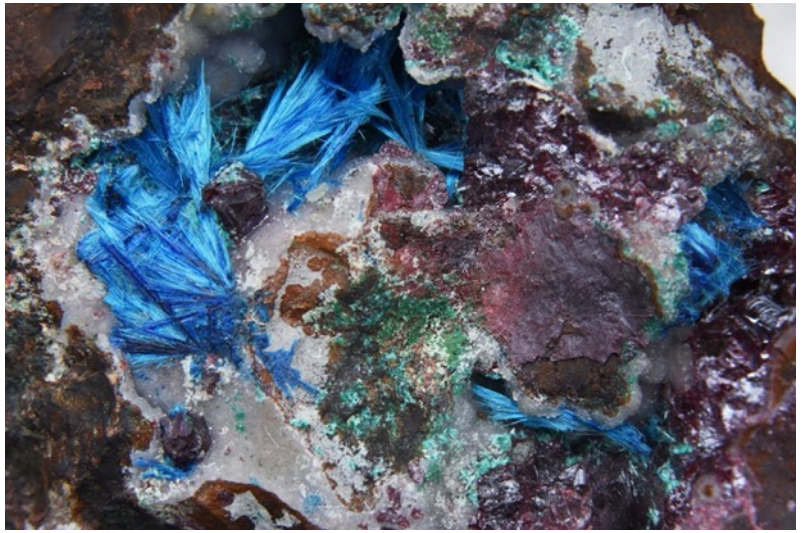
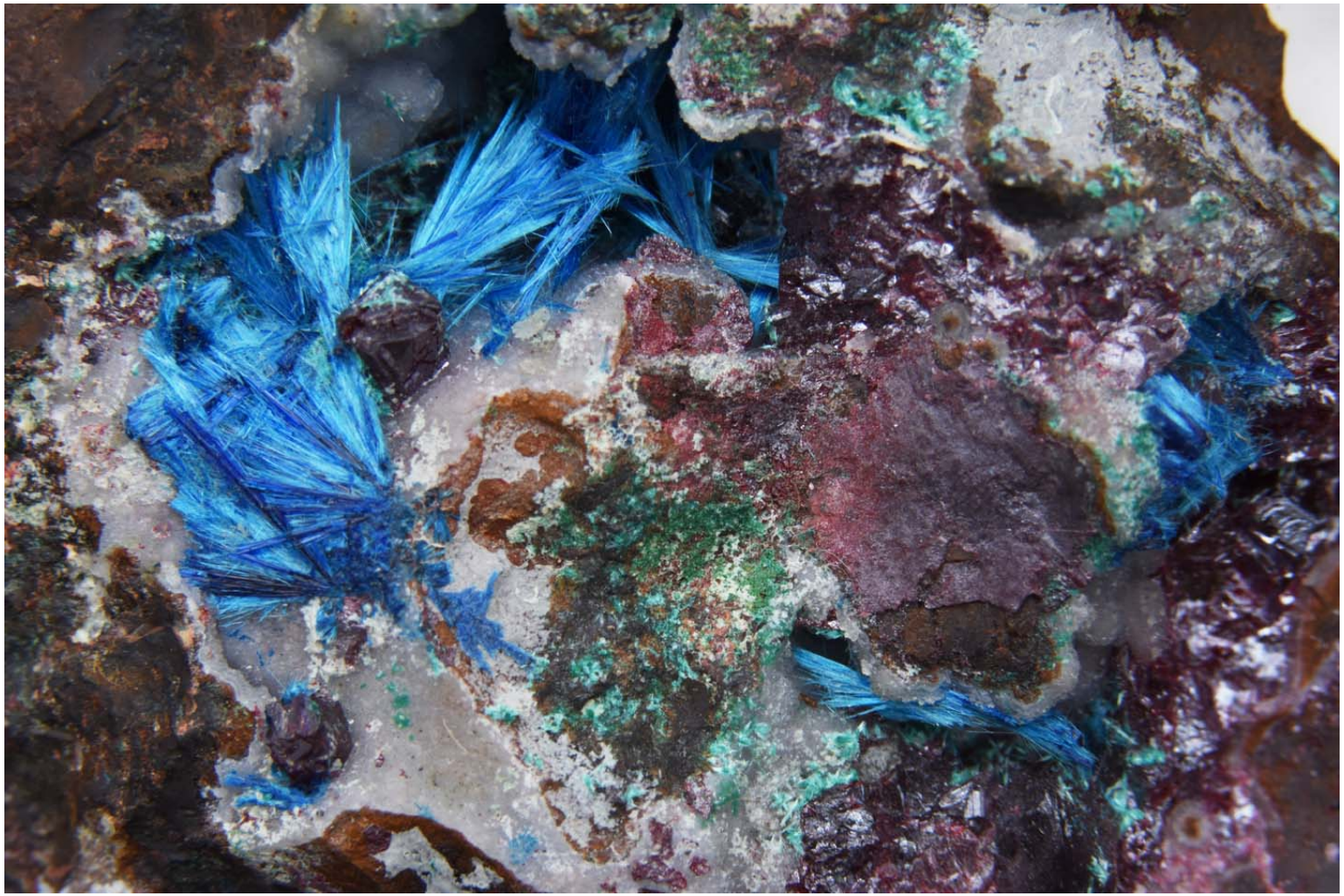
Secondary Copper Minerals of the Mount Isa Block



Peter A. Williams and James L. Sharpe

Mayne-Walkers Lecture 2019

Connellite, Great Australia mine, Cloncurry; *ca* $Cu_{19}Cl_4(SO_4)(OH)_{32}.3H_2O$; fov 20 mm



Connellite, *ca* $Cu_{19}Cl_4(SO_4)(OH)_{32}.3H_2O$ *versus* buttgenbachite, *ca* $Cu_{19}Cl_4(NO_3)_2(OH)_{32}.2H_2O$, also from the Great Australia mine, Cloncurry. Both are present in the last image.

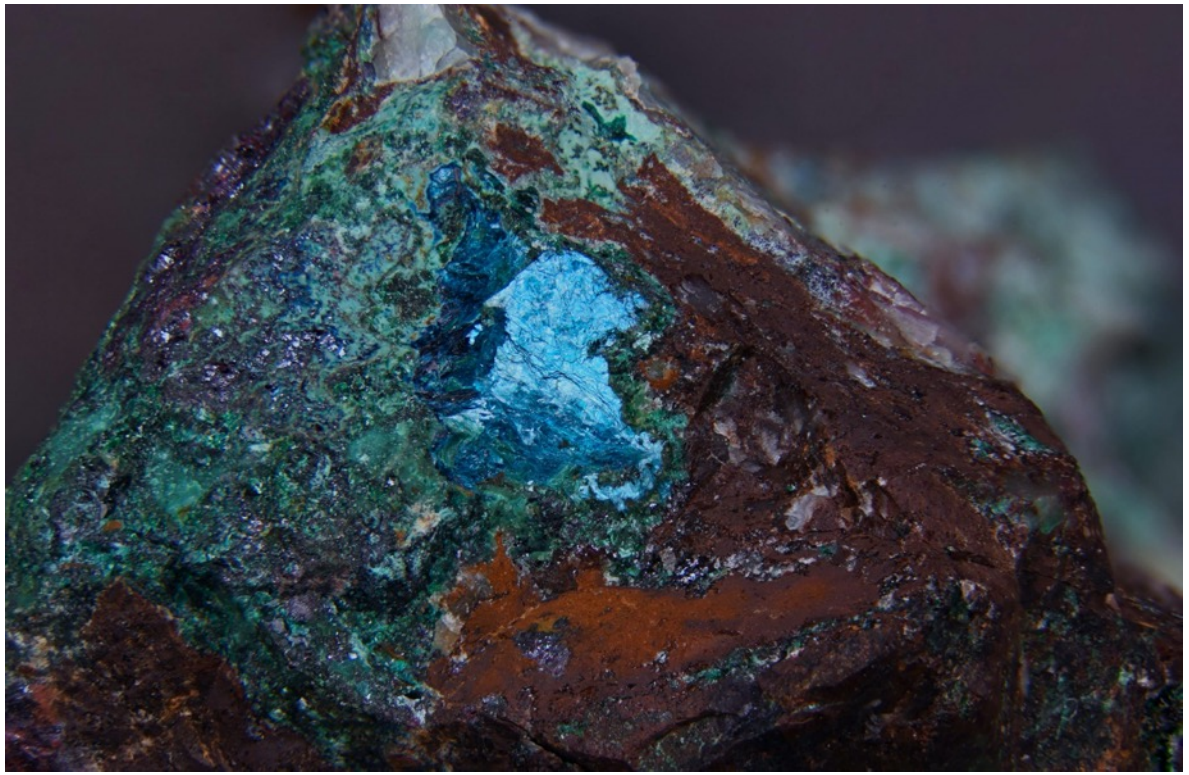
A complex solid solution between the two; analysis (chemical or single-crystal X-ray) is needed.

Note all the anions (many variables that give rise to the host of secondary minerals in the mines of the Mt Isa Block, and elsewhere).

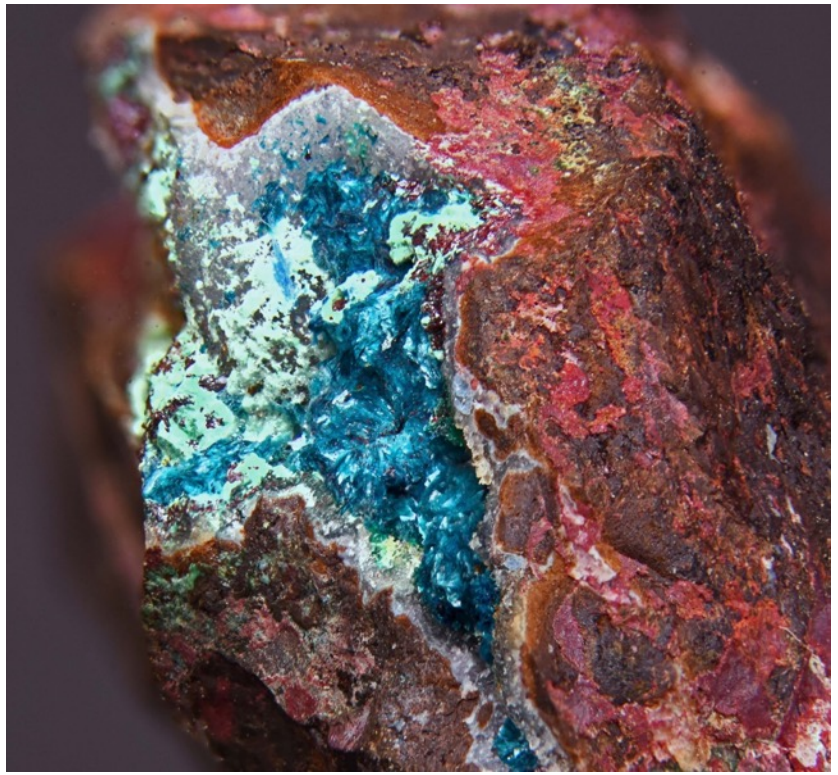
What are the variables we have in play with in the oxidized zone, besides various numbers and concentrations of different available anions and cations?

Structure, available ions, pH, redox potential, temperature, kinetic phenomena (and combinations of these factors)

Available anions and cations



Barlowite, $Cu_4BrF(OH)_6$, Great Australia mine; fov 25 mm

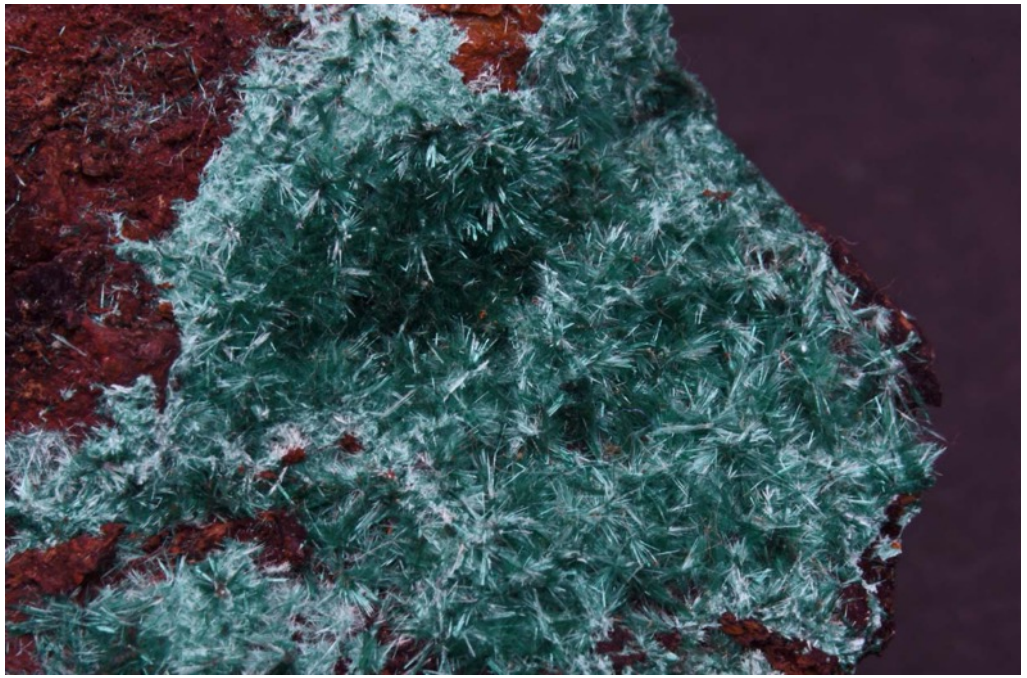


Claringbullite, $Cu_4Cl_2(OH)_6$, Great Australia mine; fov 15 mm

pH

$$Cu_3SO_4(OH)_4 + Cu^{2+} + 2H_2O \rightarrow Cu_4SO_4(OH)_6 + 2H^+$$

Antlerite, $Cu_3SO_4(OH)_4$, Monakoff mine, Cloncurry; fov 13 mm



Brochantite, $Cu_4SO_4(OH)_6$, Mount Oxide; fov 32 mm

- Antlerite is also known from Mt Oxide, the Blockade mine, Bushy Park Station, Duchess, and the Desolation mine, White Range, 50 km S of Cloncurry.
- Fine specimens of brochantite are also known from Mt Oxide, Mt Norma, 30 km SE of Cloncurry, as well as Great Australia.

Brochantite on cuprite, fov 6 mm,
Great Australia mine, Cloncurry

Redox potential – note that we have only looked at Cu^{2+} minerals so far.

Cu^{o} – native copper, Cu; Cu^{+} – cuprite, Cu_2O, and a surprise (!) nantokite, CuCl

Copper, Black Rock open cut, Mt Isa, 80 x 35 x 23 mm

Cuprite, Great Australia mine, Cloncurry, fov 15 mm

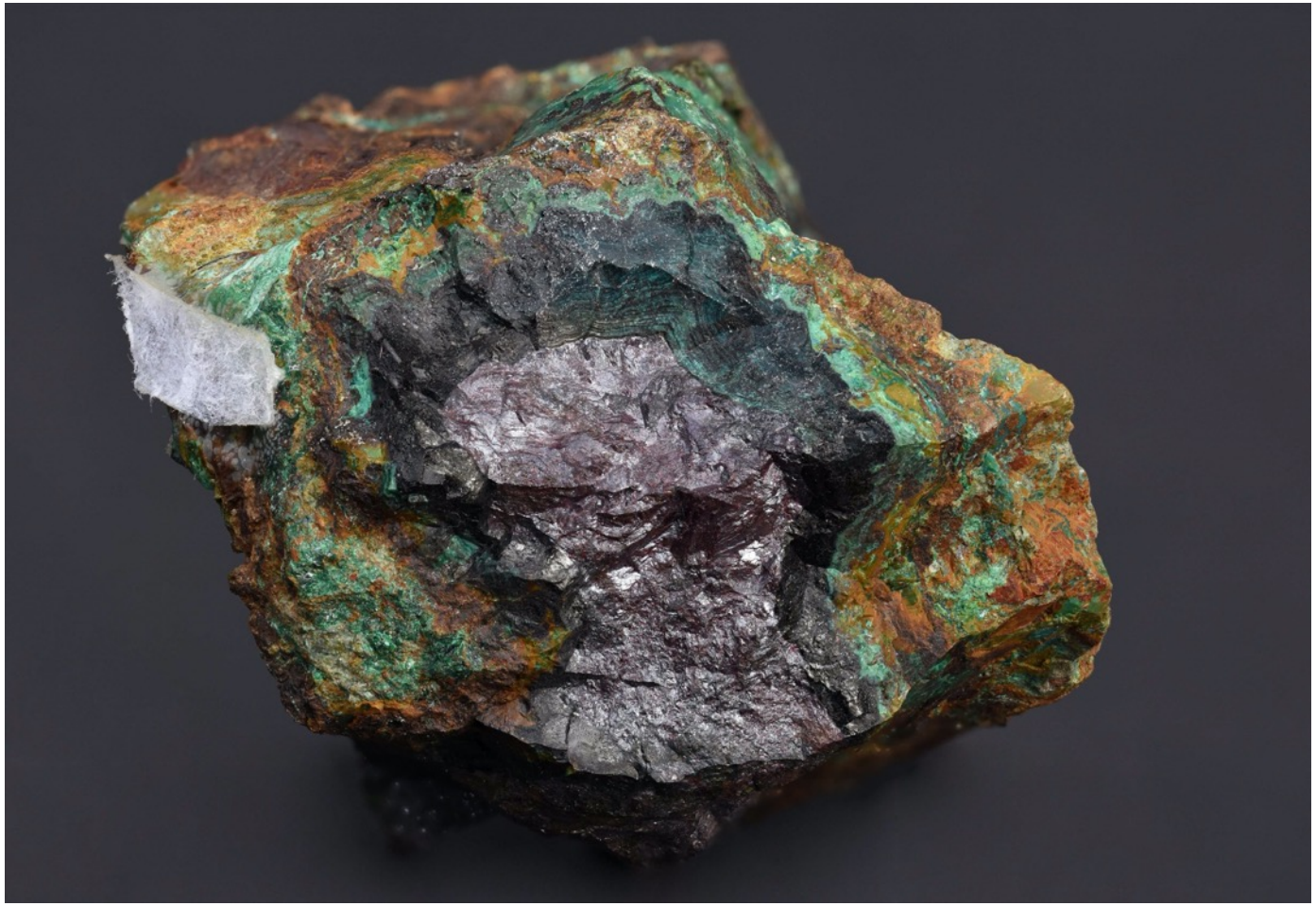
Nantokite, CuCl, the thixotropic mineral!
It is reported from the Magpie, Wewak and Great Australia mines.

Tons of “quartz plus cuprite” were recently recovered from Great Australia, but samples turned “quartz” into atacamite on transfer to Sydney!

Fine specimens of acicular cuprite (*chalcotrichite*) are known from the Black Rock open cut, Mt Isa, Great Australia, and the Starra mine, Selwyn, where it was abundant.

Cuprite occurs in most of the Cu deposits of the Mt Isa Block.

Tenorite, CuO, is commonly found as a massive alteration product of cuprite. Notable localities are the Mt McCabe and Great Australia mines.

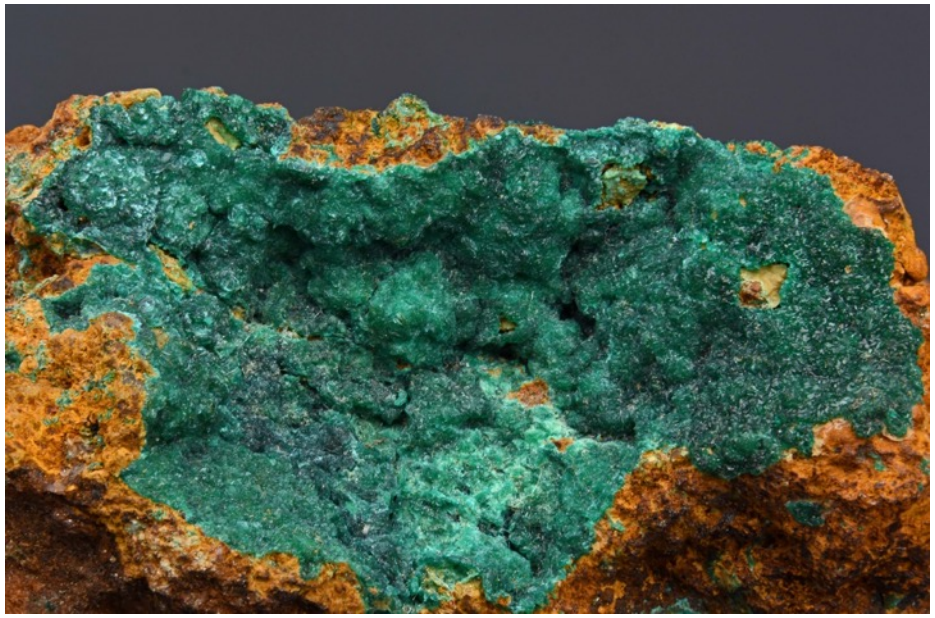


Cuprite altering to tenorite altering to malachite, Great Australia mine, 40 x 30 x 30 mm

Temperature or kinetic phenomena

- Pseudomalachite $Cu_5(PO_4)_2(OH)_4$
- Reichenbachite $Cu_5(PO_4)_2(OH)_4$

Reichenbachite, Mount Glorious mine, Cloncurry; 95 x 80 x 50 mm

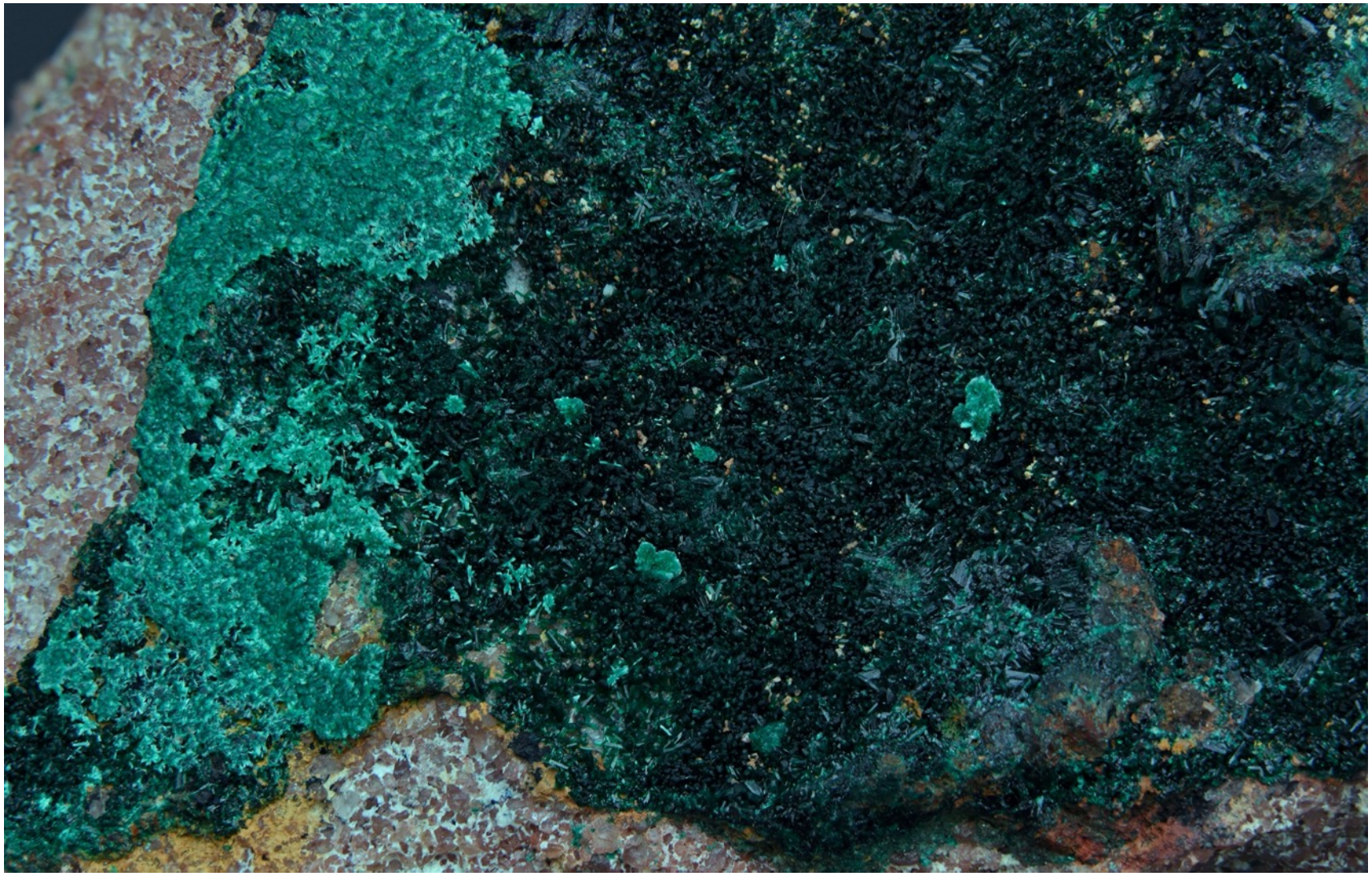


Pseudomalachite, Great Australia mine, Cloncurry; fov 23 mm

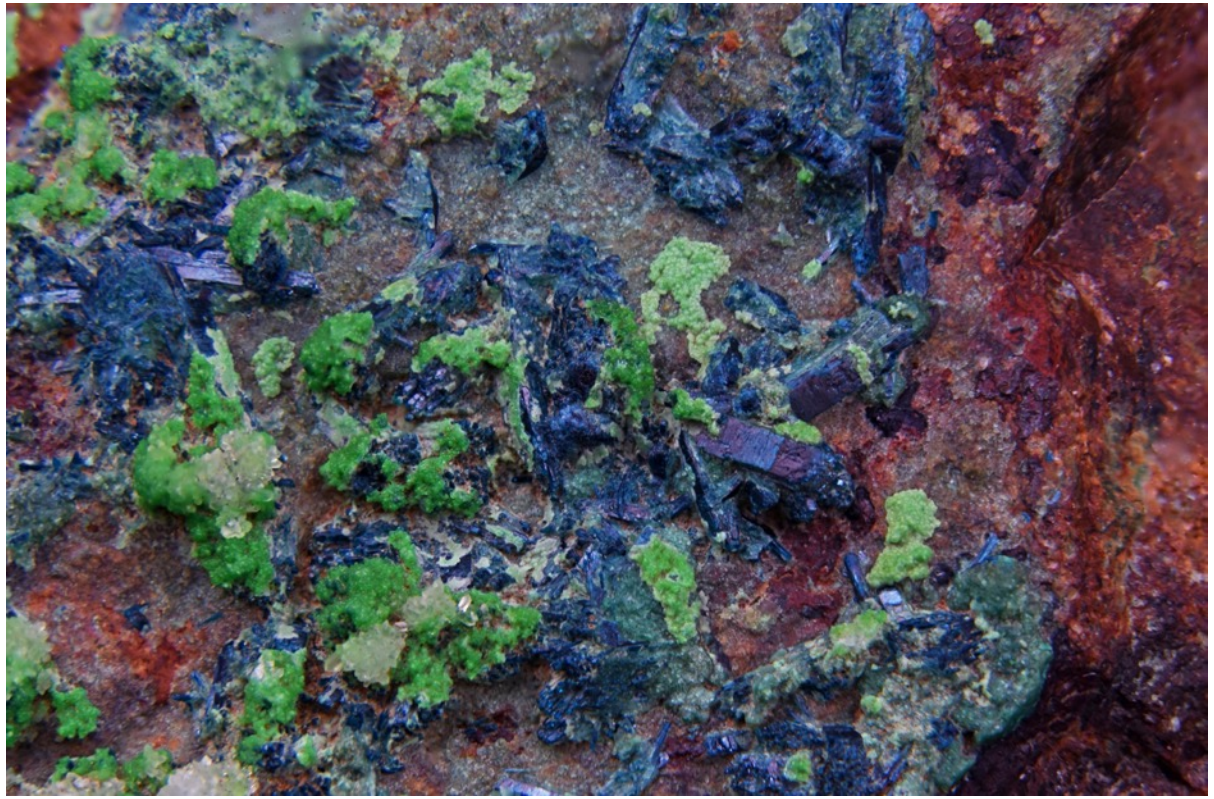
Kinetic phenomena

- The Ostwald Step Rule is in play with respect to the two phosphates just mentioned.
- Rare cornetite ($Cu_3PO_4(OH)_3$) and much libethenite (Cu_2PO_4OH) are associated with pseudomalachite and reichenbachite at Great Australia, but their formation depends on varying amounts of Cu^{2+} in solution and pH. Cornetite is also known from the Desolation and Crusader mines together with pseudomalachite and libethenite.
- Atacamite ($Cu_2Cl(OH)_3$) is known from Great Australia, Mt Oxide, the Lady Ella mine, Selwyn. Thousands of tons are present in the oxidized zone of the Osborne deposit, some 100 km S of Cloncurry. To our knowledge, the polymorphs of atacamite, paratacamite and botallackite, have not been reported from the Mt Isa Block.

Atacamite, Mt Oxide, fov 30 mm



Other arsenate analogues of copper phosphates include clinoclase, $Cu_3AsO_4(OH)_3$, from Poseiden, Lorena, Desolation and Mt Cobalt mines and olivenite, Cu_2AsO_4OH, reported from the Lorena and Desolation mines, Mt Oxide and Mt Cobalt.



Clinoclase (blue) with conichalcite (green), Lorena gold mine, fov 15mm.

Odd anions, metals and combinations

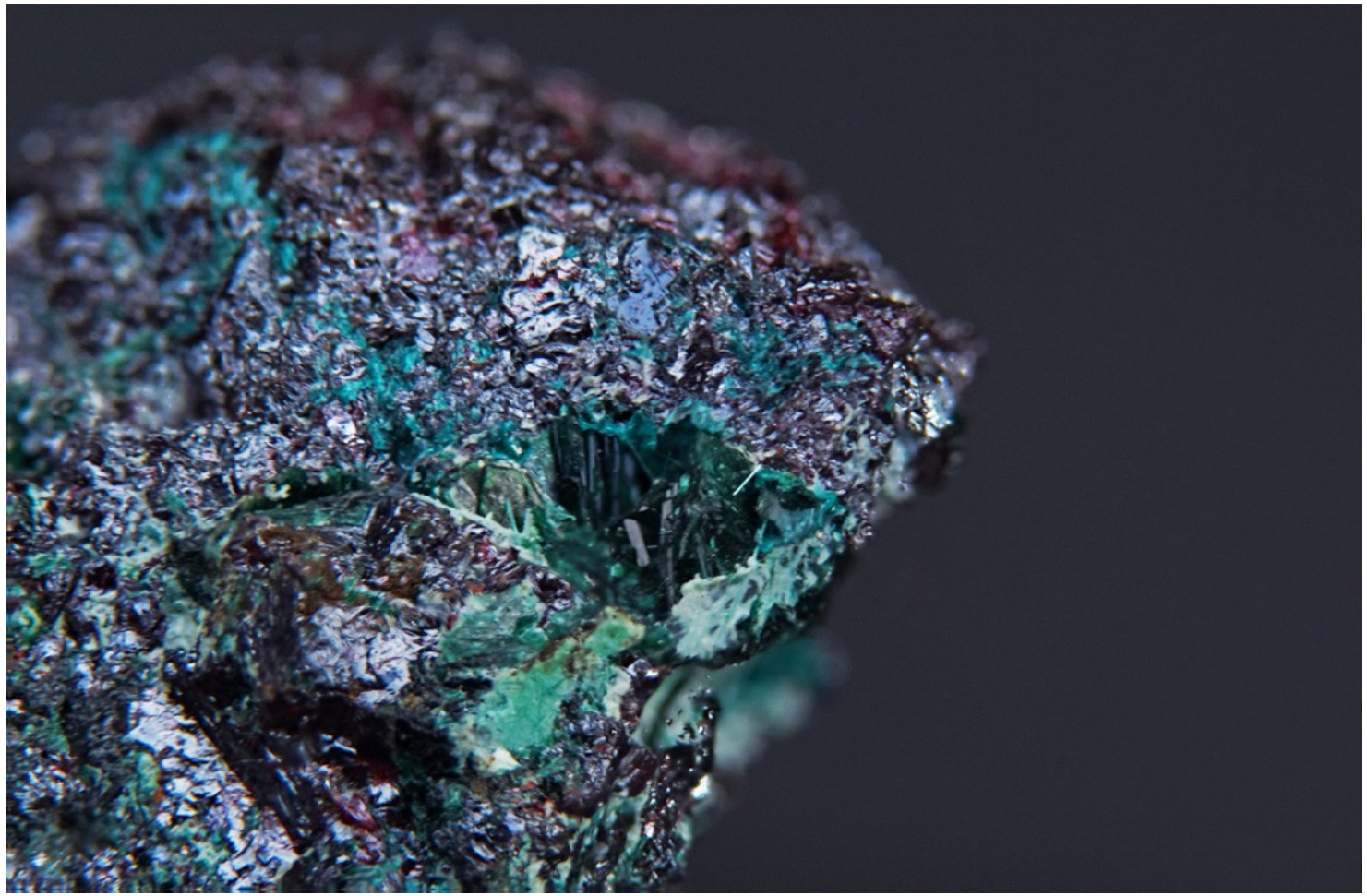
Other nitrates

- Gerhardtite, $Cu_2NO_3(OH)_3$, is known from the Monakoff and Great Australia mines.
- Likasite, $Cu_3NO_3(OH)_5.5H_2O$, is known from Great Australia (single specimen).

Multi- metal and anion species

- Agardite, $(REE,Ca)Cu_5(AsO_4)_3(OH)_6.3H_2O$, is known from Mt Oxide.
- Lavendulan, $NaCaCu_5(AsO_4)_4Cl.5H_2O$, is is a rare phase at Mt Cobalt.
- Chenevixite, $Cu_2Fe_2(AsO_4)_2(OH)_4.H_2O$, occurs in the Desolation mine.
- Conichalcite, $CaCuAsO_4OH$, is the most common secondary copper arsenate in mines of the Mt Isa Block. Notable occurrences are at Mt Cobalt, the Desolation mine and the Lorena gold mine.
- Chalcosiderite, $CuFe_6(PO_4)_4(OH)_8.4H_2O$, was found at Mt Oxide.

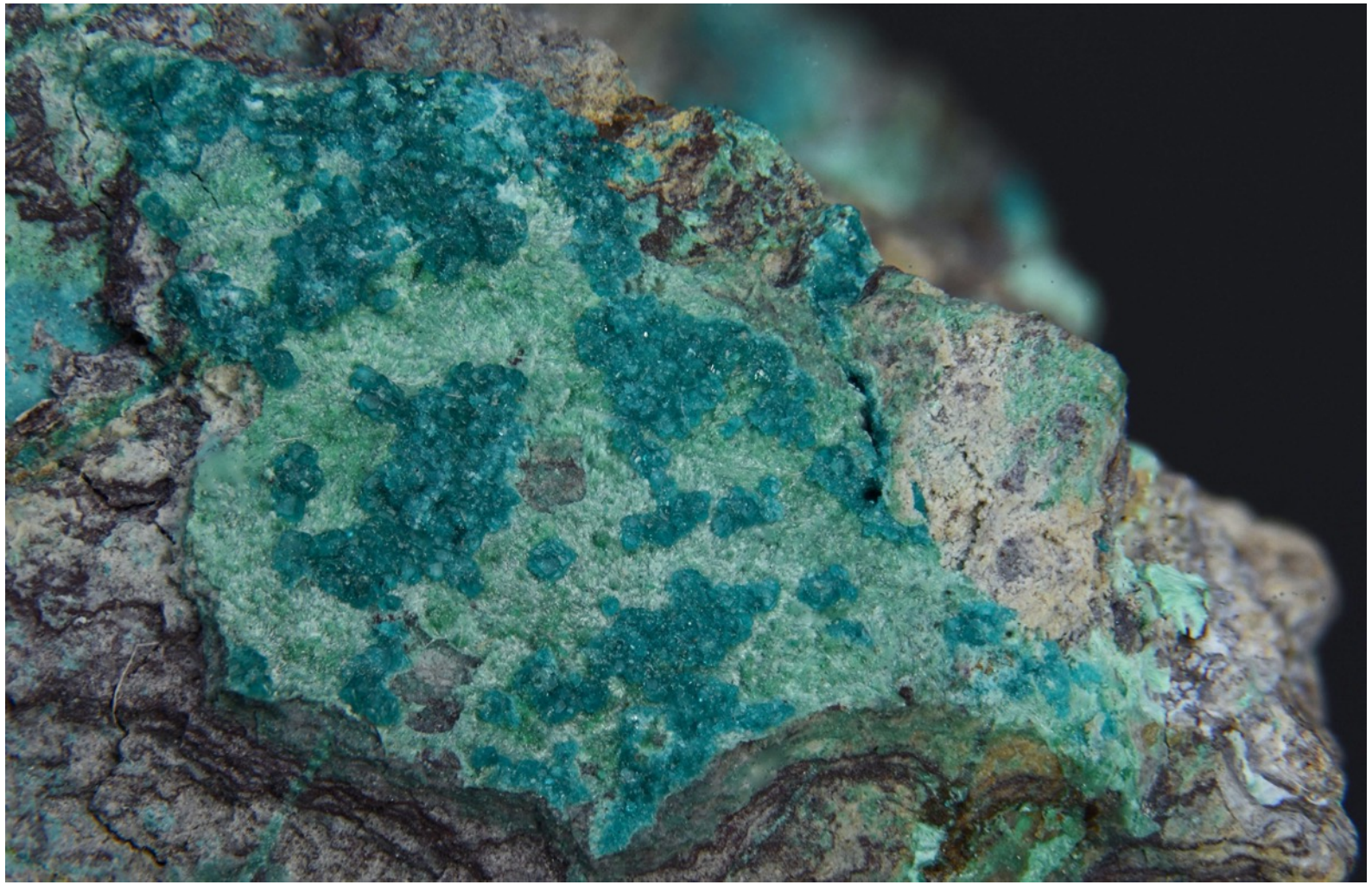
Gerhardtite on cuprite, Great Australia, fov 12 mm. **Where does the nitrate come from for this mineral, likasite and buttgenbachite?**

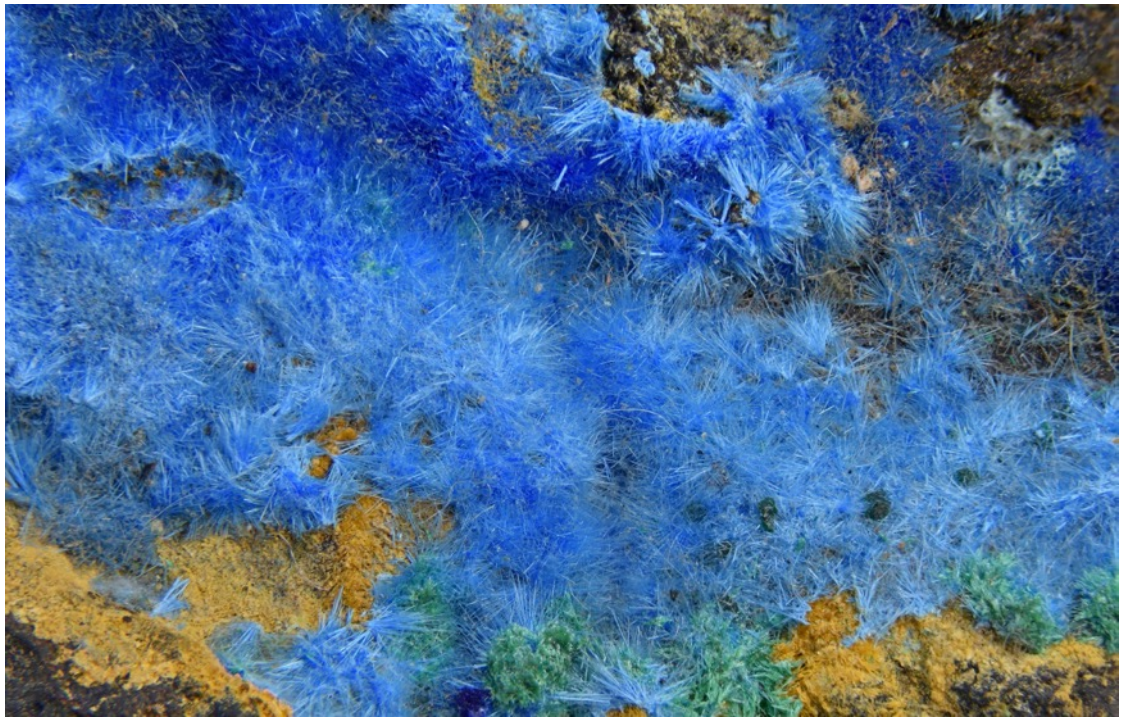


Multi- metal and anion species (cont.)

- Hentschelite, $CuFe_2(PO_4)_2OH$, is found at Great Australia, associated with cuprite.
- Metatorbernite, $Cu(UO_2)_2(PO_4)_2.8\text{-}12H_2O$, occurs in the Monakoff and Desolation mines.
- Tsumebite, $Pb_2CuPO_4SO_4OH$, occurs in the Monakoff mine.
- Turquoise, $CuAl_6(PO_4)_4(OH)_8.4H_2O$ is known from Mt Oxide.
- Sieleckiite, $Cu_3Al_4(PO_4)_2.2H_2O$, is associated with libethenite, turquoise and variscite ($AlPO_4.2H_2O$) at Mt Oxide.
- Chalcoalumite, $CuAl_4SO_4(OH)_{12}.3H_2O$, is associated with cyanotrichite and brochantite at Mt Oxide.
- Cyanotrichite, $Cu_4Al_2SO_4(OH)_{12}.3H_2O$, is found as above.
- Spangolite, $Cu_6Al_2SO_4(OH)_{12}Cl.3H_2O$, is very uncommon, but occurs in outcrop neat the open cuts at Mt Isa.

Spangolite on chrysocolla, Desolation mine, fov 12 mm.





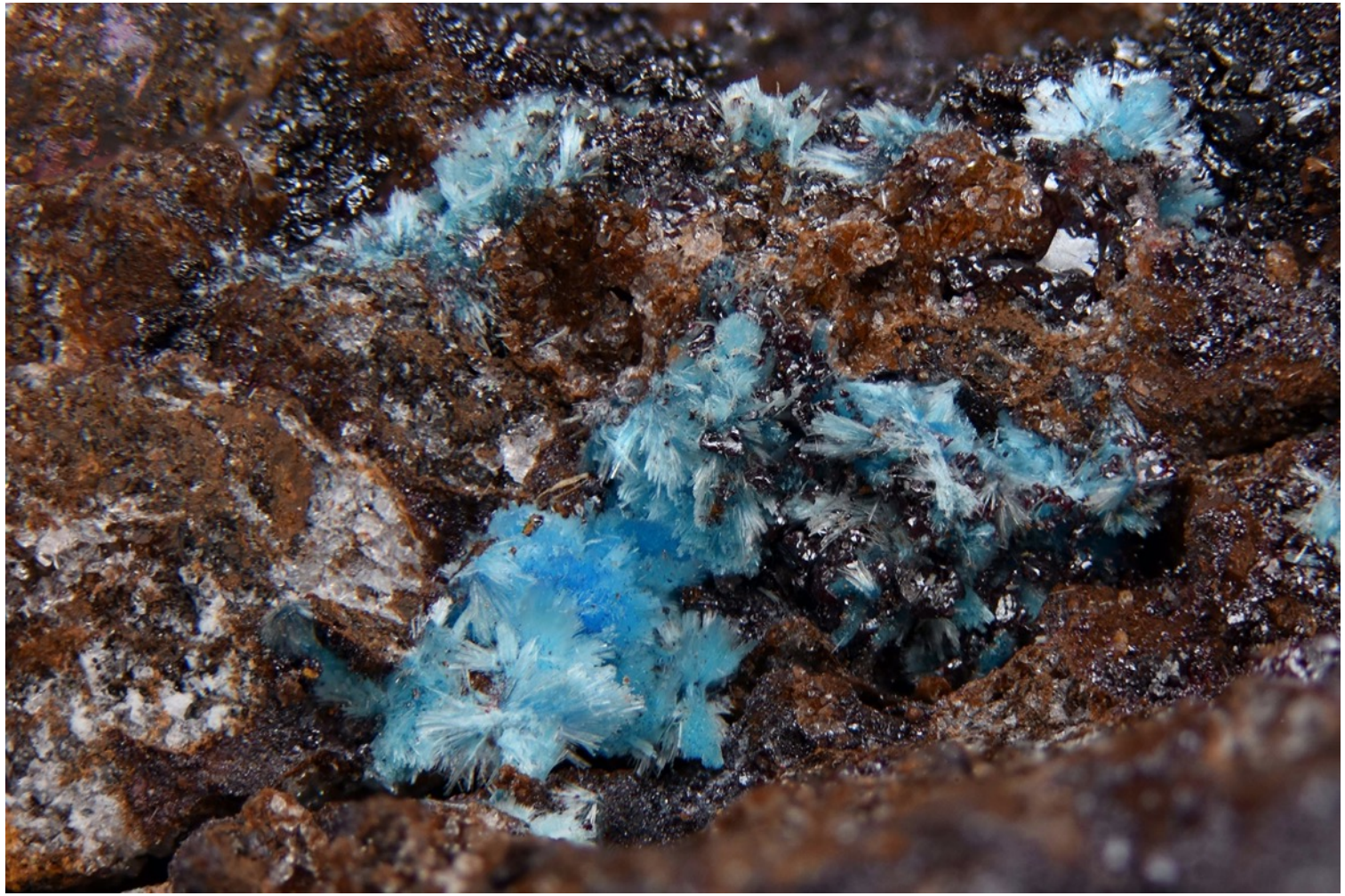
Cyanotrichite, Mt Oxide, fov 26 mm

Metatorbernite, Monokoff mine, fov 20 mm

Weird minerals!

Namibite, $Cu(BiO)_2VO_4OH$, Alone Hand mine, Duck Creek, Malbon; associated with beyerite,$(Ca,Pb)Bi_2(CO_3)_2O_2$, after bismuthinite, and gold

Cloncurryite, $Cu_{0.5}(VO)_{0.5}Al_2(PO_4)_2F_2.5H_2O$, Great Australia mine, Cloncurry



Cloncurryite on cuprite
Fov 8 mm, Great Australia mine, Cloncurry

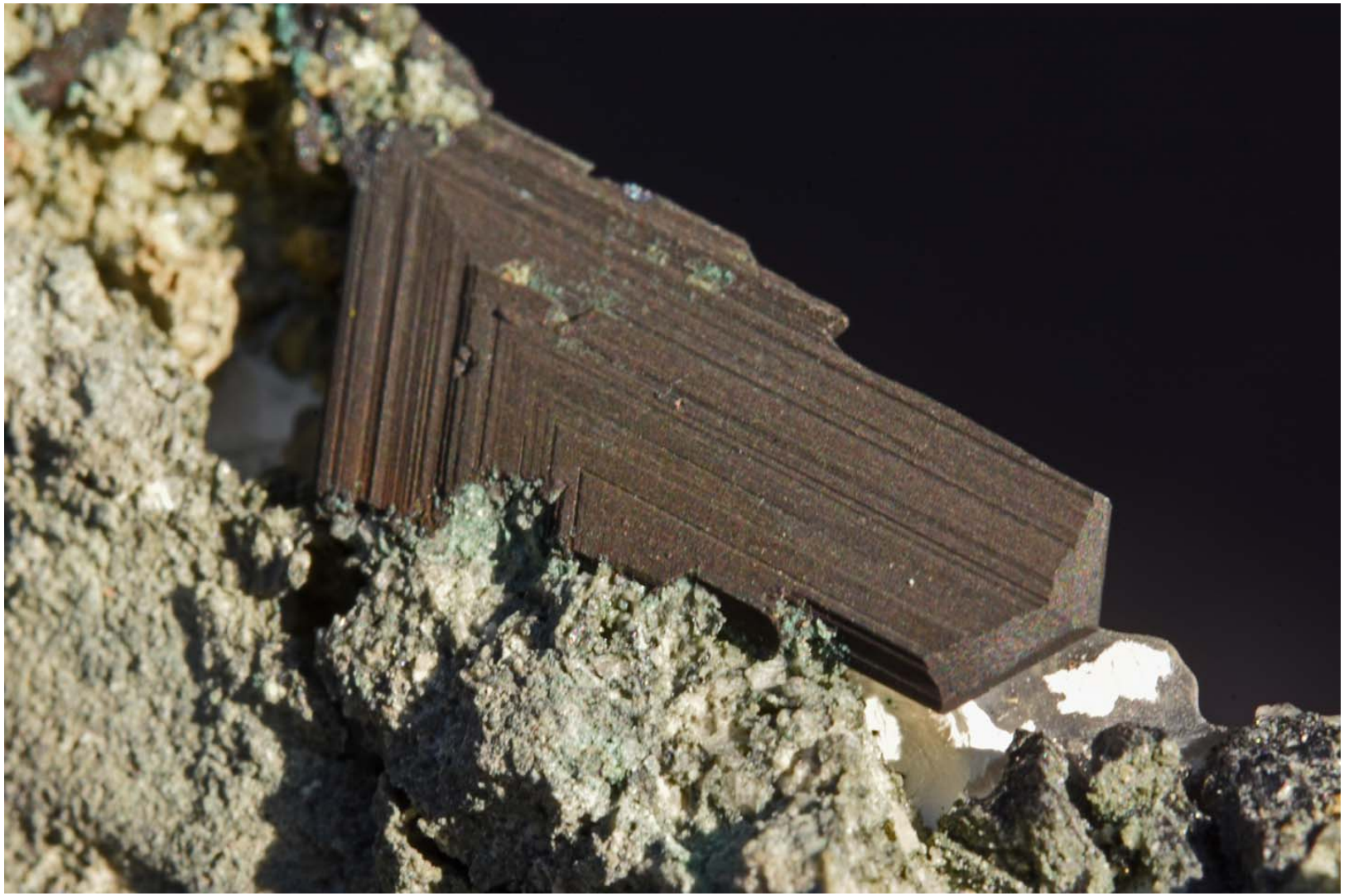
Supergene-enriched copper sulfides

We have only characterised three such species in our work and others have usually called the lot “chalcocite” (Cu_2S).

Chacocite *sensu stricto* has been characterised from Mt Oxide, the Great Australia mine and the Ernest Henry open cut just N of Cloncurry.

Digenite, Cu_9S_5, occurs in the Great Australia mine and probably elsewhere.

Anilite, Cu_7S_4, was the sole supergene-enriched species at the esperanza mine, Gunpowder. A spectacular oxidised profile comprising *ca* 100 m of gossan and a 10 cm oxidised zone with 1 cm balls of malachite passed into massive anilite that was burning as it was exposed to air!



Digenite (x 117), Great Australia mine