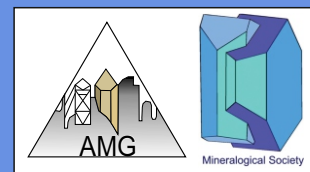


Applied Mineralogist

The bulletin of the **A**ppplied **M**ineralogy **G**roup



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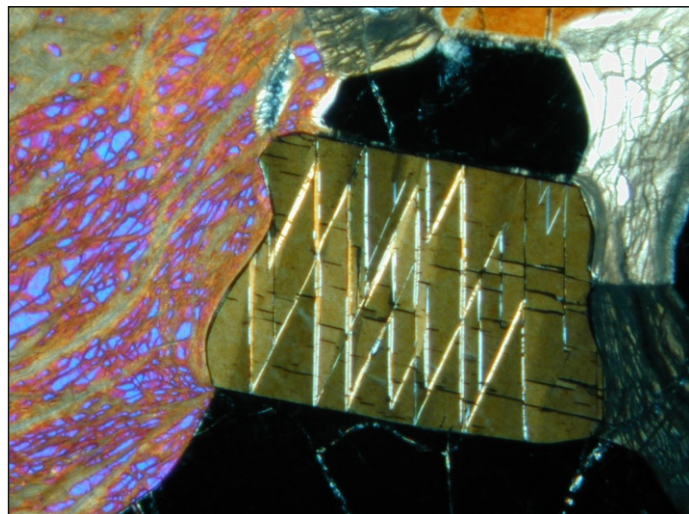
From the AMG committee

In this issue of *Applied Mineralogist* we're in for a treat, from finding out about the amazing 'nuts and bolts' world of mineral discovery and crystallography, to a down-to-earth take on recent events in the world of UK lithium. Thank you to all the contributors to this issue.

As for the *Applied Mineralogy Group*, we've been busy putting together a special issue of *Mineralogical Magazine* on the topic of Critical Metals, in partnership with the Commission on Ore Mineralogy (COM). We'll keep you posted on the publishing date!

Don't forget to apply to our bursary scheme (postgrads), details of which can be found on our webpage or Twitter. Until the next issue – enjoy!

#AppliedMineralogy @NadWGab



I came across this image while looking for pictures of coesite in thin section. It's from a webpage created by Joseph Smyth, a professor from the University of Colorado Boulder (<http://ruby.colorado.edu/~smyth/Research/Images/SRV-1/SRV-1.html>).

These kyanite crystals come from an eclogite xenolith in a South African kimberlite (a type of igneous rock). Eclogite is a high pressure metamorphic rock and this xenolith is from the upper (lithospheric) mantle, with an estimated depth of 150km (1050°C temperature and 4.9 GPa pressure). The lines are twins, which are

In this issue:

- From the AMG committee
- #AppliedMineralogy @NadWGab
- Lithium Mining in the UK?
- **Special feature: New minerals - fertile soil for solid state chemists**
- Coffee room small-talk: mineral application facts
- Calendar
- About us

the result of plastic deformation in the crystal lattice.

written by Nadine Gabriel, University College London (UCL) undergraduate and UCL museums assistant

Lithium mining in the UK? Dave Alderton

The recently announced plans to undertake lithium exploration in Cornwall have been widely reported and have generated a flurry of newspaper headlines. It is very early days, but how justified is this excitement?

Undoubtedly, the demand for lithium has increased greatly over the last decade. The metal has many applications – in lubricants, ceramics and fluxes, but the main interest stems from its use in Li-ion rechargeable batteries. The growth in the consumer electronics industry and demand for electric cars have necessitated the development of ever smaller and more powerful batteries and here lithium comes into its own. This increase in demand (coupled with a lack of recycling) has resulted in a dramatic rise in price and consequently a concomitant increase in exploration for new deposits.

Traditionally lithium has been extracted from granitic pegmatites, utilising silicate minerals (spodumene, petalite, lepidolite). As such, Australia has had the major market share. However, increasingly lithium is being extracted from brines under salt lakes ('salars') and here the production and reserves are dominated by countries in South America (Chile, Argentina, Bolivia); they now contribute approximately half of the world's supply. Processing from brines is cheaper than from silicates and this advantage is compounded by the availability here of large expanses of land and cheap solar power to aid the brine evaporation process.

Britain does possess granitic rocks enriched in lithium, notably in SW England where the lithium is mainly concentrated in mica. But as yet no viable deposits have been identified, even allowing for the fact that this material sometimes has to be disposed of as waste (e.g. from the China Clay industry). However, it has been known since the mid-1800s that thermal springs (up to 60°C) encountered at depth in some of the mines in Cornwall are also enriched in lithium (for instance the “Lithia spring” encountered in the former copper-tin mine of Wheal Clifford). It is these that are the focus of this recent exploration announcement.

The technology for lithium extraction from geothermal waters is in its infancy and there will be several challenges to make Cornish Lithium's venture economic and able to compete with other sources. Salt lake brines typically contain 200 - >1000 mg/l Li, compared to the lower concentrations measured so far in the Cornish brines, which only rarely exceed 100 mg/l. In addition, it remains to be seen whether flow rates and concentrations are sufficient and can be maintained during extended periods of pumping. This is an exciting project, but only time will tell whether the optimistic press reports of “vast resources” and the “mining revolution” are borne out.

Special Feature: *New Minerals - Fertile soil for solid-state chemists*

Mark Welch & Mike Rumsey, Dept. of Earth Sciences, Natural History Museum, London, UK

The discovery and characterisation of minerals new to science is fertile ground for solid-state chemistry and other applied physical sciences, as many of these minerals have technologically relevant structures (e.g. perovskites, alumino-silicate/alumino-phosphate frameworks). Here, we outline the features of two technologically relevant copper silicates, *TSCHÖRTNERITE* and *DIEGOGATTAITE*, discovered in 1993 and 2012, respectively.

New minerals fall into two distinct categories: (i) compositional variants of known structure topologies, e.g. Mg and Fe end-members; (ii) completely new structure topologies. For the crystallographer, the latter are the more exciting. For the past 5 years, about 150 new minerals have been discovered annually – a number set to increase as methods of characterisation become evermore sensitive. Ten years ago fewer than 100 new minerals were discovered annually.

On account of their rich topological diversity, microporous frameworks have found wide application as catalysts, molecular sieves, fast-ion conductors (the non-framework cation) and opto-electronic devices. These structures host a wide range of organic and organo-metallic molecules, transition elements and potentially mobile cations such as Na and Li.

Copper-bearing silicate and aluminosilicate frameworks are of considerable relevance to redox technology. The extremely rare mineral *tschörtnerite* [1] is an aluminosilicate that has one of the largest silicate cages. It is effectively a cauldron with six flanking smaller “pouches”, each containing an array of twelve Cu sites (Figure 1), with Cu in square planar coordination. Despite its rarity in nature, it is relatively easy to synthesize using well-established procedures. A patent for the synthesis of *tschörtnerite* was filed in 2001.

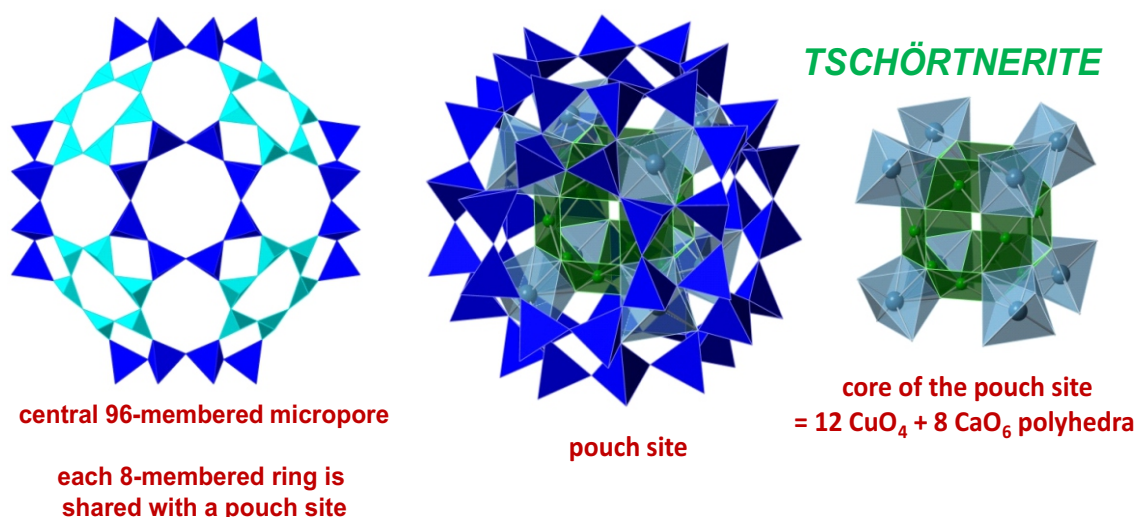


Figure 1: *tschörtnerite* framework - an aluminosilicate with one of the largest silicate cages.

DIEGOGATTAITE $\text{Na}_2\text{CaCu}_2\text{Si}_8\text{O}_{20}\cdot\text{H}_2\text{O}$:
a bridge between two major families of "techy" Cu silicates

Occasionally, a new mineral provides the missing link between two major technologically important families of synthetic structures. In 2012, we discovered and determined the structure of a new copper silicate from the famous Tsumeb mineral locality in Namibia. This new mineral, *DIEGOGATTAITE* [refs 2,3], has a novel structure topology and there is no synthetic counterpart. It is a complex sheet silicate comprising two distinct components: (i) a double-sheet of silicate tetrahedra with 6- and 8-membered rings and octahedrally-coordinated Na atoms and associated H_2O molecules occupying 6^48^2 cavities, which alternates with (ii) a layer of connected CaO_6 octahedra, NaO_6 octahedra and Cu_2O_8 dimers.

The structural features of diegogattaite combine those of the two families of related structures (gillespites and synthetic copper silicate hydrates "CuSH") to provide a unique connectivity of channels and cavities with reactive Cu sites and potentially Na migration pathways. This connectivity has obvious relevance to catalysis and fast-ion conduction, combining the technologically attractive features of both structural families. Interestingly, in the hand specimen, *diegogattaite* is intergrown with the gillespites-group mineral *effenbergerite* $\text{SrCuSi}_4\text{O}_{10}$, suggesting a possible synthesis route via a *cuprorivaite* ($\text{CaCuSi}_4\text{O}_{10}$) precursor (Figure 2).

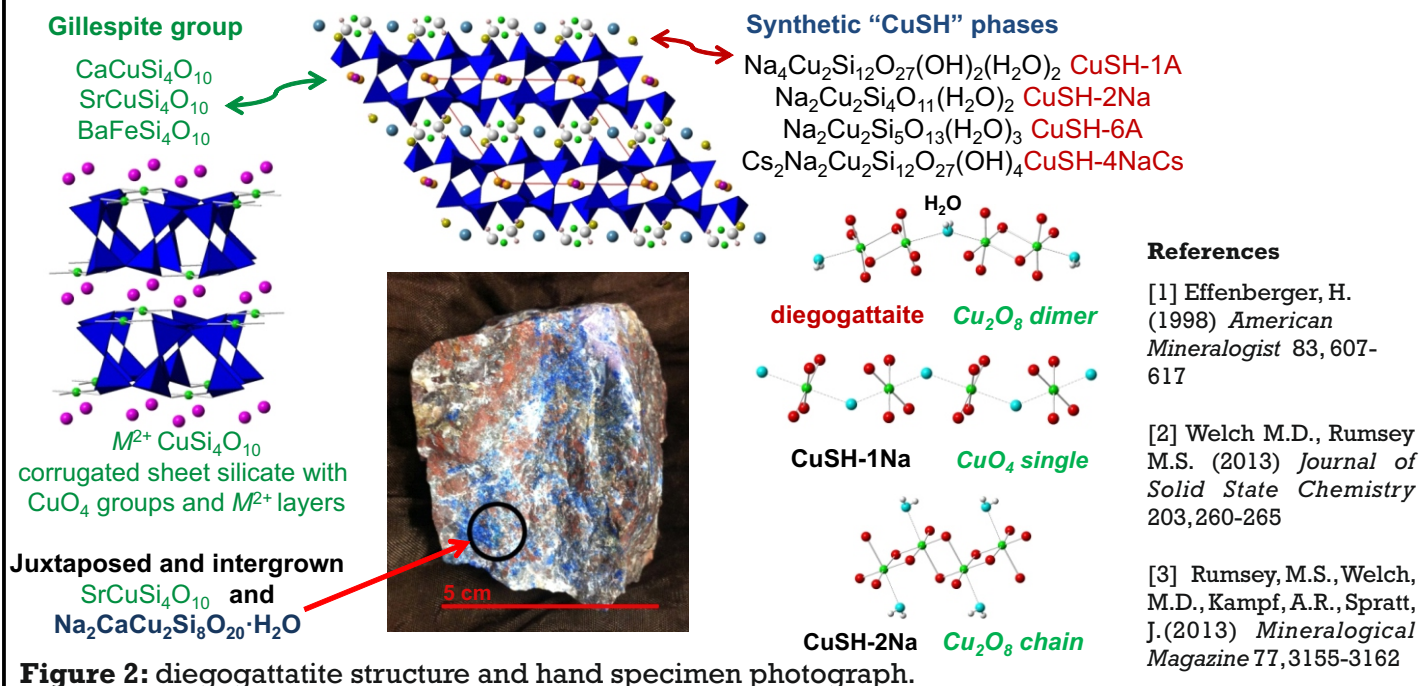


Figure 2: diegogattaite structure and hand specimen photograph.

Interested in sharing your Applied Mineralogy research in a future edition? E-mail: GuiceG@cardiff.ac.uk

Coffee break small-talk: mineral application facts

- The mythological Cassiterides are actually the Isles of Scilly that were used as a trading post for Cornish tin by the Greeks.
- The German town of Nördlingen is built out of local stone containing microdiamonds with the local church containing 5000 carats of diamond alone.
- MCM-41 is a mesoporous silicate material with a porosity similar to that of lemon sponge cake (up to 80%). However, MCM-41 has an internal surface area of $1000 \text{ m}^2/\text{g}$ and can be used as an industrial catalyst whilst sponge cake has an internal surface area $<20 \text{ m}^2/\text{g}$ and is a tasty dessert.

APR '17
3 - 4

Geochemistry Group Research in Progress meeting (GGRiP).

Details at: <http://www.minersoc.org/geochem.html>

MAY '17
7 - 11

European Microbeam Analysis Society, Konstanz, Germany. Abstract submission available at: <https://www.microbeamanalysis.eu/>

MAY '17
28 - 31

ERES 2017, Santorini, Greece. See: <http://eres2017.eresconference.eu/>

JUN '17
21 - 22

REDOX, Manchester. Special interest groups of the Min. Soc. <http://www.minersoc.org/Redox.html>

About Us

Founded in 1963 by Norman F.M. Henry, the AMG is a special interest group of the Mineralogical Society of Great Britain and Ireland. We encourage and promote the study and research of mineralogy applied to ores and related industrial mineral materials. This encompasses: ore microscopy, fluid inclusions, nuclear minerals, coals, refractories, slags, ceramics, building materials, nuclear waste disposal, carbon capture and storage, down-hole borehole alteration, and mineral-related health hazards.



Interested in joining the Mineralogical Society and Applied Mineralogy Group? Go to: <http://www.minersoc.org/> for membership details.

