Let us turn now to the compound H_2O which I'll wager, no collectors of microminerals have in their collections. In many parts of the world, at an ambient temperature of around 20°C and normal atmospheric pressure, this compound exists as water which, according to the absence of an entry in Fleischer, is not a mineral. But upon freezing at 0°C (32°F), it becomes a mineral with the entry:

Ice, H_2O , hex., type locality unknown....

So under familiar ambient conditions, liquid mercury is a mineral but water is not and at lower temperatures solid mercury is not a mineral but ice is. Another logical dilemma. Further comments please. – Contributed by Noel Kennon



Boleite, Amelia Mine, Boleo District, Mexico. Stack of 9 images. 15mm FOV.

An addition to the list of Kingsgate minerals

John Haupt

The mineral tooeleite has been identified from Kingsgate in New South Wales. Tooeleite was first described from Gold Hill, Tooele County, Utah in 1991. It has since been found sparingly from several other localities in Europe. It is an arsenate mineral with the chemical formula $\text{Fe}^{3+}_6(\text{As}^{3+}\text{O}_3)_4(\text{SO}_4)(\text{OH})_4 \cdot 4\text{H}_2\text{O}$.

At Kingsgate it occurs as small orange to red crystals on scorodite. It was found in material collected by Bernie and Margaret Day from the dumps believed to be from the old 25 pipe in 2004.

Thank you to Peter Elliott for analysing a specimen of the mineral.



Glassy crystals of tooeleite (red) with scorodite (yellow). 2mm FOV.



Clockwise from top left:

Groups of tooeleite crystals on scorodite. 3mm FOV.

A group of tooeleite crystals. FOV 1.5mm tall.

A single 0.2mm crystal of tooeleite with glassy crystals of scorodite.

The NSW Micromineral Group

The Micromineral Group of The Mineralogical Society of NSW was established in 2007 as a small collective of interested members. Our first meeting was held on 11th October at the home of Graham Ogle who became our Convenor for the nearly 40 meetings held to date. Our group was, and remains, small with eight regulars and a few who attend when they can.

Originally, we met irregularly every two months or so at the homes of members in rotation but at the end of 2013 it became evident that bimonthly meetings provided little continuity and we decided to meet regularly on the second Saturday of each month. This now takes us as far north as Maitland, as far south as Dapto and as far west as Penrith. The topics of our meetings have been ad hoc varying from 'my favourite specimen', to 'Broken Hill', to 'south-eastern USA' and anything in between. Again, there was little continuity of effort.

Last year, 2014, after the usual kind of meetings in February and March, we met at Brian England's in April to look at Russian minerals as he had made several collecting trips there, had a good range of micros for us to examine and several boxes of freebies. We looked at some stunning specimens that Brian had collected at Dal'negorsk and localities on the Kamchatka Peninsula and elsewhere. It was a most enjoyable and informative way to spend a Saturday afternoon, but essentially it was more of the same.

During that meeting, one of our members, Dieter Mylius, suggested that instead of continuing as we had been, our meetings should become focused in some way. He informed us about discussions in the Society Committee about how the Society could define and publish the extensive knowledge held by various Society members about NSW localities, which would contribute to the natural history record and also help dissemination of interesting information, particularly in light of the need for more contributions to the ANZ Micromineral News. There was general agreement and enthusiasm for the proposal and we settled on devoting regular meetings to minerals of Australian localities that have not been well studied. Prior to a meeting of this kind, we would gather available information about our agreed locality then, at the meeting, use our collective specimens to try to assemble a comprehensive list of the locality minerals, photograph what we could and then prepare an article for the News with information sent on to mindat. Of course, this presupposes that we, as a group, have the wherewithall to take publishable photographs of small specimens and we are working on that.

We hope that readers of the News will be encouraged to contribute by adding to the list of minerals, providing other photographs and amplifying the information thereby giving the mineralogical community improved insight into that particular locality. At Dieter's suggestion we settled on a study of Woodlawn for the May meeting and our first 'mini-treatise'.

The Society members who participate in our meetings are Greg Andrew, John Behrens, Graham Delaforce, Brian England, Ann Kennon, Noel Kennon, Dieter Mylius, Jeanette Munsel, Graham Ogle and Ed Zbek.

Micro mineral news from Victoria

John Haupt

The lapidary club exhibitions/shows held in spring are now over - the larger ones being at Bendigo, Nunawading, Waverley and Geelong. Most have minerals collected by club members or are donated from old collections. It is always interesting to go through the smaller specimens for micros and usually most rewarding too. The recent shows had many micros from Broken Hill, Lake Boga and other Australian localities as well as a smaller number from overseas. A couple that I obtained are shown below:



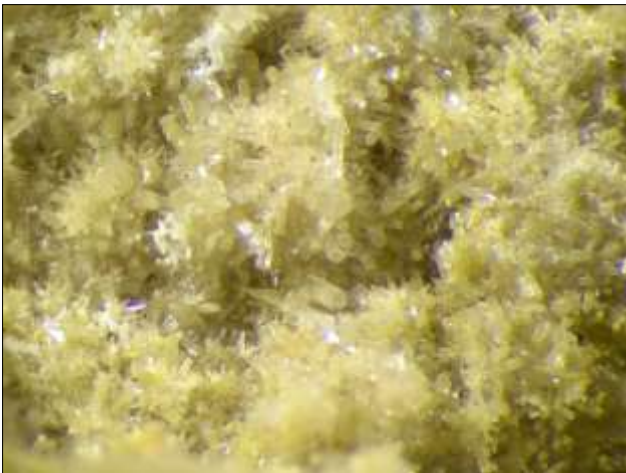
Tsumcorite crystals from the EZ Mine, Puttapa, South Australia. At the Bendigo show. 3mm FOV.



Wavellite, leucophosphite and variscite from Mt Oxide Qld. At the Nunawading Show. 3mm FOV.

The Victorian Society's Micro Group continues to meet each month, albeit with a smaller number of people. Unfortunately regular attendees Judy Rowe and George and Muriel Lysiuk are now unable to travel - like most groups the members are getting older and we **NEED** younger people to join in.

Our recent topics have continued to bring out interesting micros to study. September was minerals containing calcium except calcite and aragonite, and minerals from the Kintore opencut in November.



Phosphohedyphane 4mm FOV.



Serpierite 5mm FOV, both from the Kintore opencut.

Micro Group Meetings, Western Australia

Clive Daw

Good day Steve, just a brief note to advise you that in Western Australia we only have three micromounters: Ted Fowler, Alan Longbottom and Clive Daw. Actually that's not quite true as all three will be out of the state until mid-September chasing minerals! (Probably back by now, Ed.).

We have been quite active in holding "micro" sessions for others to increase the numbers of enthusiasts and we're sure these efforts will be worthwhile thanks to Ted.

You are no doubt aware of our success in seeking out new minerals and here I am pleased to acknowledge the valuable assistance of Dr. Peter Elliot and the Adelaide Museum.

Putnisite being the main one. This, while a very rare mineral, is a little different to the original find at Polar Bear Peninsula, Lake Cowan, a gold prospect with no more found since the original handful. Our find carries a trace of Ni but not enough to be a new sub-specie. I have since found 1 specimen on gaspeite from 132 North Mine (Mount Edwards), Widgiemooltha. There is no gaspeite at Armstrong, Widgiemooltha, our main find.

Others still in the melting pot are a Ni, Cl, and a Cu, As. Both require more work so will keep you in the loop. Cheers Clive Daw.

Crystallography for Micromounters: Part I – Introduction and Composition

Noel Kennon

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Introduction

When you, as a collector of microminerals, look at a specimen of a crystalline mineral, be it small or large, do you wonder about the shapes of the crystals in that specimen? Think for a moment about the crocoite micro shown in Figure 1. The crystals are near perfect small, rectangular prisms and the array is beautiful to behold. The same could be said about specimens of many other mineral species either alone (as in Figure 1) or in combination (Figure 2). In addition to the pleasure of the aesthetic appeal, do you wonder whether there is anything you can learn from looking at the shapes of those crystals. The answer is yes there is, and this series of eight articles has been prepared to explain the study of crystals – crystallography – in terms that are sufficiently simple and non-mathematical that micromounters and other readers might gain a better appreciation of what they look at with their microscopes.



Figure 1: Crocoite from the Adelaide Mine, Dundas, Tasmania.



Figure 2: Cerussite and malachite from Brown's Prospect, Rum Jungle, Northern Territory.

However, be warned, crystallography is not a simple science for it involves three dimensional concepts that prove difficult to visualise or to draw on paper. Fortunately, many of those concepts have two dimensional equivalents and these will be used from time to time as an aid to presenting the concepts. Should you wish to gain some knowledge of these concepts as a way of improving your insight into the nature of crystals you will need to persevere through the series of articles. When the going gets tough you may well be tempted to give up but should you persist you will emerge at the end with enough crystallography under your belt to appreciate the true beauty of one of nature's greatest gifts.

If you had been around in the early days as a mineral collector you would have had few scientific instruments and to learn about crystals you would have had little more than the shapes of those crystals to work with. You and others would have devised ways to measure the shapes and use that information to build up ideas about the arrays of atoms and molecules that could result in those shapes. When x-rays were discovered in 1896 and methods were developed for using them to study the internal structure of matter it became clear that those ideas you devised were essentially correct. How x-rays and crystals interact is dealt with in the final Part VIII of this series. Now, the instrumentation available to us is highly sophisticated and we have gained considerable knowledge about crystals and the crystalline state. This knowledge enables us to provide a reasonable, but not encompassing, answer to the often asked question "what is a mineral?". This is where we will begin.

COMPOSITION

In essence, a **mineral** is a naturally occurring single *phase* solid substance that has a specific chemical composition and is crystalline with a specific crystal structure. There are exceptions to each of these generalisations. One mineral, mercury, is liquid; several minerals, including plagioclase, exist over a range of compositions; and a few minerals such as opal are not crystalline. It should be noted that in crystallography, the term *phase* refers to homogeneous solid that exists over ranges of composition, temperature and pressure. The range may be large or, in the case of composition, exceedingly small.

The characteristics of composition and structure together uniquely identify each mineral species and the entries you will see in catalogues and reference books look something like these:

anatase	titanium dioxide	TiO ₂	tetragonal
calcite	calcium carbonate	CaCO ₃	rhombohedral
pyrite	iron sulphide	FeS ₂	cubic

Thus, pyrite is that mineral which is iron sulphide with composition FeS₂ and a cubic structure. This combination of particular composition and particular structure distinguishes pyrite from the thousands of other mineral species. In particular it distinguishes it from marcasite which also has the composition FeS₂ but has an orthorhombic structure. And so it is for every mineral that has been discovered or is awaiting discovery.

Composition is the easy part of this specification. Every mineral is a single element or a combination of elements. There are nearly thirty single element minerals including:

gold (Au) and
sulfur (S).

Minerals comprising two or more elements in combination as a molecule with small whole number ratios of atoms may be written as formulae. A formula may be simple as in:

ice (H₂O) or
galena (PbS) or

complex as in:

andyrrobertsite $\text{KCaCu}_5(\text{AsO}_4)_4[\text{As}(\text{OH})_2\text{O}_2] \cdot 2\text{H}_2\text{O}$.

No matter how simple or complex, a formula simply tells us which elements are present in a mineral and in what proportions. Of course, to read those formulae it is necessary to know the meanings of symbols such as Au, S, H, O, Na, Cl and so on. Many readers will know that these symbols are our short hand ways of referring to the elements that comprise all matter in the universe. It is very useful to have knowledge of these symbols or at least the more common of them.

The formula for a mineral can be used to find the composition which is simply the percentage of each chemical element which is essential to that mineral. There are several ways in which the percentages can be measured and prescribed. Let us consider, for example, the mineral halite which many readers will know as salt, common salt or sodium chloride. The molecular formula is NaCl which tells us that there are atoms of two elements present in equal numbers. So, in terms of these numbers, the composition is:

50 atom % sodium, and
50 atom % chlorine.

However, because atoms of sodium and chlorine have different weights, the weight percentages of the two constituent elements are different. The atomic weights of all elements are specified relative to the weight of one particular carbon atom (carbon-12) taken to be 12. Thus the atomic weight of a sodium atom is 22.99 and of a chlorine atom is 35.45.

Consequently, the weight of a molecule of NaCl is $(22.99 + 35.45) = 58.44$. This is called the molecular weight. It follows that:

the proportion by weight of sodium in NaCl is $22.99/58.44 = 0.3934$ or 39.34 weight %, and the proportion by weight of chlorine is $35.45/58.44 = 0.6066$ or 60.66 weight %.

It is possible to make this kind of calculation for every mineral having a composition that can be expressed as a chemical formula. However, it must be appreciated that composition given as either atom % or weight % is idealistic as it applies only to the perfectly pure mineral. No naturally occurring substance (or for that matter, no substance at all), is perfectly pure and every mineral contains impurity atoms that do not appear in the specification of composition. It is important to note that impurity atoms can and do have a

significant influence on some properties of some minerals. Additionally, the impurity can be important for other reasons. For example, the mineral zircon ZrSiO_4 contains a trace of hafnium (Hf), which is the only source of that metal. In the rest of this series of articles about crystallography, the term *pure* will be used to refer to any single substance which naturally contains small levels of many natural impurities.

There is other information that can be obtained from the chemical formula of a mineral. In particular, the majority of minerals comprise two parts – a metallic part and a non-metallic part. These two parts inform us about the nature of the chemical compound comprising the mineral. The metallic part is simply the symbols for one or more metals such as Na (sodium), Cu (copper), Fe (iron), Zr (zirconium), Mo (molybdenum) and so on. The non-metallic part is an assembly containing one or more non-metallic atoms that tells us the nature of the compound, as set out below.

O or O_2 or O_3 – oxide as in Al_2O_3 – corundum

S or S_2 – sulphide as in MoS_2 – molybdenite

(CO_3) or similar – carbonate as in CaCO_3 – calcite or aragonite or vaterite

(SO_4) or similar – sulphate as in BaSO_4 – barite

(SiO_3) or similar – silicate as in $\text{Mg}_2\text{Si}_2\text{O}_6$ – enstatite

(PO_4) or similar – phosphate as in $\text{Ca}_3(\text{PO}_4)\text{F}$ – fluorapatite

And so on for many other combinations.

There are some minerals for which composition cannot be represented by a specific chemical formula. For example, opal has a variable composition often expressed as $\text{SiO}_2 \cdot n\text{H}_2\text{O}$, which is silica SiO_2 plus an indeterminate amount of water $n\text{H}_2\text{O}$, up to about 20%. On the other hand some minerals are solid solutions. What, you may ask, is a solid solution?

Two pure substances which are soluble in each other in all proportions are said to form a *solution series*. This series is a single homogeneous mixture (a phase) that exists continuously from one pure substance through all compositions to the other pure substance.

All gases are mutually soluble and form a single gaseous phase. Our atmosphere is an example. In the liquid state, there are fewer instances, but one is water and alcohol which mix together in all proportions to form a single liquid phase from pure water through to pure alcohol.

In the solid state, complete mutual solubility of two pure solids is severely restricted by several conditions including the necessity that they are *isomorphous*, that is, they have the same crystal structure. It is only under this restriction that the composition can change continuously from one pure solid to the other. This cannot occur if the two crystal structures are different. The significance of this requirement will become clearer as we progress through this series of articles.

The metals copper and nickel have the same structure and are mutually soluble to form a continuous phase (sometimes called a continuous series of solid solutions) from pure copper to pure nickel. This single phase is usually called the alpha (α) phase. Likewise, the mineral

species albite ($\text{NaAlSi}_3\text{O}_8$) and anorthite ($\text{CaAl}_2\text{Si}_2\text{O}_8$) are soluble in each other in all proportions forming a continuous phase that is called the 'plagioclase feldspars'. It is worth noting that plagioclase feldspars with compositions regularly intermediate between albite and anorthite are simply part of that continuous phase but have been named oligoclase, andesine, labradorite and bytownite for convenience. It is only the end members of these feldspars that have specific compositions. Other pairs of minerals which are mutually soluble include members of the garnet group, members of the pyroxene group as well as siderite-rhodochrosite and siderite-magnesite.

Additionally, some mineral species are partly soluble in each other and exist as a single phase over a limited composition range. The composition of this phase is variable over the range between the composition limits which might vary with temperature.

Notwithstanding those examples of minerals with compositions that are difficult to specify, and ignoring the impurities present in all minerals, it can be said that for the most part the composition of a mineral can be represented by a chemical formula. For some minerals the formula represents a molecule in which the component atoms are bonded to one another in a certain configuration. For other minerals the formulae simply tells us the numbers of the different elements that are present in those minerals.

But what about the other part of the definition of a mineral? What do 'tetragonal' and 'rhombohedral' and 'cubic' and the others mean? Geologists and collectors who have some mineralogy in their background know about these things. But collectors without that knowledge may be perplexed by the terms – and rightly so. These collectors will find answers in the following Parts of this series:

- II Crystals,
- III Crystal Geometry,
- IV Symmetry,
- V Crystal Systems,
- VI Crystal Descriptions,
- VII Miller Indices,
- VIII Crystals and X-Rays.

Microminerals found in the Iron Ore deposits of the Pilbara, WA.

Jason Bennett

The Pilbara is well known for its rich mineral resources, currently for the massive Iron Ore deposits throughout the Hamersley Basin, with ores such as the Mt Whaleback microplaty hematite which is almost 100% iron oxides! However, the massive iron ore deposits themselves are not known for their microminerals. The only picture online found on Mindat

is for Mt Whaleback, and the specimen shown (a small cabinet piece of dolomite crystals on a hematitic dolomite matrix) is probably the most atypical specimen that could be shown.

When I started working in the Pilbara in 2012 with BHP Billiton in the Graduate Program, I was determined to find some nice examples of the iron oxides. After all, with rocks close to 100% iron oxides there must be something, right? For 18 months my search was almost fruitless. Admittedly, 6 months restricted from site due to a broken ankle didn't help (a story for another time, but I should raise the OH&S alert about walking down stairs, backwards. Don't do it.)



Botryoidal goethite and goethite pseudomorphing dolomite. 20mm FOV.

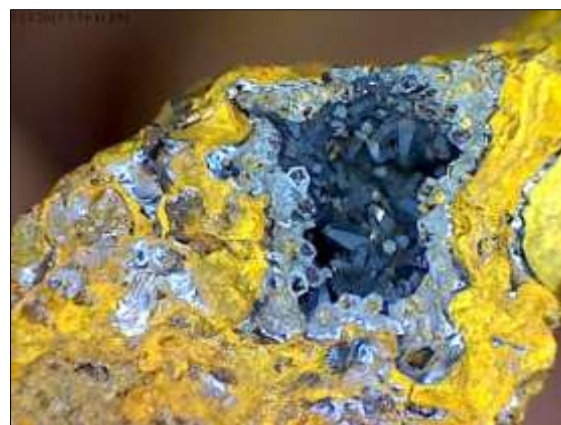


Dolomite. 10mm FOV.

Most of my efforts were focused on examining vugs and cavities within what is known as the 'hardcap' zone, a local term for the variably altered ferricrete that overprints near-surface material. The variability of the hardcap is driven by differences in meteoric fluid chemistry and the anisotropy in fluid permeability and flow rates through the bedrock (which is quite frustrating for grade control, I assure you). The effect is mobilisation and deposition of iron, silica and alumina in different patches here and there. The silica usually is deposited as amorphous masses, either as a fine powder, fibrous-acicular material, botryoidal growths/crusts or with alumina in clays. Some Halloysite has been identified based on stoichiometry and its tubular appearance from SEM EDS. The iron is mostly deposited as vitreous goethite in the hardcap matrix, uncommonly in a botryoidal habit, rarely in a 'coralline' growth habit and very rarely as stalactites.

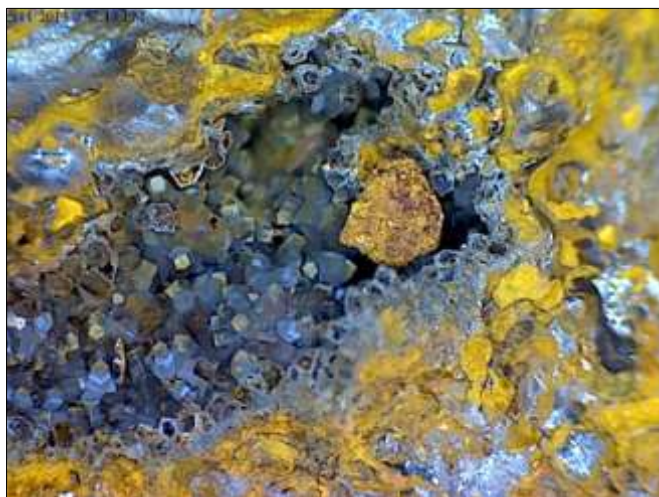


Dolomite rosette. 10mm FOV.



Goethite after dolomite. 10mm FOV.

Going deeper into the deposits, the mineralisation is mostly (with the exception of Whaleback which is, quite frankly, weird) martite (hematite after magnetite), goethite and limonitic/ocherous goethite orebodies. Even the martites are usually goethitised, so I have yet to find a piece of ore suitable for micromounting. In polished section however, the textures can be quite interesting, but there are no nice euhedral crystals. The best preserved martites can be found in the unenriched banded iron formation (BIF) at depth underneath the main zones of mineralisation.



Goethite after dolomite - hollow. 10mm FOV.



Halloysite balls. 10mm FOV.

Manganese is highly variable throughout the orebodies in the hardcap zone, on one occasion some wonderful pyrolusite needles were saved from mining activities at the last minute (literally, they were gone that afternoon when I went back to try and collect more). Oh, and there's plenty of tiger's eye, and associated reibeckite var crocidolite. I have yet to collect some crocidolite, as my fellow colleagues know my geological kleptomania well, and watch me like a hawk's eye (that was a pun). The micromineral scene, however, was looking rather bleak.

It turns out I needed to be looking in the variably consolidated tertiary detrital sequences. These sediments are well studied, as they not only host high grade goethite and maghemite pisolitic ores, which are also mined throughout the Pilbara, but are full of fossilised wood fragments and pollen, which has helped contribute to our understanding of the paleoclimatic history of the region.

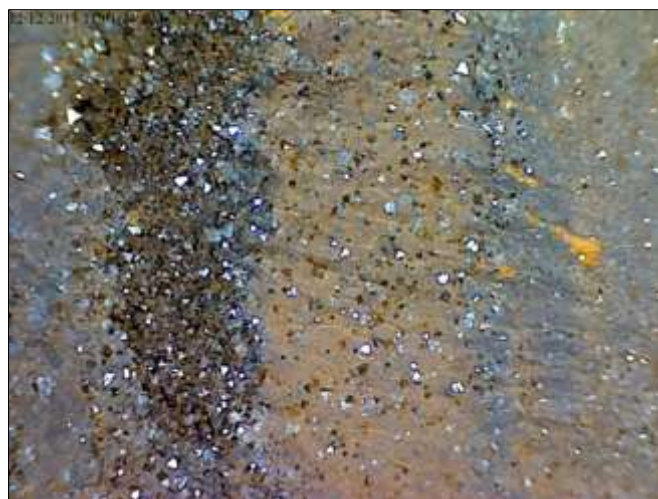
The same process that drives hardcapping in the bedrock drives lithification of the sediments. There is a carbonate zone in the sediments, and this carbonate zone hosts the most well developed microminerals I have found to date, where the carbonate has been replaced with silica and iron. Beautifully terminated quartz crystals, dolomite rosettes and an interesting array of pseudomorphs have been found in the silicified carbonates. Goethite/limonite replacing dolomite rhombohedra are common, as well as goethite replacing prismatic dolomite. There are also some interesting scalenohedral hematites which may be primary or pseudomorphs after calcite. However, calcite is rare, most of the carbonates are dolomitic. Admittedly, none of these have been analysed quantitatively, however whole rock assays show high magnesium contents (the Ca:Mg ratio is usually close to 1) and any nice rhombohedral crystals show curvature of the crystal faces. These

hematites/calcites are also further replaced with goethite, and usually have hollow centres partially filled with limonite.

Ok, so it's hardly comparable to Lake Boga granite quarry, but it just goes to show that if you look hard enough, eventually you'll find *something* to micromount!



Hematized wood fragment. 10mm FOV.



Martites in goethite matrix. 10mm FOV.



Pyrolusite. 10mm FOV.



Quartz. 10mm FOV.



Suspected pyroaurite-desautelsite. 10mm FOV.



Turgite. 10mm FOV.

Minerals from Jindivick, Victoria

John Haupt

An abandoned basalt quarry at Jindivick has produced a number of interesting zeolite minerals. Mineralogical Society (Victoria) member, Bob McPherson, drew the society's attention to the quarry at Jindivick in 1983. It was investigated and became a popular collecting locality during the 1980s to the mid-1990s.



Above: A Mineralogical Society of Victoria field trip to the Jindivick Quarry, October 1988.

The Minerals

A summary of the minerals found at Jindivick follows. Additional information on these is contained in the references, Birch (1987; 1988) & Haupt (1989) and hence it is not repeated here.

Analcime was uncommon at Jindivick and usually occurred as small glassy crystals lining small cavities in the basalt. It was commonly associated with levyne.

Calcite was relatively common at Jindivick, occurring in several forms and colours. Attractive micros of yellowish brown slender tapering crystals were found with either white 'cubes' of calcite or sprays of thomsonite perched on the terminations (see photographs). Pinkish club shaped calcite sprays are often overgrown with white calcite crystals. Calcite also forms lustrous clear crystals and less commonly, deep orange-red 'dog-tooth' crystals.



White calcite rhombs overgrowing a 6mm tall club shaped cluster of calcite.



Clear calcite rhombs and a twinned chabazite crystal growing on slender orange calcite crystals. 6mm FOV.

Chabazite was the most abundant zeolite found at Jindivick, forming as clear glassy pseudocubic crystals, usually as simple penetration twins. The more complex twin, known as phacolite, rarely occurred at Jindivick.



A 2mm chabazite twin on thomsonite spheres. Specimen: V. Hannah.



Orange 'dog tooth' calcite crystals to 1mm on chabazite.

Cowlesite was first found by the author at Jindivick. It forms brilliant white globular crusts and rosettes to 0.5mm across in small vesicles to 10mm. Cowlesite has a distinctive pearly lustre. The individual crystals are tapered and curved with a thickness in the order of $2\mu\text{m}$ (Birch, 1988). The adjacent vesicles usually contained levyne or an unidentified clay infilling.



Globular rosettes of cowlesite lining a 6mm basalt cavity. Note the characteristic pearly lustre.



Radiating cowlesite spheres, 1mm across, showing a mass of bladed crystals.

Levyne. Initially thought to be barite, it was found by Fred Kapteina in the quarry in 1983. It forms interlocking flat hexagonal crystals up to 5mm across. The tabular (0001) face commonly has a white frosted appearance from an overgrowth of offretite. Levyne is often associated with analcime.



A group of levyne crystals, to 3mm, typically found at Jindivick.



Sketch showing the growth mechanism of offretite on levyne (from Tschernich, 1992).

Offretite. Commonly an intergrowth with erionite, it occurs as fibrous growths and ridges on the tabular face of levyne crystals.



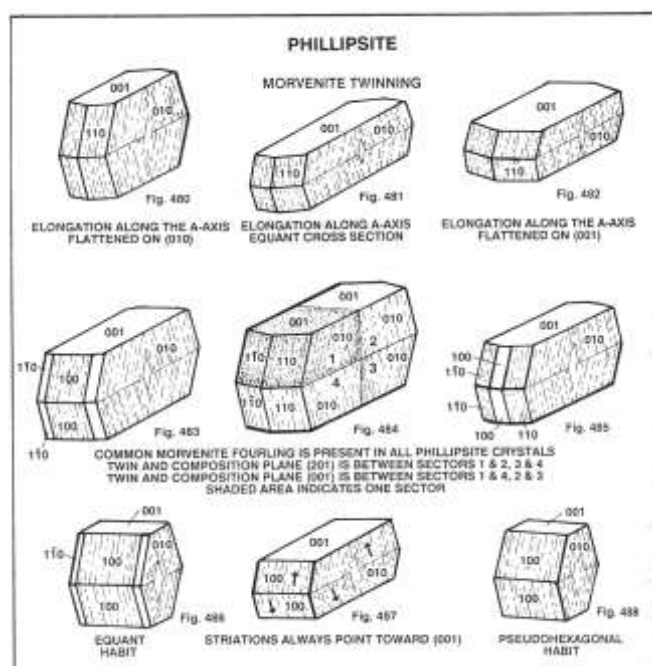
Fibrous offretite overgrowths on levyne. 5mm FOV.



Phillipsite crystals in a cavity lined with globular thomsonite and 'cob-web' thomsonite. 8mm FOV.



Phillipsite crystals lining a basalt cavity, 10mm across.



Sketch showing the morvenite twinning of phillipsite (from Tschernich, 1992).

Phillipsite occurred sparingly at Jindivick. Phillipsite always forms complex penetration twins - untwinned phillipsite has never been found (Tschernich, 1992). At Jindivick it forms clear to white morvenite twins up to 5mm in cavities to 2 cm across.

Thomsonite is the most ubiquitous mineral at Jindivick, occurring in various forms. Most common are cream to grey spherules with a greasy lustre, up to 2 mm across. When magnified they can be seen to consist of a tightly packed mass of elongated crystals. The stacking of the spherules creates worm-like structures. Some are stacked in decreasing

diameter, creating 'cork-screw' structures. Small individual crystals and 'bow-tie' crystal groups are occasionally found perched on slender calcite needles. Translucent white fibres exhibiting a 'cob-web' appearance over chabazite-lined cavities have been identified as thomsonite.



A spray of thomsonite crystals growing on 0.5mm tall calcite crystals. V Hannah specimen.



Sprays of thomsonite crystals growing on pale orange calcite. 4mm FOV.



A 10mm tall stack of thomsonite spheres creating a worm-like structure on chabazite.



Right: Fibrous 'cob-web' thomsonite covering chabazite crystals. 10mm FOV. V. Hannah specimen.

Accompanying photographs:

All the photographs have been taken by John Haupt unless otherwise noted.

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An 8mm cavity with grey to cream lustrous thomsonite spheres and worm-like growths with fibrous thomsonite (white).



Fibrous thomsonite growths on thomsonite spheres, 4mm FOV. J. Price specimen.



Fibrous thomsonite on thomsonite spheres. 4mm FOV. V. Hannah specimen.



Fibrous thomsonite lining a 10mm basalt cavity.



Right: A worm-like or 'Corkscrew' growth of thomsonite. 5mm FOV.

Minerals of the Woodlawn Mine in the Southern Tablelands of NSW **The Micromineral Group, Mineralogical Society of New South Wales Inc.**

Introduction

The Woodlawn Mine site is 39 km south of Goulburn and 69 km northeast of Canberra near the town of Tarago in the Southern Tablelands of New South Wales. Open cut mining began in 1977 with underground mining commencing 10 years later producing 13.4 million tonnes of high grade copper, lead and zinc ore together with significant gold and silver from deposits within the Lachlan Fold Belt. In 1998 it closed when the operator at the time, Denehurst Limited, went into receivership due to financial difficulties that left wage entitlements of \$6.5 million unpaid to 160 employees.

In 2004, the mine site was re-opened, and soon after, the former mine workers received their entitlements from the new owners, Veolia. That company used (and continues to use)

the vast open-cut pit for disposal of waste from Sydney, and an 11 turbine wind farm has been established on the site. Later, in 2013 the NSW Government gave approval for the site to be redeveloped for mining by the Canadian-Australian company TriAusMin thereby creating 200 construction jobs and 140 ongoing jobs. It appears that the mine has the capacity to produce 150,000 tonnes of copper, zinc and lead concentrates annually from 1.5 million tonnes of tailings and ore extracted from proven underground reserves, for at least 20 years. Whether this development occurs or not will depend on the world markets for base metals.

Geology

This information was prepared from the sources listed in the Bibliography.

The original deposit, estimated to be 10 million tons, was located on the eastern limb of the Woodlawn syncline within an area of Middle to Late Silurian acid volcanics near an unconformity with Late Ordovician sediments. The ore body evidently occurred within porphyry, tuffs, shales and schists collectively known as the Woodlawn volcanics and was about 200m long, 300m deep, dipping to the west and striking north-south. Consequently, it has been classified as a volcanic hosted massive sulphide deposit with mineralization typical of deposition under submarine conditions on the margin of a volcanic rift followed by metamorphic alteration.

The ore mostly comprised massive zinc-lead-copper sulphides together with minor stockwork and disseminated mineralization. Small scale stratiform banding and gross chemical zoning occurred within the massive sulphides. The main primary minerals comprised sphalerite, pyrite, galena, chalcopyrite and tetrahedrite together with lesser covellite, chalcocite and malachite. Minor barite and fluorite were present within the gangue which included talc, quartz, chlorite and phlogopite.

Minerals

According to Mindat, the following minerals have been identified in the Woodlawn deposit:

arsenopyrite, barite, bismuthinite, calcite, chalcocite, chalcopyrite, 'chlorite group', covellite, fluorite, galena, gold var electrum, greenockite, limonite, malachite, marcasite, muscovite, phlogopite, pyrite, pyrrhotite, quartz, sphalerite, stannite, talc, 'tennantite-tetrahedrite' series and tetrahedrite.

Photographs of three forms of greenockite are the only images of Woodlawn minerals shown in Mindat.

In addition, considerable silver in yellow ochrous corderite was present in the gossan and barite, corderite, cerussite, chrysocolla, tenorite and copper carbonates were observed in the oxidised zone (pers. comm. Pogson R., 2014).

The NSW Micromineral Group

Eight members of the Group met at the home of Dieter Mylius on Saturday 10th May 2014, to study mineral specimens from the Woodlawn Mine. These specimens had been gathered during a visit to the mine site by members of The NSW Mineralogical Society in May 1999

and both previously and subsequently in several individual visits. The Group continued to work on this report during several following meetings.

The following mineral species, not listed in Mindat, were identified in the specimens that were examined.

aurichalcite $(\text{Zn,Cu})_5(\text{CO}_3)_2(\text{OH})_6$

Aurichalcite was found as tufts of bluish green crystals in cavities in a limonitic gossan together with cerussite on dump material. It appeared to have formed on grains of cerussite with individual sprays about 0.5 to 0.8mm across as shown in Fig. 1.



Fig. 1 Aurichalcite with cerussite, fov (field of view) 5mm, depth of field enhanced with Combine ZM stacking software (CZM), specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.

azurite $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$

Azurite seems to be uncommon other than as occasional stainings on gossan but stubby crystals up to about 1mm, Fig. 2, have been observed and seem to have formed directly on limonitic gossan and on cerussite, Fig. 3.

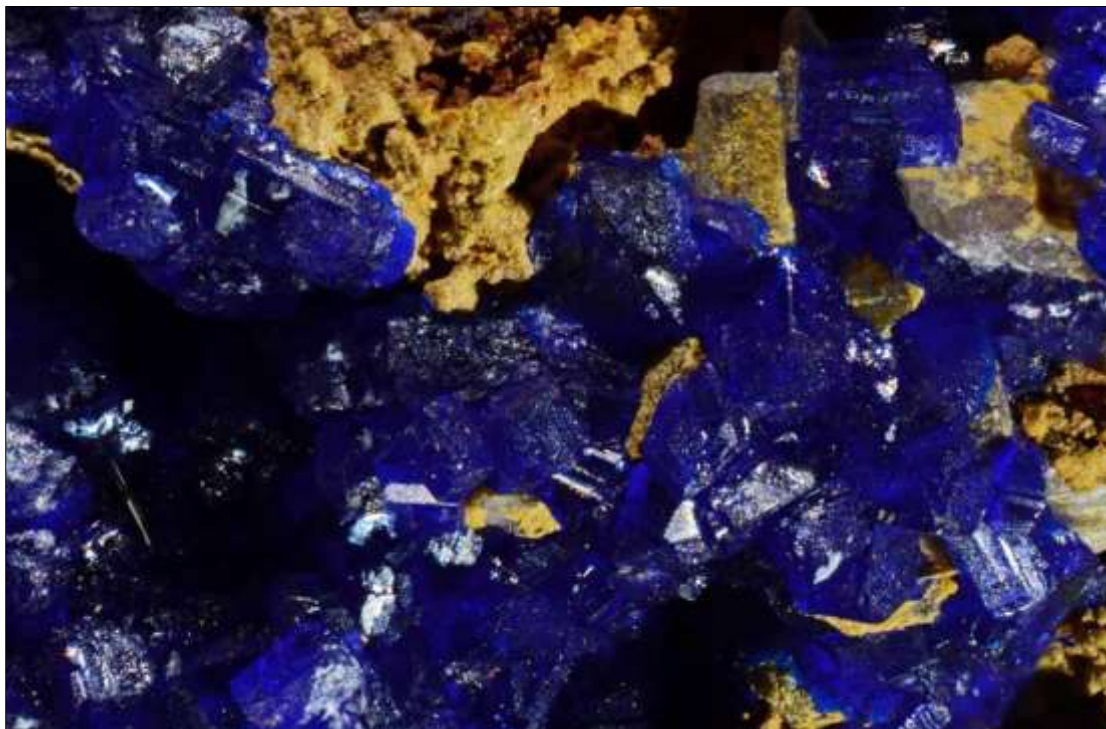


Fig. 2 Azurite on limonite with minor cerussite, fov 7mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.

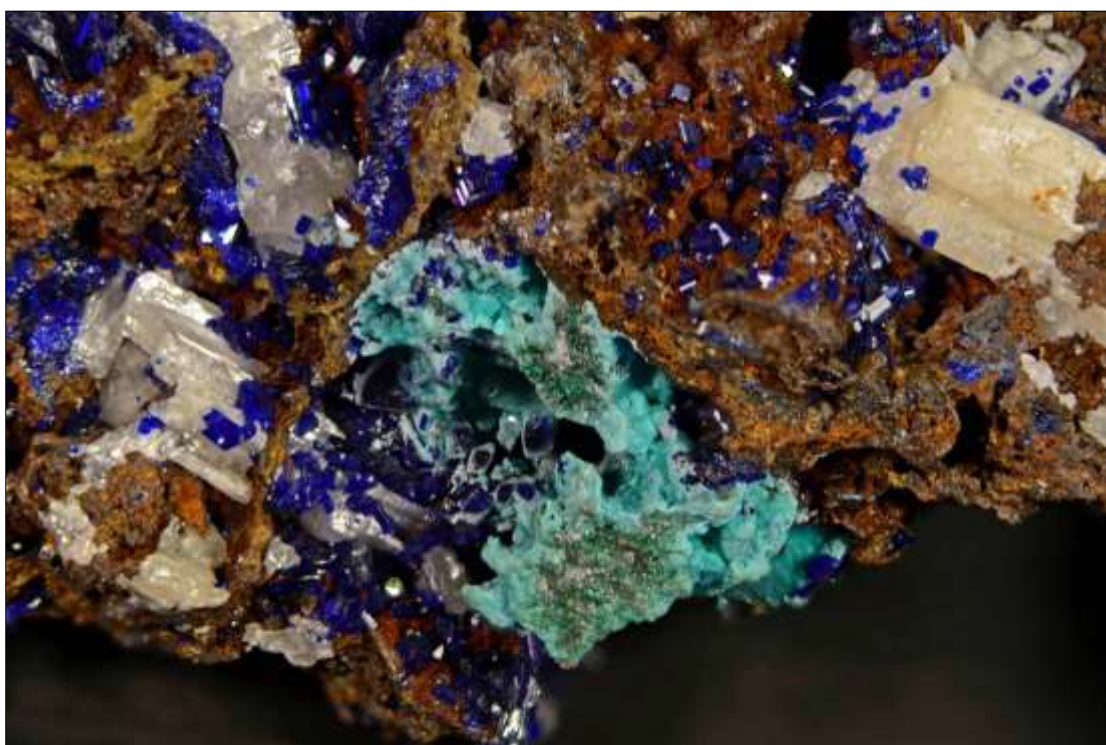


Fig. 3 Stubby azurite crystals on goethite, cerussite and a blue/green unknown mineral with malachite, fov 14mm, depth of field enhanced with CZM, specimen John Behrens, photograph Dieter Mylius.

brochantite $\text{Cu}_4(\text{SO}_4)(\text{OH})_6$

Brochantite is an uncommon mineral at Woodlawn, but has been observed in one specimen as granular crystal aggregates on malachite, Fig. 4, which in turn had formed on limonite.



Fig. 4 Brochantite on malachite and limonite, fov 8mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.

cerussite PbCO_3

Cerussite is common in the gossan at Woodlawn, and has been found in pockets and veins of appreciable size, Fig 5. There are often several generations in single specimens, with the matrix also occasionally consisting of small granular crystals. Many of these attractive specimens were obtained by Dieter Mylius and Doug Austin from one large boulder that yielded collectable pieces up to 420mm in size. A large vein of cerussite in the boulder was amazing but the real beauty was in the details of the three generations of cerussite in the smaller specimens such as shown in Figs. 6 and 7. Other regions of the same boulder revealed pure white cerussite, Fig. 8, and cerussite associated with malachite Fig. 9, while other occurrences included isolated small twinned crystals on goethite, Fig. 10. In some specimens, the cerussite is partially reticulated, Fig. 11 and in others it occurs as nests of thin elongated crystals, some with iron staining, Fig. 12.



Fig. 5 Pocket of pale straw-coloured cerussite, specimen size 45 x 25mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected November 1998.



Fig. 6 Cerussite with goethite, showing colourless to milky blocky cerussite on second generation needles of cerussite, stained golden by goethite, on first generation crystals of cerussite thickly coated with brown goethite, fov 7mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected November 1998.



Fig. 7 Stubby clear/white crystals of cerussite on golden goethite stained elongated crystals of cerussite and a dark heavily coated crystal, fov 6mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius.



Fig. 8 White elongated crystals of cerussite, fov 80mm, specimen and photograph Dieter Mylius.



Fig. 9 Blocky and elongated crystals of cerussite together with spheroidal arrays of small malachite crystals, fov 12mm, specimen and photograph Ann & Noel Kennon.



Fig. 10 Cerussite twin on dark goethite in cavity, fov 7mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected November 1998.



Fig. 11 Partially reticulated cerussite, specimen size 28 x 20mm, specimen and photograph Dieter Mylius. Specimen collected November 1998.



Fig. 12 Nest of acicular cerussite crystals, some with iron staining which appears random in occurrence, fov 23mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected November 1998.

clinozoisite $\text{Ca}_2\text{Al}_3[\text{Si}_2\text{O}_7][\text{SiO}_4]\text{O}(\text{OH})$

Clinozoisite was found occasionally as small elongated crystals in cavities in the host rock of the ore body, Fig. 13.



Fig. 13 Elongated crystals of clinozoisite in a cavity, fov 5mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius.

connellite $\text{Cu}_{19}^{2+}\text{Cl}_4(\text{SO}_4)(\text{OH})_{32}\cdot 3\text{H}_2\text{O}$

Connellite is uncommon at Woodlawn, and is only occasionally found as aggregates of small dark blue crystals on gossan, Fig. 14. It does not appear to form in generic association with any other minerals.

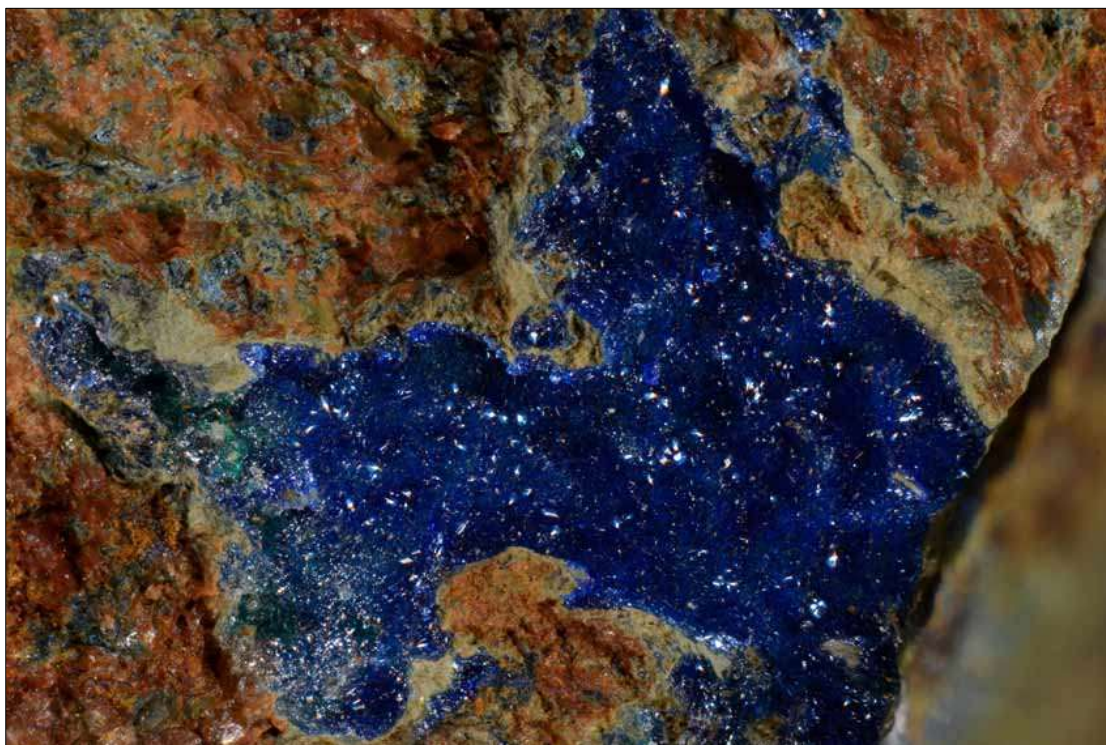


Fig. 14 Connellite, fov 7mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.

goethite $\alpha\text{-Fe}^{3+}\text{O}(\text{OH})$

Goethite is ubiquitous as the gossan and host to secondary minerals other than the sulphides. It is usually earthy, limonitic and massive, but can form attractive brown to grey nodular growths, Fig 15. Typically, such nodules are not associated with other minerals and have a semi-vitreous lustre making them attractive specimens, Fig. 16.



Fig. 15 Nodular goethite, fov 18 mm, specimen and photograph Ann & Noel Kennon.



Fig. 16 Goethite nodule, specimen size 40 x 35mm, specimen and photograph Dieter Mylius. Specimen collected November 1998.

gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

In 1998, gypsum was found in on-site water courses as massive beds of post mining evaporative deposits. A number of small patches of delicate crystals found on host rocks on the dumps, Fig. 17, are also likely to be post-mining occurrences.



Fig. 17 Efflorescent groups of gypsum crystals (<0.5mm) are probably post mining and found on occasional pieces of host rock, fov 8mm, specimen 40 x 22mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected November 1998.

hemimorphite $\text{Zn}_4\text{Si}_2\text{O}_7(\text{OH})_2 \cdot \text{H}_2\text{O}$

Hemimorphite occurred in one specimen as profuse tufts of small white bladed crystals, Fig. 18.

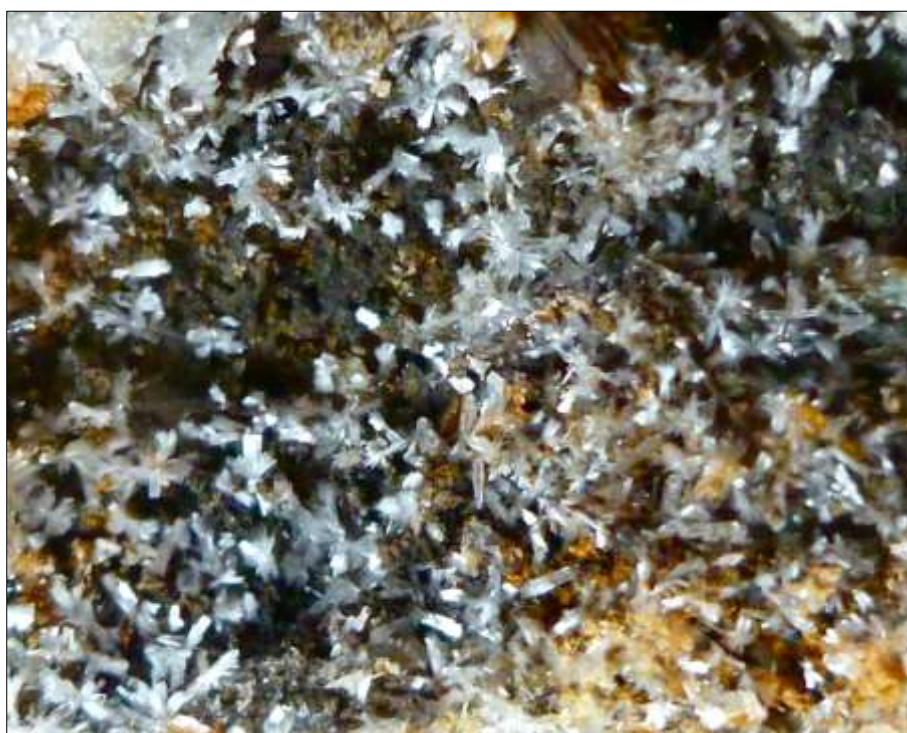


Fig. 18 Small white bladed tufts of hemimorphite on gossan, fov 18mm, specimen and photograph Ann & Noel Kennon.

linarite $\text{PbCu}(\text{SO}_4)(\text{OH})_2$

Linarite was rare but occurred in several specimens as a coating on cerussite, Fig. 19, mostly in association with cerussite.



Fig. 19 Linarite staining on cerussite on gossan rich in cerussite, fov 55mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected by Paul Melville.

magnetite Fe_3O_4

A single specimen of massive magnetite from the gossan was circulated. The specimen was weakly magnetic and had been gifted to Graham Ogle by E. J. Malone in about 1975. It was not photographed.

rosasite $(\text{Cu,Zn})_2(\text{CO}_3)(\text{OH})_2$

Rosasite occurred in its usual morphology of small blue-green spheroids, Fig. 20.



Fig. 20 Rosasite on cerussite, fov 8mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius.

serpierite $\text{Ca}(\text{Cu}^{2+}, \text{Zn})_4(\text{SO}_4)_2(\text{OH})_6 \cdot 3\text{H}_2\text{O}$

Serpierite occurred as areas of small light blue crystals, Fig. 21.



Fig. 21 Serpierite on calcite, fov 9mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected in 1998.

silver Ag

A specimen containing small wires of silver and owned by Doug Austin was sighted by Graham Delaforce but was not available to be photographed.

smithsonite ZnCO_3

Smithsonite occurred as small whitish elongated spheroids typical of the species, Figs. 22, as aggregates, Fig. 23, and as small green crystals, Figs. 24 and 25.

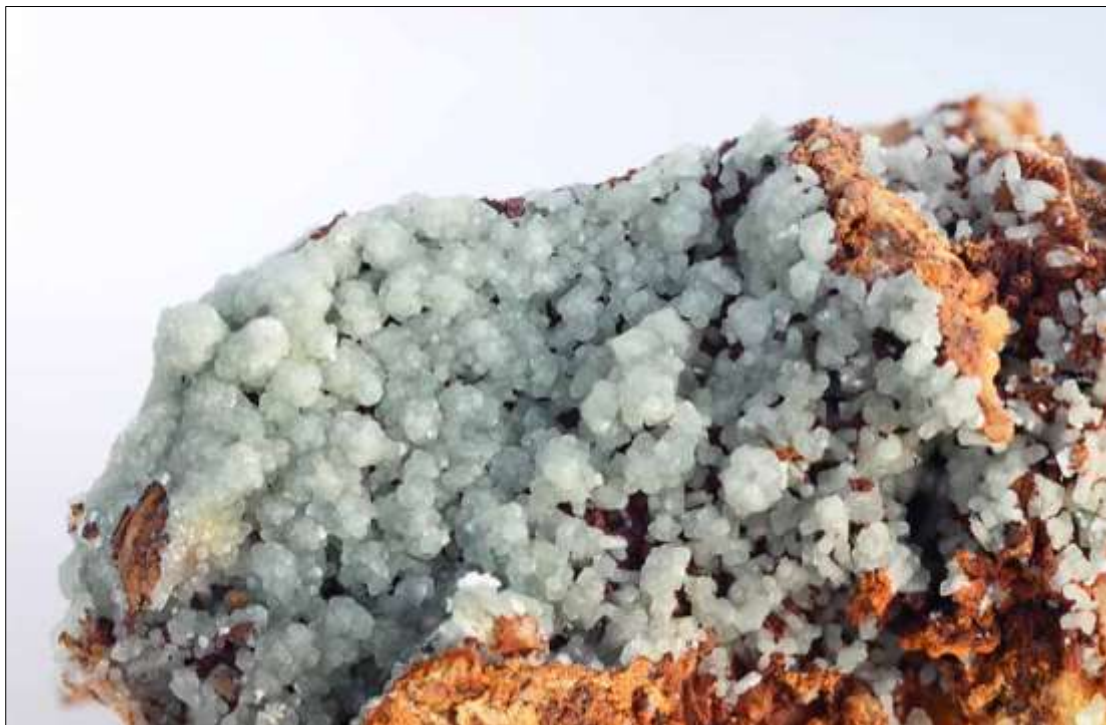


Fig. 22 Smithsonite crystals with typical morphology to 1mm, on gossanous quartz, fov 30mm, specimen 30 x 22mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.



Fig. 23 Aggregates of crystals of smithsonite, fov 5mm, depth of field enhanced with CZM, specimen Graham Ogle, photograph Dieter Mylius.



Fig. 24 Crystals of green smithsonite, fov 25mm, depth of field enhanced with CZM, specimen Graham Ogle, photograph Dieter Mylius.



Fig. 25 Crystals of green smithsonite, fov 5mm, depth of field enhanced with CZM, specimen Graham Ogle, photograph Dieter Mylius.

Discussion

All fifteen minerals described above were identified by morphology and colour as observed by stereoscopic microscopy and reference to known characteristics of some species. No X-ray diffraction or micro-chemical analyses were carried out so that some of the identifications remain provisional. However, the identification of serpierite, shown in Fig. 21, has been confirmed by X-ray fluorescence analysis.

In addition to the species not listed in Mindat and described above, several listed minerals were common in the specimens the Group examined. These species included the following:

- (i) covellite as small dark blue equant crystals, Fig. 26,
- (ii) secondary galena as cubes, Fig. 27,
- (iii) greenockite in several morphologies such as shown in Figs. 28 and 29,
- (iv) malachite as thin crystals, Figs. 30, 31, botryoidal masses, Fig. 32, as thin coatings on cerussite, Fig 33, and as pseudomorphs after azurite in one specimen (in a small deep vugh which precluded photography),
- (v) massive tetrahedrite, Fig. 34,
- (vi) pyrite as cubes, Fig. 35.

It will be noted that Ross Pogson observed “silver in yellow ochrous corkite” in the gossan, and “barite, corkite, cerussite, chrysocolla, tenorite and copper carbonates” in the oxidised zone. Of these minerals, corkite, chrysocolla and tenorite are not listed in Mindat and were not detected in the present study.



Fig. 26 Very small crystalline aggregates of metallic blue covellite on mixed fine grained sulphides, fov 7mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius.



Fig. 27 Very small sub-metallic cubes of secondary galena on matrix of fine grained sulphides, fov 6mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.



Fig. 28 Vitreous yellowish to reddish brown ball-shaped clusters of greenockite to 1.5mm on mixed sulphides. The specimen, obtained from a site metallurgist in the mid 1990's by Geoff Parsons, had two patches of greenockite about 7 and 20 mm in length, each being nearly continuous on the host sulphide rock. The exposed surface was virtually all in the form of vitreous complete multi-faceted ball structures although several were fractured probably where they had contacted the other side of the fissure in which they formed. Depth of field enhanced with CZM, photograph Dieter Mylius.



Fig. 29 Yellow to orange to red microcrystals of greenockite on mixed fine grained sulphides, fov 8mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected November 1998.



Fig. 30 Acicular crystals of malachite lining a cavity in gossan, fov 9mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen obtained from Gerry Morvell in 1998.



Fig. 31 Spray of acicular crystals of malachite on gossan, fov 15mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius.

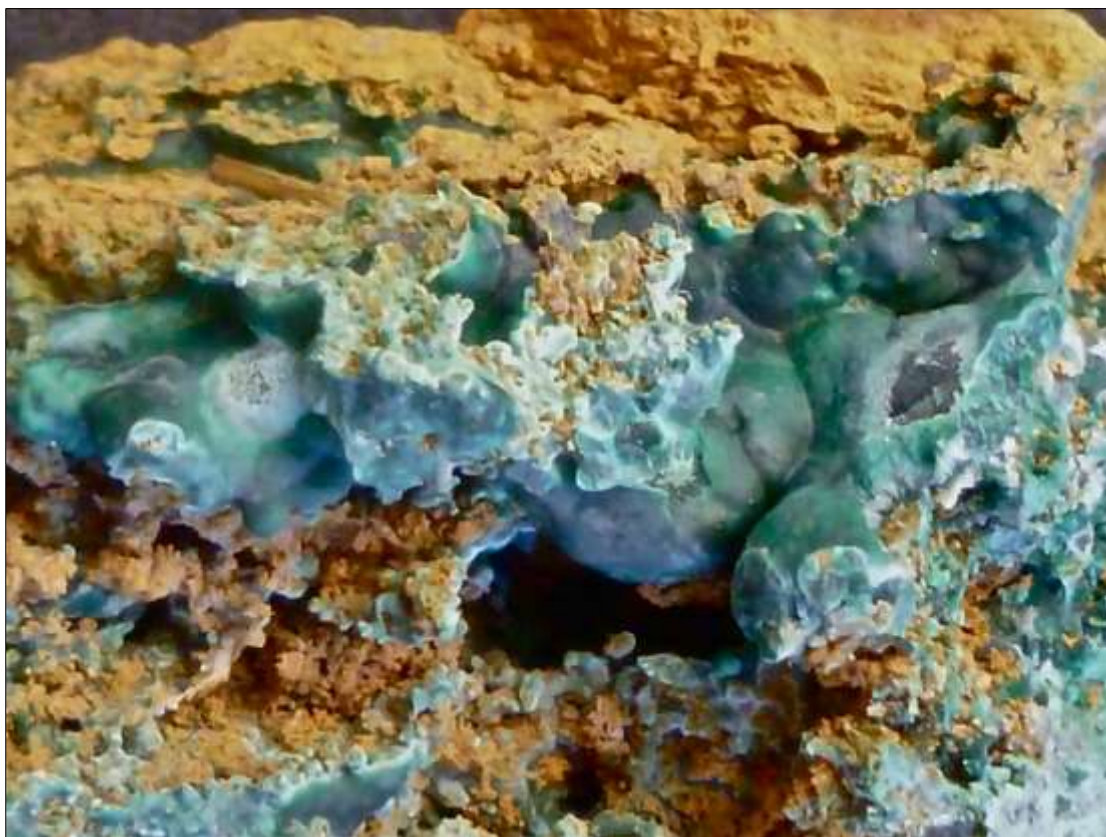


Fig. 32 Botryoidal malachite in gossan, fov 16mm, specimen and photograph Ann & Noel Kennon.

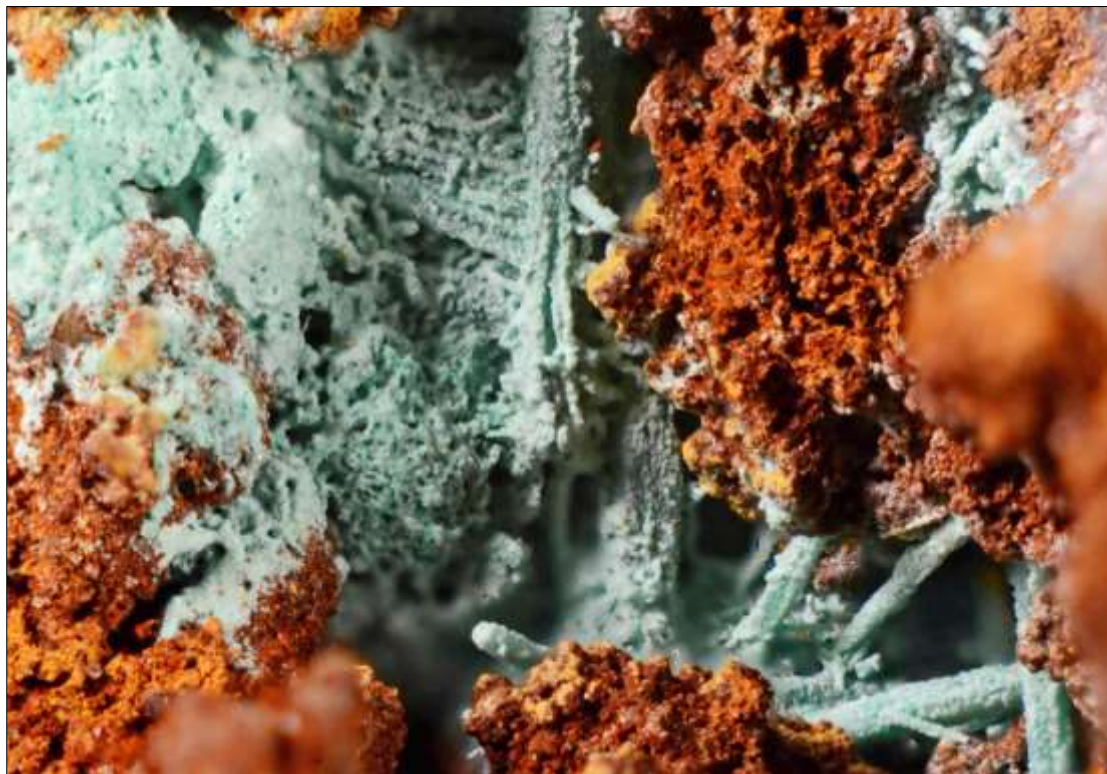


Fig. 33 Thin coating of malachite on cerussite in gossan, fov 7mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius.



Fig. 34 Massive tetrahedrite (30mm long), depth of field enhanced with CZM. Specimen Graham Ogle from Jim Sharpe, photograph Dieter Mylius.

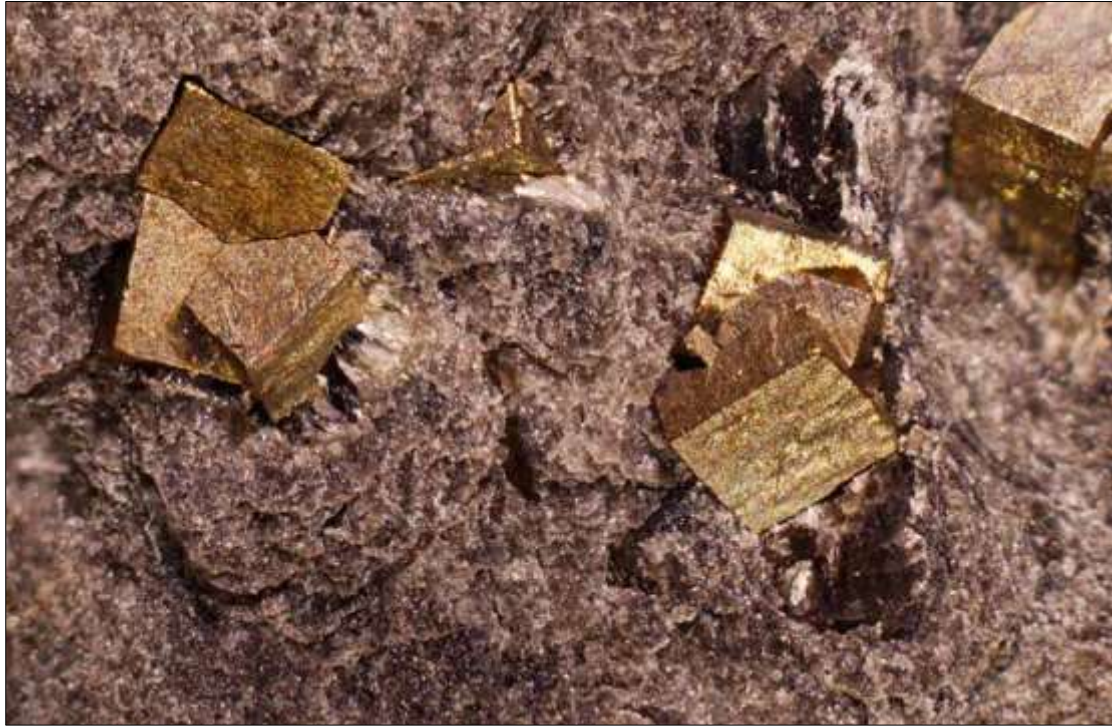


Fig. 35 Small cubes of pyrite in a foliated host rock, fov 8mm, depth of field enhanced with CZM, specimen and photograph Dieter Mylius. Specimen collected in 1998.

Conclusion

Fifteen minerals, not cited in Mindat, have been identified in specimens from the Woodlawn mine. However, it is probable that several of the identifications proposed here will remain provisional until such time that occasional laboratory resources in active research establishments are devoted to X-ray or micro-chemical analyses of specimens from this locality. It was clear from the range of species in the specimens available to members of the Micromineral Group that this first exercise has been successful and this publication will add significantly to the literature on this locality. It is quite possible that other collectors will have specimens in which additional species might be identified and hopefully reported in *ANZ Micromineral News*.

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Note – Ross Pogson (Mineralogy Collection Manager of the Australian Museum, Sydney) had a long and interesting association with Woodlawn. As a student he worked at the mine for 6-7 months each year for the five years from 1975 to 1979 and lived on-site. This was the period of exploration and reserves-proving and when the gossan was being shallow-drilled on a grid pattern to test the metal contents. He remembers a lot of silver being found in yellow ochrous corkite. Ross was also part of a 4-man geophysical prospecting team helping to delineate the deposit. In those early days he saw a lot of the minerals from the oxidised zone (barite, corkite, cerussite, chrysocolla, tenorite, copper carbonates, etc.) and also explored the local geology with test pits to sample the sulphides – much of which were banded and folded. His recollections of those days have been most helpful in preparing this article and are gratefully acknowledged.

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