Hello and welcome to the June edition of The Applied Mineralogist! We present a special feature on lithium pegmatite mineralogy with brand new research from the Kamativi Pegmatite in Zimbabwe. This issue sets out to visit the research opportunities and new resources that have emerged during these unprecedented times. Finally, test your mineralogical vocabulary on the Mineralogy crossword.

From the AMG committee

Responsible Raw Minerals Virtual Conference (11th-15th May)

Summary report by Rose Clarke, University of Leicester

Whilst Covid-19 continues to affect us and create a great deal of uncertainty, it also brings with it an opportunity to shape how life will look once we have overcome this challenge. Governments worldwide are considering what happens next, and what world we wish to emerge into. The virus has been transformative, making people aware that global issues – whether they be a virus, climate change, or the way the world extracts and uses raw materials – require a global response.

With this in mind, we ran the virtual Responsible Raw Materials conference from the 11th – 15th May with the aim of hearing ideas, opinions, anecdotes and concerns from those working across industry, academia, production, finance, insurance, policy and risk management. Hosting a conference during this time, when connecting with each other is more meaningful than ever, actually enabled this diverse group to meet, when perhaps they otherwise wouldn’t.

Whilst the overall aim of leveraging existing initiatives, techniques and policy to create a technical framework that removes the disconnect between operations and investment is still very much in progress, the conference was well received and will hopefully act as a springboard for many, as well as providing evidence for those wishing to move forward.

Details, along with abstracts, slide decks and videos of the presentations can be found on the 'Conference Materials' page on our website: www.responsiblerawmaterials.com. We also have a 'Learning Materials' page with a range of reports, resources and links for anyone interested in delving deeper or getting more involved.

#AppliedMineralogy
@DrTMNZ

From your #ThinSectionThursdays, #FieldworkFridays & #MineralMondays, our #AppliedMineralogy winner is...

@DrTMNZ

with a cataclastically deformed dunite from the moon, Apollo sample 72415
The Ore Deposits Hub is an open talks platform, filling in the gap left by conference and meeting cancellations throughout 2020 as a result of the COVID-19 pandemic. Researchers, academics and industry representatives can present online talks covering a whole host of subjects across the economic geology spectrum. Some of the talks already given can be found at: https://www.youtube.com/oredpositshub

Some recent talks include:

(Wed, 27 May, 8:00am – 8:30am) Charlie Beard – HiTech raw materials in alkaline-silicate and carbonatite systems
(Wed, 27 May, 4:00pm – 5:30pm) Mathias Burisch – Recent advances in the understanding of the Erzgebirge Mineral System
(Wed, 3 June, 8:00am – 9:30am) Anne-Sylvie Andre-Mayer – Mineral systems in Proterozoic times: focus on gold in West Africa
(Wed, 3 June, 4:00pm – 5:30pm) Adam Simon – The evolution of iron oxide - copper - gold (IOCG) and iron oxide - magnetite (IOA) mineral systems

These are available to watch via the group’s YouTube channel. Find out more information and sign up at: https://oredepositshub.com/.

SEG Podcast: Discovery to Recovery

This weekly podcast, partnered with Seequent, is bringing out stories from the geoscience and technology worlds. Keep up to date with the Society news, hear discussions about the ore deposits industry and keep in touch with relevant topics. Episodes 1, 2 and 3 are already out, discussing the impact of COVID on the SEG 2020 Vision conference as well as delving into basins and how they help control the formation of ore deposits. Check them out here:

Web page: https://www.segweb.org/SEG/Events/Podcasts/SEG/100th/Discovery-to-Recovery-Podcast.aspx?hkey=ef5eea217-0dce-4893-aa41-09560bc8f6cf

Spotify link: https://open.spotify.com/show/2bShSiKGL1Ev Ul2YaNTAd?si=NXXoiff8TVqaYDZdYN3xw

Other Online Resources

Springer have recently released over 65 free textbooks covering a wide breadth of geological, computational and technological sectors.

Check out what is available at: https://towardsdatascience.com/springer-has-released-65-machine-learning-and-data-books-for-free-961f8181f189
How exactly do you unravel the complex mineralogy of lithium pegmatites?

Richard Shaw and Kathryn Goodenough, British Geological Survey

Decarbonisation of transport is a hot topic at the moment, with governments around the world promising to reduce the number of fossil fuel-powered vehicles on the roads in favour of low-emission electric vehicles (EVs). Consequently there is a huge amount of interest in lithium, primarily because of its use in Li-ion batteries that are used to power EVs. Because of this, demand for lithium is forecast to increase by approximately 500% by 2050 [1]. So where do we currently get our lithium from? Globally there are two main sources of lithium: (1) salars (i.e. salt lakes) found predominantly in Chile, Bolivia and Argentina; and (2) LCT (lithium-caesium-tantalum) pegmatites, which are presently worked in countries like Australia, Zimbabwe, Brazil and China. Here I am going to focus on LCT-pegmatites.

A quick geology 101 – what is a pegmatite and what exactly is an LCT-pegmatite? To give the textbook definition, a pegmatite is “essentially an igneous rock, mostly of granitic composition that is distinguished from other igneous rocks by its extremely coarse but variable grain-size or by an abundance of crystals with skeletal graphic, or other strongly directional growth habits” [2]. In very simple terms pegmatites are, highly-evolved, fluid-rich melts associated with the last stages of fractional crystallisation of a magma body, or generated during low-degree partial melting of mica-rich metasedimentary rocks. So what about LCT-pegmatites? Well, they are in fact similar in many ways to standard granitic pegmatites (e.g. in terms of their grain size and textures); however, the above definition is expanded to incorporate an important distinction between the two “an LCT-pegmatite is one that hosts appreciable beryl, lithium aluminosilicates, phosphates other than apatite, oxides other than magnetite or ilmenite, and other rarer minerals” [3]. Basically, it is relatively small volumes of late-stage melt into which incompatible elements (e.g. Li, Cs, Ta, Sn and Be) typically become concentrated, to the point where they start to form distinct mineral species. In LCT-pegmatites the most important Li-ore minerals are the Li-aluminosilicates spodumene (LiAlSi₂O₆) and petalite (LiAlSi₄O₁₀). The former is typically converted to lithium carbonate to produce Li-ion batteries, whereas the latter is used to produce high-performance glass and ceramics. The purity and form of these minerals is hugely important, as this will ultimately dictate their end-use.

Recently we have been working on a set of samples from the Kamativi Pegmatite in Zimbabwe. This is a Neoproterozoic (c. 1000 Ma) LCT-pegmatite that is particularly enriched in tin. In fact the pegmatite was worked for almost 60 years for tin, producing some 37,000 tonnes during its lifetime. Even though lithium minerals are known at Kamativi they were never commercially extracted from the mine. Interestingly, the tailings at Kamativi are being evaluated for their lithium potential by Zimbabwe Lithium, and the resource currently stands at 26 million tonnes at 0.6% Li₂O [4]. LCT-pegmatites are incredibly complicated rocks to work with; these intrusions can be complexly zoned and contain a whole raft of weird and wonderful minerals that are sometimes closely intergrown. Alteration of primary ore minerals often adds to this complexity! I have certainly found working with the samples from Kamativi a steep-learning curve. For a start, many of the lithium minerals have very similar optical properties (Figure 1) and the descriptions of these minerals in standard mineralogy texts are often short! So, how do you unravel the complex mineralogy of these pegmatites?

![Figure 1. Optical crossed-polar image of complexly intergrown spodumene, albite, analcime (zeolite) and quartz. Scale bar = 200 microns.](image_url)

The first port of call is always the optical microscope. Even though many of these lithium minerals can look very similar (i.e. low to moderate relief, low-birefringence colours and non-pleochroic) a lot of useful information can be gained, particularly about textures and mineral relationships. Optical cathodoluminescence (CL) can be particularly helpful in identifying lithium minerals, especially where two or more phases are intergrown, or where primary minerals have been partially broken down.
Under CL, each of the various lithium minerals has a characteristic luminescence, e.g. spodumene has a bright orange luminescence (caused by the presence of manganese) (Figure 2), whereas petalite tends to be more blue-purple in luminescence colour. Determining the chemistry of these minerals also helps with phase identification, although this is not at all straightforward as lithium is not detectable by electron beam methods such as SEM-EDS.

This is because lithium is a very light element that produces very weak x-rays when excited under the beam; these x-rays are simply too weak to exit the sample. All is not lost however, as many of the lithium minerals contain very few elements and typically have very distinctive element ratios (e.g. Al:Si), which can be used to identify mineral phases with some degree of confidence. At BGS we have been developing mineral phase mapping methods on our new Zeiss FEG-SEM (field emission gun-scanning electron microscope). These are not element maps, but rather maps that show the distribution of mineral phases based on chemistry. We can use all of the other information we have gathered from other techniques to produce a set of user-defined filters that the SEM uses to assign the mineral phases. For example, if a mineral is present that contains very few elements apart from Al and Si, and the Al:Si ratio is 1:2, it is likely to be spodumene. However, if the Al:Si ratio is 1:4 it is more likely petalite. We can also use other parameters, such as the analytical totals, to give us additional confidence in our phase identifications. For instance, a total of 92–94% would be typical of spodumene, which has an Li₂O content of 6–8 wt. %. A total of 95–96% would be more typical of petalite with an Li₂O content of 4–5 wt. %. At BGS we have also been developing high-resolution LA-ICP-MS (laser ablation inductively coupled plasma mass spectrometry) element mapping methods to quantify the distribution of lithium and other light elements, e.g. boron and beryllium, in different mineral phases. This is a particularly useful tool for understanding the fate of lithium when primary lithium minerals have broken down. The resulting high-resolution maps (Figure 3) are a fantastic way to better understand the complex mineralogy of these rocks.

![Figure 2. Optical CL image of spodumene (orange) rimmed by blue-purple petalite. Scale bar = 200 microns.](image)

![Figure 3. SEM phase map of the area shown in Figure 1. Here it is much easier to see the different mineral phases: yellow = quartz; pink = orthoclase; red = spodumene; pale blue = analcime (zeolite); and dark blue = albite. Scale bar = 100 microns.](image)

**References**


Forget about the return of the Premier League, stop worrying if the Tokyo Olympics will ever take place, the talk of Twitter (well, a small nerdy corner of Twitter) is the return of the prestigious Mineral Cup for its 2020 edition. The 2019 competition saw 2018’s runner up, the winter queen, ICE finally take the crown, narrowly defeating quartz in the final, taking 52% of a staggering 6348 votes (up from a winning 2230, 52%, votes for garnet in 2018).

Things are hotting up in the organisation for 2020 with the introduction of this year’s novice entrants soon to be decided through a series of ‘mini-cups’.

There will be eight new minerals introduced for 2020, with 24 returning from 2019; ice will be left in the cold this year as it is forced to take the customary champion’s break. Five new entrants (bismuth, smectite, ulexite, zoisite and borax) from 2019 were relegated in the first round, suggesting there may be a degree of favouritism shown towards the competition’s old boys – will that trend be bucked this year? Stay tuned @MineralCup on Twitter for updates.

2020 winner prediction: the experienced olivine or garnet as previous winners, or the dark horse of apatite

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**Ice fact file**

**Formula:** H₂O

**Crystal habit:** The most common naturally occurring form on Earth is hexagonal ice - ice Ih, but there are 18 known crystalline phases of ice and three amorphous phases.

**IMA mineral list info:** Unknown country of origin, unknown discovery date; the only polymorph recognised by the IMA is ice-VII; a metastable high-pressure cubic phase first observed as a diamond inclusion from the Opera kimberlite, Botswana in 2017.

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References

Mineralogy Crossword

1) Topical texture
2) The favourite mineral of one of the oldest and most widespread mythological symbols
3) Vikings used this stone for navigation. Light source.
4A) This feldspar shares its name with one of Britain's most beloved pets
4D) Cornish family member of 2
5) Iron impurities can turn this otherwise boring silicate into a cure for intoxication according to the Ancient Greeks
6) It is a mining district and a metal - ironically famous for its production of 7
7) Atomic number 47 but gifted for 25
8) Enough of this mineral should keep scurvy away
9) A type of opal with daylight induced luminescence. You might get a shock if you touch it

Solutions are at the bottom of Page 3

Notices
Get Involved
If you would like to become more involved in the AMG, elections are held yearly at the AGM. Spaces for Student Representatives come up regularly. If you would like to be considered for a committee spot please email Eimear Deady (Chair).

AMG Postgraduate Bursaries
The AMG provides bursaries for postgraduate students in the disciplines of Applied Mineralogy, Crystallography, and Petrology and Geochemistry. Bursaries are intended to support conference attendance and associated travel costs, although other activities may be considered. Application guidelines can be found at www.minersoc.org/amg-bursaries

Please note there are two bursary application deadlines each year: 1st March and 1st September. Requests for funding must be received well in advance of the event to allow for consideration by the committee.

Funding
We welcome applications from both individuals or organisations for funding in support of events covered in the AMG remit. Further guidelines on how to apply can be found at www.minersoc.org/amg-funding

Editorial
Thank you to those who have contributed to this issue of Applied Mineralogist. Please forward any articles, comments or notices of events and conferences to amgminsoc@gmail.com. All previous issues of Applied Mineralogist are available at www.minersoc.org/amg-applied-mineralogist

Thanks for reading; our next Applied Mineralogist will be out in September 2020. Keep up on what is happening in the meantime by following us on twitter @amg_min.

Calendar
With the current situation regarding COVID-19 continuing with uncertainty, a lot of upcoming conferences have been forced to change. Here is a summarised list of key changes:

Jun '20 21 - 26 Goldschmidt Conference Virtual replacement
Aug '21 European Mineralogical Conference (EMC)
Krakow, Poland (postponed until August-September 2021)
Sep '21 SEG 2020 Vision Conference (postponed until September 2021)
TBC Geochemistry Group 50th Anniversary Symposium and GGRiP (postponed)

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.