From the AMG committee
Welcome to the Christmas special of 'Applied Mineralogist'!

As an update, the European Mineralogical Conference (EMC) went down a storm, with a brilliant array of presentations, including, of course, our joint AMG-COM (Commission on Ore Mineralogy) session on “The future of critical metals: mineralogy, metallogenesis and geometallurgy” (S23), led by John Bowles, Nigel Cook and Hannah Hughes. The AMG and COM together awarded seven £250 bursaries to students presenting in the session. Additional student bursaries were made available from the SGA. Thank you to all the sponsors and participants! Out of this session, and in collaboration with the sessions on “High-Tech metals in Europe” (S20) and “Platinum-group elements” (S22) we now have a special issue of Mineralogical Magazine scheduled on ‘Critical metals’. The abstract deadline is 15th January! Submit online at: http://minmag.allentrack2.net

From ignimbrites to quartz crystals in Au-Ag-Cu deposits, this issue of Applied Mineralogist includes information for the December Mineral Deposits Studies Group meeting and some Christmas-related ‘coffee break small-talk’. Enjoy! And from all the AMG committee, Happy Christmas and New Year.

#AppliedMineralogy @KeelePetrology

This figure highlights a complex breakdown reaction taking place within a transitional miaskitic to agpaitic syenite autolith taken from the Caldeira-Castelinho ignimbrite, Terceira, Azores. The image displays a highly corroded olivine crystal core, surrounded by a distinctive double rim of variable breakdown products. These interestingly-textured olivines are found within syenite-hosted trachytic enclaves, which are represented in the image as the surrounding crystalline groundmass of anorthoclase, aegirine-augite, ferro-edenite, and katophorite. This image was taken as part of an ongoing study into the petrogenesis and evolution of the ignimbrite-forming magmas of Terceira, involving collaborators from the Universities of Keele and Manchester, U.K., the University of California, U.S.A., the University of the Azores, Portugal, and the Centro de Informação e Vigilância Sismovulcânica dos Açores. Adam Jeffery

MDSG preview: Dr Frances Copper
(Mon 19th - Wed 21st December, University of Bristol)

The 40th Annual MDSG Meeting (mdsgbristol.org) will be held in the heart of the University of Bristol campus. It will feature an Icebreaker Reception and a Conference Banquet in the historic Wills Memorial Building, as well as two days packed with talks and posters on the latest mineral deposit research.

The meeting is being organised by the Bristol PCD Project (bristolpcd.org), an interdisciplinary endeavour that seeks to understand the links between volcanism, tectonics, and porphyry copper mineralisation. The meeting will kick off with a pre-Icebreaker talk by Professor Sillitoe on Volcanoes and Porphyry Deposits, introduced by Professor Steve Sparks. Professor Sillitoe is a world expert on porphyry and epithermal mineralisation and the 2016 recipient of the Society of Economic Geologists R.A.F. Penrose Gold Medal. His experience of porphyries in over 90 countries makes this a talk not to miss!

Six keynote speakers are lined up to talk on a range of topics that cover gems, metals, volcanoes, and the future of mineral exploration:

- Jeremy Richards, University of Alberta, Canada (2016 SEG Thayer Lindsley Visiting Lecturer): Tectonomagmatic controls on arc metallogeny.
- Matthew Field, Amec Foster Wheeler, UK: Kimberlite volcanology and diamond resource evaluation.
A few years ago, I began looking at some sulfosalt-rich samples from a high-grade feeder zone beneath the El Indio Au-Ag-Cu deposit in Chile. I was surprised to consistently find euhedral quartz crystals enclosed within a matrix of sulfosalt minerals (Figure 1). Looking through published reflected light photographs, I found these euhedral quartz microcrystals were present in ores from at least 19 other deposits (see Tanner et al. 2015 for the full list). My research team was excited, because we thought we could use the chemistry of these quartz microcrystals to independently test our hypothesis that sulfosalt minerals in the high temperature feeder zones at El Indio were initially deposited as a melt at >650°C, from ascending magmatic gas (Mavrogenes et al. 2010; Henley et al. 2013).

**Figure 1:** Reflected light photograph of ore from a high-grade feeder zone beneath the El Indio Au-Ag-Cu deposit in Chile.

**Method**

Whole clusters of quartz microcrystals were separated from the ore using Selfrag®, which disaggregated quartz clusters along sulfide grain boundaries to preserve their delicate morphology (Figure 2). Crystal clusters were mounted in a polished block and the texture of crystals was mapped using cathodoluminescence (CL) imagery (Figure 3) and electron microprobe maps (Figure 4).

**Figure 2:** Transmitted light photograph of a cluster of quartz crystals, separated using Selfrag®.

**Figure 3:** Cathodoluminescence image of the texture within a cross section through a double-terminated quartz crystal.

Oxygen isotopes were measured in situ using a sensitive high resolution ion microprobe for stable isotopes (SHRIMP SI) and trace element abundances were measured in situ with a 157 nm laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS), to obtain corresponding trace element analyses. The polished block was then double polished for Raman Spectroscopy.

**Unexpected results…**

If our hypothesis was correct, we would expect the quartz to have a "magmatic signature" (i.e. δ¹⁸O=+5.5 to +10‰) – but if we were wrong – the quartz should form at lower temperature and exhibit a “meteoric signature” (i.e. δ¹⁸O<+5.5‰). Instead, we found something unprecedented. We discovered that oscillatory growth zones within quartz ranged from +3.6 to +16.2‰ (± 0.5‰). One 300μm crystal contained a δ¹⁸O range from +3.6 to +14.3‰! Such elevated δ¹⁸O values are more similar to metamorphic quartz than magmatic or hydrothermal quartz.

*Why?*

Investigating the mineralogy of the quartz more carefully helped unravel the δ¹⁸O data. CL images revealed that the euhedral quartz microcrystals grew from a cryptocrystalline silica substrate (Figure 5). Using Raman Spectroscopy, we found evidence of metastable silica hydrates (opal and moganite) associated with cryptocrystalline textures. These textures demonstrate that the euhedral quartz microcrystals

**Figure 4:** Maps of the aluminium concentration in quartz microcrystals, annotated with oxygen isotope data (corresponding ion microprobe pits are highlighted as white spots).

**Figure 5:** Raman Spectroscopy revealed metastable silica hydrates (opaline silica and moganite), associated with regions of cryptocrystalline silica.
crystallised via silica maturation akin to silica diagenesis, but at high temperature and in a sub-volcanic environment. As hydrated silica polymorphs increase in crystallinity during maturation, water is progressively released from their structure. This dehydration of silica polymorphs results in non-equilibrium fractionation of \( \delta^{18}O \), as \( \delta^{18}O \) is preferentially enriched in the liberated fluid, thus residual anhydrous quartz is enriched in \( \delta^{18}O \) (Figure 6) – explaining the complexity of the measured \( \delta^{18}O \) data. This is the first evidence of non-equilibrium \( \delta^{18}O \) fractionation in a sub-volcanic environment.

**Conclusion**

Realising that euhedral quartz may have cryptic, less crystalline precursors has implications for studying any high-temperature ore deposit or volcanic system where silica supersaturation may have occurred. The salient point from this study (Tanner et al., 2015), is that the euhedral quartz crystals do not record environmental conditions attendant during deposition, instead their chemistry and inclusions record conditions attendant during silica maturation – which is a process we know very little about.


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**Calendar**

- **DEC ’16**
  - 19 - 21 40th MDSG conference, Bristol, UK. Registration and abstract submission is available at: [http://www.mdsgbristol.org/index.html](http://www.mdsgbristol.org/index.html)

- **JAN ’17**
  - 4 - 6 TSG-VMSG-BGA joint assembly, Liverpool. Registration and abstract submission is closed.

- **MAY ’17**
  - 7 - 11 European Microbeam Analysis Society, Konstanz, Germany. Abstract submission is available at: [https://www.microbeamanalysis.eu/](https://www.microbeamanalysis.eu/)

- **MAY ’17**

- **JUN ’17**
  - 21 - 22 REDOX, Manchester. Special interest groups of the Mineralogical Society.

**Coffee break small-talk: mineral application facts**

- Tinsel was originally invented in Nuremberg and was made out of silver from post-Variscan deposits in the nearby mountains surrounding Bavaria.
- ‘Bristol Diamonds’ are actually quartz crystals that were misidentified in the 1500s – you can see them in the Bristol City Museum.
- If a goose really did lay a golden egg then it would weigh almost 2.9 kg.

**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 in ores, nuclear minerals, coals, refractories, slags, ceramics, concretes and other building materials, nuclear waste disposal, carbon capture and storage, down-hole borehole alteration, and mineral-related health hazards.

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**Dominique Tanner** is a postdoctoral researcher at **Cardiff University**, but will commence a lectureship in geochemistry at the University of Wollongong in January 2017.