AUGUST 2026 vol 11.

the Applied Mineralogist

OF THE MINERALOGICAL SOCIETY

WEB: www.minersoc.org/amg.html
EMAIL: amgminsoc@gmail.com

From our editors...

Welcome to the August 2026 issue of the Applied Mineralogist! We are thrilled to bring you this issue of the Applied Mineralogist Newsletter following the amazing MinSoc 150 Conference in Manchester. On behalf of the Applied Mineralogist team and the AMG committee, thank you to the organizers of the MinSoc 150 conference!

In this issue, we open with an interesting special feature from Dr. Christian Bishop, of the BGS. He shares information about the journey from sulphides to weathering products. We then have a report from Kate Canham of Leicester, who used the AMG bursary to spend two weeks at the Scottish Universities Environmental Research Centre (SUERC) in East Kilbride, Scotland, completing sulfur isotope analysis. We end with our review of the MinSoc 150 conference.

Thank you to everyone who contributed to this issue. We hope you enjoy this month's publication.

SPECIAL FEATURE

by Christian Bishop (BGS), Pierre Josso, Anna Lichtschlag, Stephen Roberts, Thomas M. Belgrano, J. Andy Milton, Maxime Lesage, Bramley J. Murton

Sulphides to weathering products: metal evolution in seafloor massive sulphide deposits at the Semenov hydrothermal cluster, Mid-Atlantic Ridge

Seafloor massive sulphide (SMS) deposits are potential sources of Cu, Zn, Au and Ag, but their long-term metal budget is unclear. Unlike terrestrial deposits, where acidic meteoric fluids can drive strong supergene enrichment (Emmons, 1917; Yesares et al., 2014), submarine systems are continually buffered by seawater. This limits acidity, promotes near-neutral oxidation, and changes how metals are mobilised, retained or lost during sulphide breakdown. At the Semenov hydrothermal cluster on the Mid-Atlantic Ridge (Figure 1), sulphide weathering produces secondary Fe-oxyhydroxide (FeOOH; Hu et al., 2022) and atacamite (Hannington, 1993), both of which record metal redistribution during the transition from fresh sulphide to fully oxidised material.

The main problem is that oxidation does not simply destroy SMS deposits; it reorganises their metal inventory. Pyrite- and chalcopyrite-dominated sulphides react with oxygenated seawater, producing FeOOH, secondary Cu minerals and locally mobile metal-bearing fluids. Chalcopyrite appears to oxidise early, forming covellite and chalcopyrite-derived FeOOH, while pyrite oxidation produces pyrite-derived FeOOH. These early FeOOH phases retain a chemical signature of

Highlights

Edited by
Michaela (Kay) Turanski &
Matthew Cundell

their sulphide precursor, including trace-element associations inherited from pyrite or chalcopyrite. However, this primary signature is progressively overprinted by seawater interaction, Cu-rich fluids and later mineralogical transformation.

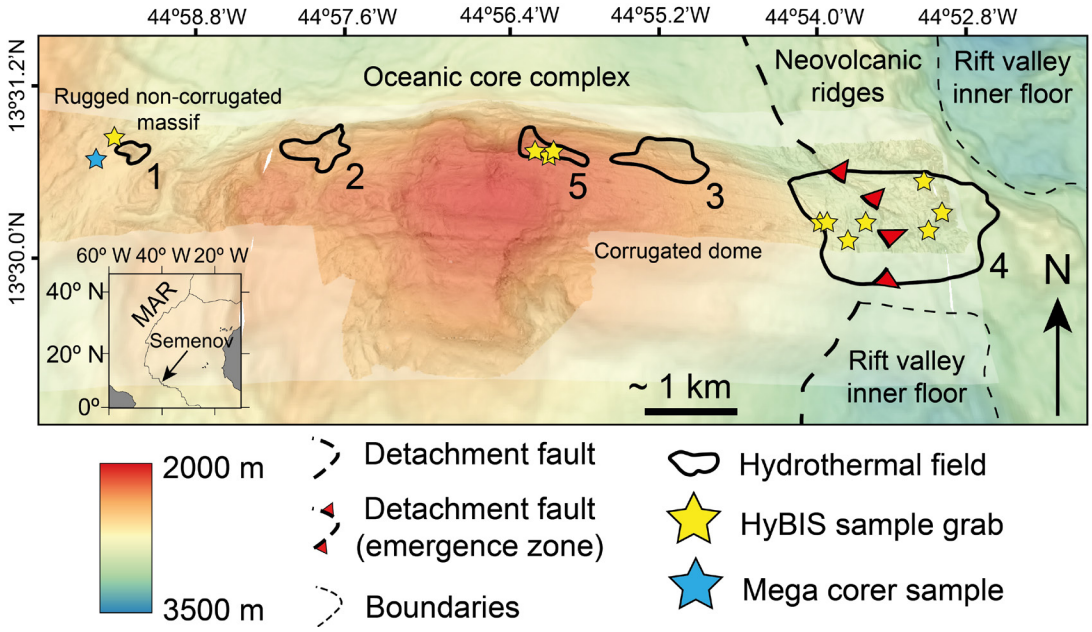


***Figure 1**: 1.5x vertical exaggeration 3D bathymetry map of Semenov illustrating major tectonic features and the location of hydrothermal mounds. The inset image shows the regional location of Semenov on the Mid-Atlantic Ridge (MAR). Bathymetry after Escartin et al. (2014), with tectonic settings, boundaries and location of hydrothermal mounds after Firstova et al. (2022) and Pertsev et al. (2012). The oceanic core complex is made up of the corrugated dome and the rugged non-corrugated massif. Numbers represent a hydrothermal cluster (i.e., 1 is Semenov-1 and so on).*

At Semenov, most FeOOH is secondary, formed by sulphide oxidation rather than direct hydrothermal precipitation (primary FeOOH; Hekinian et al., 1993). Initially, ferrihydrite forms as the dominant FeOOH phase and can incorporate or adsorb trace metals released during sulphide oxidation (Herzig et al., 1991; Jambor & Dutrizac, 1998; Cornell & Schwertmann, 2003). Pyrite-derived FeOOH is relatively enriched in As, Fe and Au compared with chalcopyrite-derived FeOOH, whereas chalcopyrite-derived FeOOH contains more Cu and Ag. Yet mass-balance relationships show that FeOOH compositions cannot be explained solely by precursor inheritance: Cu, Zn, Mo and Sb can be added, redistributed or diluted during continued weathering.

Post-formational modification is therefore central to FeOOH evolution. Modified FeOOH, found in fully oxidised samples, is enriched in seawater-derived components such as Si, Ca, Na, Mg and REEs, and depleted in several sulphide-derived elements including Zn, As, Sb, Mo, Au and Ag. t-SNE clustering identifies distinct elemental associations reflecting sulphide inheritance, seawater overprint, Cu–S–Cl mobilisation, and Mn-oxide-related inputs. These relationships show that FeOOH behaves as an evolving metal sink rather than a static weathering product. Its composition changes as seawater circulates through the deposit and as metals released from

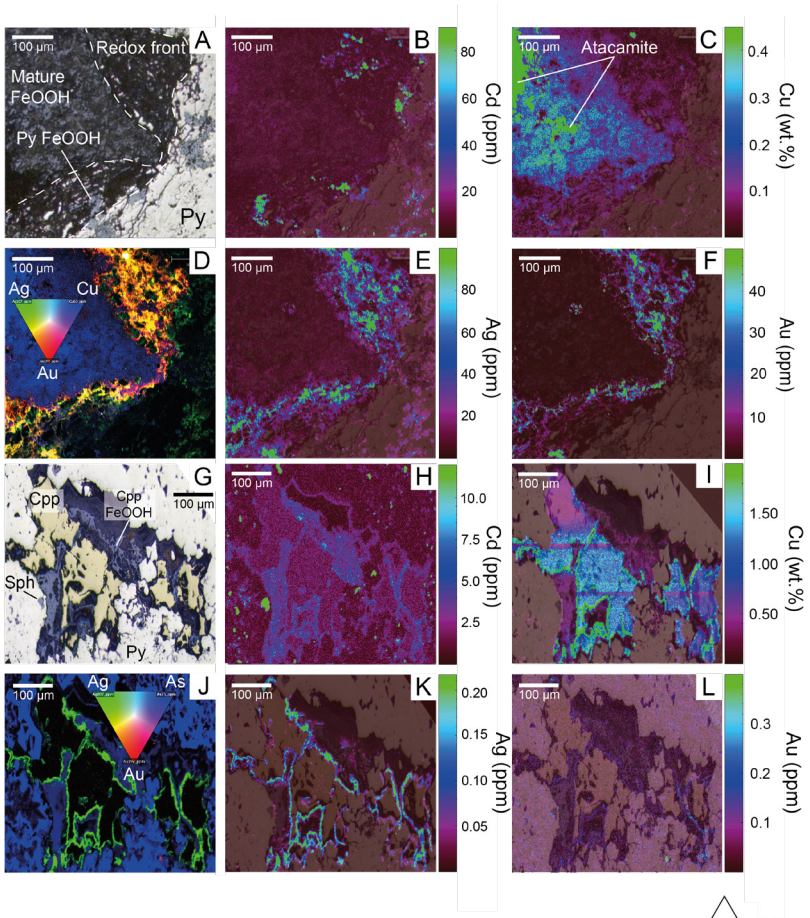


***Figure 2:** Semi-quantitative LA–TOF–ICP–MS trace elemental maps for two sites of actively weathering sulphide within 82_HY_06b. (A) Reflective microphotograph image of site 1 and trace elemental maps for (B) Cd, (C) Cu, (E) Ag and (F) Au. (D) shows a red-green-blue image for Au, Ag and Cu respectively to illustrate their correlation. (G) Reflective microphotograph image of site 2 with element maps of (H) Cd, (I) Cu, (K) Ag and (L) Au. (J) illustrates a red-green-blue image for Au, Ag and As respectively to show their correlation. Ccp – chalcopyrite, py – pyrite, sp - sphalerite.*

nearby oxidising sulphides are adsorbed, reprecipitated or flushed from the system.

Copper is the clearest example of metal retention. Sequential leaching shows that most Cu in weathered Semenov samples is hosted by atacamite and ferrihydrite, with atacamite accounting for roughly 60% of total Cu and FeOOH for a substantial additional fraction. Cu released during chalcopyrite oxidation likely migrates as chloride complexes through FeOOH before adsorbing to ferrihydrite or precipitating as atacamite where Cu-rich fluids mix with oxygenated seawater. Atacamite therefore marks zones of Cu mobilisation and may indicate Cu-rich FeOOH crusts or underlying Cu-rich massive sulphide. Ferrihydrite gradually transforms into goethite over time (Schwertmann & Murad, 1983; Grundl & Delwiche, 1993). And this transformation can release large proportions of Cu and Zn (Vu et al., 2013; Sajih et al., 2014), but weak correlations between goethite abundance and metal depletion suggest that some released metals may re-adsorb onto adjacent FeOOH (Vu et al., 2013), partly buffering deposit-scale metal loss.

Gold and silver behave differently. Laser ablation time-of-flight inductively coupled plasma mass spectrometry (LA-TOF-ICP-MS) maps show that Au and Ag are concentrated along pyrite and chalcopyrite rims at active oxidation fronts, rather than being incorporated into newly formed FeOOH (Figure 2). Early FeOOH may appear enriched in Au or Ag where sulphide inclusions remain, but fully modified FeOOH contains very low Au and Ag concentrations. This indicates that precious metals are initially displaced to sulphide margins during oxidation and are later mobilised once sulphides are completely destroyed. Under seawater-buffered conditions, Au and Ag may be transported as thiosulphate complexes (Webster and Mann, 1984) rather than retained in FeOOH (Becking et al., 1960; Glasby & Schulz, 1999). Depending on fluid-flow direction, they may be lost to seawater, precipitated near FeOOH–carbonate sediment interfaces, or migrate downward to redox boundaries within the mound (Webster, 1986; Kalinin et al., 2019).

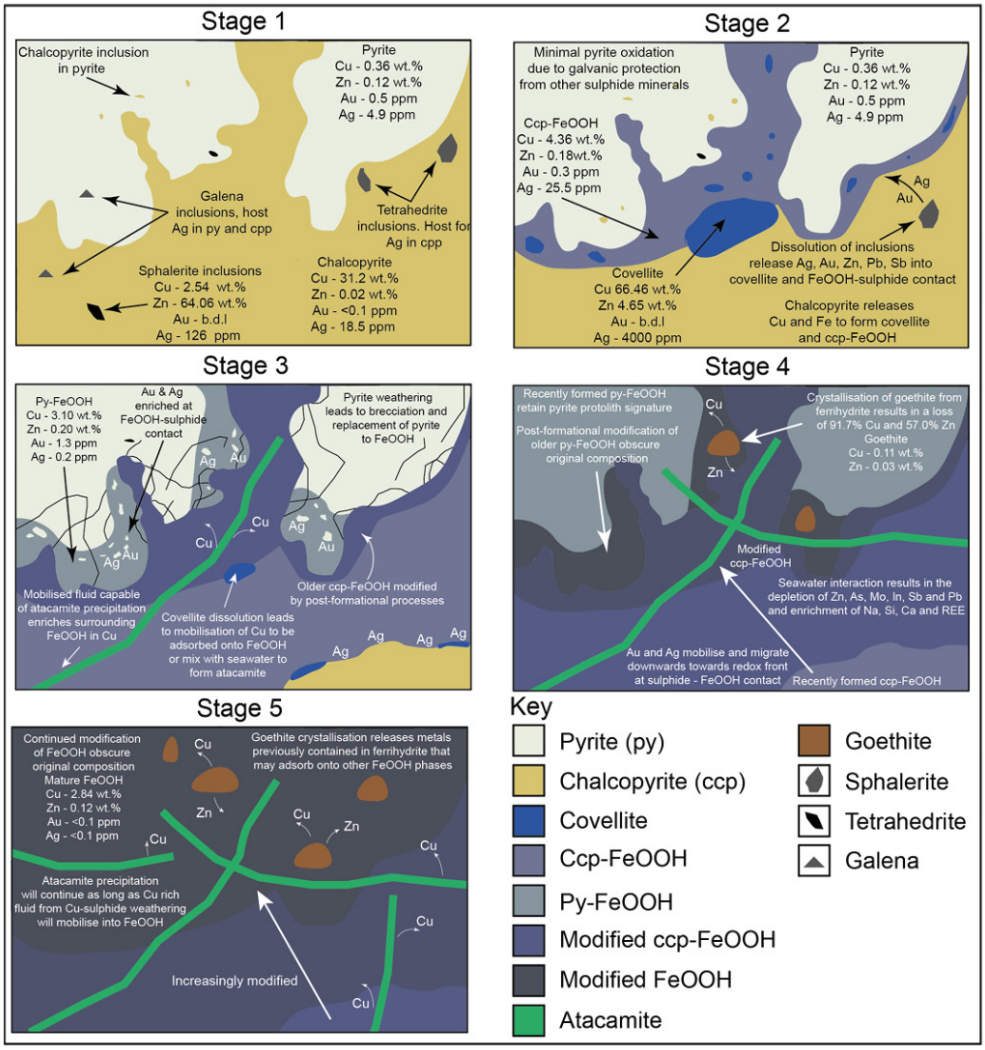


Figure 3: *Schematic illustration of SMS deposit evolution and associated geochemical changes.*
Stage 1: Formation of unoxidised sulphides.
Stage 2: Minor oxidation of chalcopyrite forms covellite and ccp-FeOOH.
Stage 3: Pyrite oxidation forms py-FeOOH, with Cu-sulphide weathering releasing Cu and enriching FeOOH via adsorption and atacamite precipitation.
Stage 4: Complete sulphide oxidation drives Au and Ag migration, while seawater interaction enriches FeOOH in Na, Si, Ca, and REEs and depletes sulphide derived Zn, As, Mo, In, Sb and Pb.
Stage 5: Post-formational processes obscure the sulphide protolith, with ongoing goethite crystallisation releasing Cu and Zn that mayadsorb onto surrounding FeOOH.

Overall, SMS deposits evolve from fresh sulphide assemblages through partial oxidation, FeOOH formation, Cu mobilisation, atacamite precipitation and progressive seawater overprint (Figure 3). FeOOH crusts at older, extinct deposits can therefore act as marine gossans, preserving

significant Cu and locally Zn even after complete sulphide oxidation. However, they may underestimate precious-metal potential because Au and Ag are not retained in fully oxidised FeOOH. This model expands exploration interest to weathered and off-axis SMS systems, where FeOOH and atacamite may record concealed sulphide mineralisation and preserve part of the original base-metal endowment.

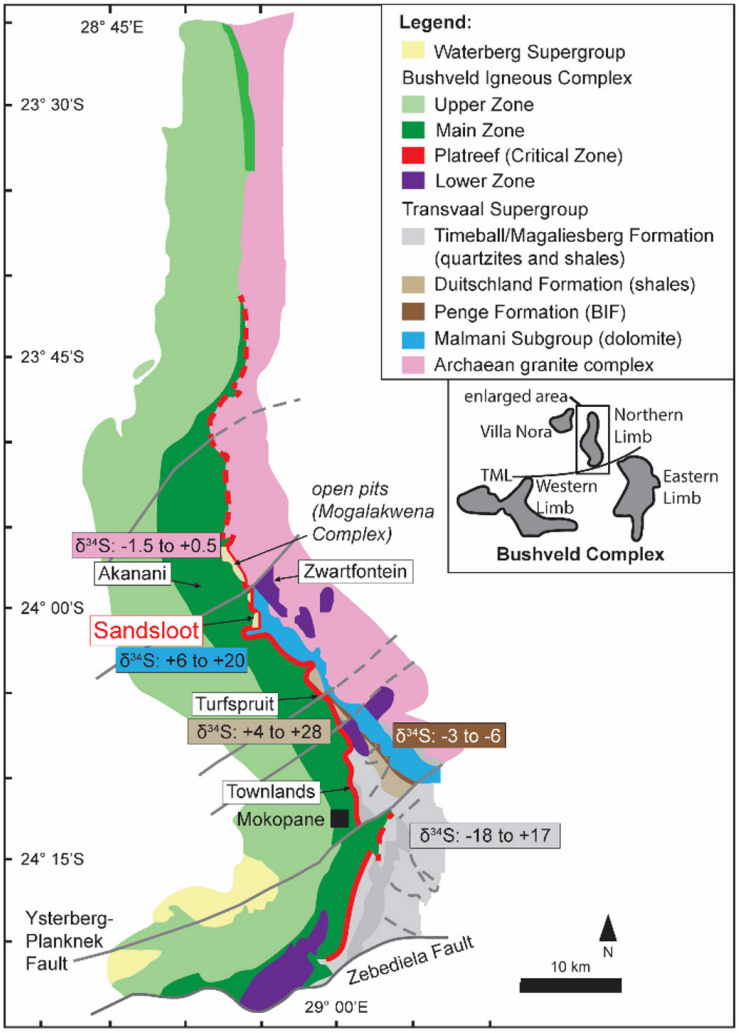
References

Cornell, R.M. and Schwertmann, U. (2003) The iron oxides: Structure, properties, reactions, occurrences and uses. 2nd edn. Weinheim: Wiley-VCH.
Emmons, W.H. (1917) US Geological Survey Bulletin. 625
Hannington, M.D. (1993) The Canadian Mineralogist. 31: 945–956.
Hekinian, R., et al. (1993) Econ Geol. 88: 2099–2121.
Herzig, P.M., et al. (1991) Econ Geol. 86: 1747–1755.
Hu, S., et al. (2022) Science of the Total Environment. 819: 153091.
Kalinin, Y.A. (2019) Ore Geology Reviews. 109: 358–369.
Vu, H.P., et al. (2013) Applied Geochemistry. 39: 119–128.
Webster, J.G. (1986) Geochimica et Cosmochimica Acta. 50: 1837–1845.
Webster, J.G. and Mann, A.W. (1984) Journal of Geochemical Exploration. 22: 21–42.
Yesares, L., et al. (2014) Ore Geology Reviews. 58: 14–26.

BURSARY REPORT

By Kate Canham (Centre for Sustainable Resource Extraction, University of Leicester)

On the trail of contamination: S isotopes in the deep Platreef at Sandsloot, Northern Bushveld Complex



The metallogenic development of magmatic sulfide Ni-Cu-PGE deposits is shaped by several factors, including sulfide fractionation, contamination from country rocks and hydrothermal overprinting. The Platreef Ni-Cu-PGE deposit, located in the Northern Bushveld Complex, South Africa, is one of the world's largest resources of PGE. It was emplaced into a complex sequence of S-rich sediments of the Palaeoproterozoic Transvaal Supergroup and underlying Archaean basement (Fig, 1; McDonald and Holwell, 2011; Kinnaird and Nex, 2015). This geological setting of highly variable S-rich sediments makes the Platreef a valuable case study for assessing the role of contamination in the genesis of giant magmatic sulfide systems—whether as a trigger for sulfide saturation or as a post-emplacement modifier through S addition and downgrading of metal tenors.

Figure 1 *- Geological map of the Northern Limb with the Sandsloot farm indicated (adapted from van der Merwe, 1976). The δ34S values (in ‰) of the footwall rocks are also indicated on the map (taken from Buchanan et al., 1981; Cameron, 1982; Sharman-Harris et al., 2005; Holwell et al., 2007; Guo et al., 2009; Sharman et al., 2013; Smith et al., 2016).*

The currently mined, sub-cropping shallow Platreef is well characterised and exhibits variable metal tenors and mineralisation styles along-strike. However, while the shallow Platreef is well understood, recent studies have shown the Platreef flattens, thickens, and exhibits increased metal tenors down-dip. This down-dip extension has been identified on the Turfspruit-Macalacaskop-Rietfontein (Grobler et al., 2019), Akanani (Yudovskaya et al., 2011) and Sandsloot farms (Thompson et al., in press) (Fig. 1).

S isotope studies have played a key role in deciphering the heterogeneity of Platreef mineralisation. δ34S values within the Platreef vary along-strike from mantle-like signatures (+1±1‰) to heavier, non-magmatic, values (up to +10.5‰) (Manyeruke et al., 2005; Sharman-Harris et al., 2005; Holwell et al., 2007; Sharman et al., 2013; Smith et al., 2016; Keir-Sage et al., 2021; Fig. 1). However, despite the along-strike variation the uppermost highly PGE-enriched portions of the Platreef often preserve magmatic $\delta^{34}S$ values, suggesting a dominantly magmatic sulfide origin (Keir-Sage et al., 2021; Keet et al., 2021). The heavier $\delta^{34}S$ values have been attributed to localised assimilation of S from footwall sediments or transfer via hydrothermal fluids (e.g., Holwell et al., 2007; Keir-Sage et al., 2021).

An alternative hypothesis proposes that in situ assimilation of external S directly triggered sulfide saturation and ore formation (e.g., Buchanan and Rouse, 1984; Maier et al., 2023). Under this model, magmatic $\delta^{34}S$ values in the most PGE-enriched portions of the Platreef could reflect dilution by high R-factor, where a high R-factor represents a large volume of silicate magma equilibrating with the sulfide liquid (Campbell and Naldrett, 1979). This process can dilute earlier crustal $\delta^{34}S$ signatures (Lesher and Burnham, 2001). While numerous S isotopes studies have focused on the shallow Platreef, the discoveries of the down-dip Platreef offer new opportunities to evaluate the competing hypotheses of in situ assimilation of external S as (1) an ore-forming process or (2) an ore modifier.

In the down-dip Platreef at Sandsloot (Fig. 1) two distinct zones of Ni-Cu-PGE mineralisation have been identified: the PGE-Reef and the Base Metal Zone. The PGE-Reef is enriched in Pt+Pd and represents the down-dip continuation of the mined shallow Platreef horizon (Thompson et al., in press). The Base Metal Zone lies up to 150 m below and hosts Fe-Ni-sulfide mineralisation enriched in Os-Ir-Ru-Rh (Canham et al., in press).

To dig into the role of external S in the down-dip Platreef, I spent two weeks at the Scottish Universities Environmental Research Centre (SUERC) in East Kilbride, Scotland. During my time at SUERC I carried out both conventional and in-situ S isotope analyses. The samples I selected for analysis represented the full range of mineralisation styles across the down-dip Platreef at Sandsloot. This analytical work was funded by a Natural Environment Research Council (NERC) Facilities Grant (IP/2539.0422), plus additional support from a Student Bursary awarded by the Applied Mineralogy Group (AMG) that covered my accommodation costs.

During my time at SUERC Laura Hepburn, Adrian Boyce, Nicolas Bompard and Andrew Tait trained me in all things S isotope related! We converted sulfides into SO2 gas, purified through a gas line system, and then loaded this into the Isotope Ratio Mass Spectrometer (IRMS) (Fig. 2). The SUERC team's guidance was instrumental in both acquiring and interpreting the data.

The results of this study will help us better understand the role of external S in the down-dip Platreef. Plus, thanks to the bursary from the AMG, I gained valuable hands-on experience with a new analytical technique and working in a different lab environment. Watch this space for the results and what S isotopes can tell us about the story of the Platreef!

Figure 2 - *S isotope lab work at SUERC, with the gas line system attached to the laser system and IRMS.*

Thanks to Anglo American and the NL4D Consortium for their help in facilitating this work.

References

Buchanan D.L. and Rouse J.E. (1984) Institution of Mining and Metallurgy. 141–146
Buchanan D.L. et al. (1981) Econ Geol. 76(3): 568–579
Cameron E.M. (1982) Nature. 296(5853): 145-148
Campbell I.M. and Naldrett A.J. (1979) Econ Geol. 74(6): 1503-1506
Grobler D.F. et al. (2019) Miner Deposita. 54(1): 3-28
Guo Q. et al. (2009) Geol. J. 37(5): 399-402
Holwell. D.A. et al. (2007) Econ Geol. 102(6): 1091-1110
Keet J.J. et al. (2021) Can Mineral. 59(6): 1363-1380
Keir-Sage E. et al. (2021) Miner Deposita. 56: 91–102
Kinnaird J.A. and Nex P.A. (2015) Council for Geoscience, Pretoria, South Africa: 293–341
Lesher C.M. and Burnham O.M. (2001) Can Mineral. 39(2): 421-446
Maier W.D. et al. (2023) Miner Deposita. 58(5): 881-902
Manyeruke T.D. et al. (2005) SAJG. 108(3): 381–396
McDonald I. and Holwell D.A. (2011) Reviews in Econ Geol. 17: 297–327
Sharman-Harris E.R. et al. (2005) Appl. Earth Sci. 114(4): 252–263
Sharman E.R. et al. (2013) Econ Geol. 108(2): 365-377

MINSOC 150 CONFERENCE: A REVIEW

By Matthew Cundell and Michaela (Kay) Turanski

A Review of the 150th Anniversary of the Mineralogical Society of the UK and Ireland Conference: Past Discoveries and Future Frontiers

This June, from the 22nd to the 25th, we celebrated the 150th Anniversary of the Mineralogical Society of the UK and Ireland at the Past Discoveries and Future Frontiers conference…and it was a HOT ONE! The University of Manchester hosted this historic conference, with most of the proceedings based out of the Schuster Building.

The conference began on the evening of June 22nd, with the pre-conference icebreaker. Here, we were offered drinks and snacks as we reconnected with friends and colleagues, and we met some new faces amongst the mineralogy enthusiasts!

Presentations kicked off on Tuesday, June 23rd, with our first fantastic plenary talk from 2026 Hallimond Lecturer Helen Williams (University of Cambridge, UK), who discussed her research into “Searching for Earth’s Missing Magma Oceans”. The conference then split into four sessions: Minerals for a Sustainable Environment, Crystal Records of Volcanic, Magmatic, and Mineralization processes, Advances in Mineralogical Analysis, and Universal Mineralogy through time. These sessions featured a variety of keynote, academic, and student presentations.

Tuesday evening brought the Mineralogical Society banquet, held in the magnificent Whitworth Hall. Here, we celebrated both the rich history and exciting future of the Mineralogical Society, presented by President Sam Shaw. As we enjoyed excellent, food, wine, and conversation, we also heard from delegates of other societies expressing congratulations for the Society’s achievement. Russell Rajendra and Kevin Murphy were thanked for their incredible service to the Mineralogical Society and given awards in recognition.

On Wednesday morning, the day began with the 2026 George Brown Lecturer Jocelyne Brendle (Université de Haute-Alsace (UHA), France), who gave her plenary talk on “Clay-Based Stimuli-Responsive Materials: A Versatile Platform for Smart Functional Systems”. This time, the conference split into 3 sessions: Biogeochemical Impacts on Mineral Cycling in Natural and Engineered Systems, Engineered Minerals for Existing and Emerging Technologies, and Metamorphism and Fluid-Melt-Rock Interactions within the Lithosphere. Matt especially

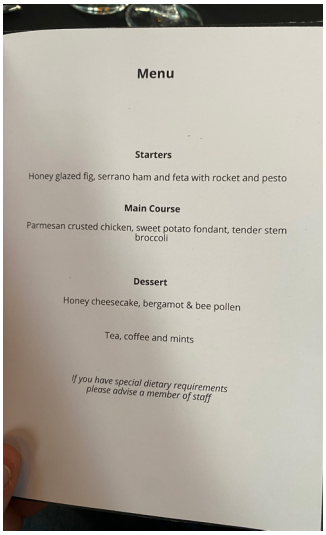
enjoyed the talk based on the mineralogy of aircraft deposits! This day also featured a variety of keynote, academic, and student presentations.

In the afternoon, the conference exploded into conversation during the poster session. There were nearly 50 posters submitted to this section, and over half of them were presented by students and early career researchers. We both really enjoyed presenting our posters and talking with researchers and attendees of different backgrounds – what an amazing chance to network and learn about new topics!

Thursday was the final day of the conference, and we began with three different sessions: Minerals, Contaminant Dynamics and Remediation in the Environment, Critical Minerals and Energy Transition, and Evolving Mineralogy of the Earth System. Kay really enjoyed Katie McFall's talk about volatiles and the different types of melt! The conference fittingly ended with a plenary talk about the future. This talk was given by the winner of the 2026 Neumann medal, by Andrew Berry (Australia National University, Canberra), and Andrew discussed "Research on the Edge".

The Mineralogical Society 150th Anniversary conference also highlighted three outstanding researchers. These three medal winners were: Barb Dutrow (Louisiana State University, USA) who was presented with the Collins Medal; Lin Ma (University of Manchester, UK), who was awarded the Max Hey Medal; and James Byrne (Bristol University, UK), who received the Howie Best Paper Award.

The meeting was generously sponsored by Rigaku, Blue Scientific Ltd., Renishaw, JEOL UK, and Elemental Scientific Instruments. Thank you very much to Sam Shaw (President) Kevin Murphy, and Russell Rajendra, the University of Manchester, and to all other organizers of the Mineralogical Society 150 Conference, for making this experience possible!



Credit to Matt Cundell and Kay Turanski for these photos

Upcoming Events!

Major conferences **SEG 2026** (September 30-October 3) and **GSA Connects 2026** (11-14 October, 2026) are coming up quick!

The **SEG Conference** regular deadline is **September 15, 2026**. The SEG Conference higlights mining, exploration, and ore deposit research and incredible techincal content. They will also host incredible fieldtrips around the American Cordillera.

Find out more here: **https://www.segweb.org/SEG-2026/seg-conference/seg-2026/home.aspx**

The **GSA Connects** early registration deadline is **August 27, 2026**, and the regular registration deadline is **October 2, 2026**. GSA Connects is hosting a celebration of 100 years of understanding continental drift, sharing knowledge on riverscapes and their processes, and highlighting research and innovation 'from Deep Earth to Deep Space'.

Find out more here: **https://connects.geosociety.org/**

WORD SEARCH

X H U O O E O F D R U Z E J L W Q S E Z
M V R V E E B O P R X H N C U P C Z G Y
A P N Q H N P N R S I W W D I O Y Y E Z
G W I D F N B X R E L L M A Q R G G B F
N P O I G E E P I T B E L V U P O A J M
E C R I X X L X A F H O P L T H O R D K
T X N O M U T D R T W O D S V Y U N N M
I D F L S P G Z S G H U O Y E R T E P I
T C L C F P S A G P Z F M Q I Y C T P N
E U R F S D E A W Z A Q I D N K R C D E
T Z S A E R S C L C C R U N F L O T V R
M P E Z G Z E U T T P A R A D B P S Z A
Q P J A A Q M N C L E L V O R E U J A L
P Y R I T E Z V T N T R F I T T R C S O
X G T O E H H Z F T V Z A O F E Z O S G
U R Q Y V Y U H I D J D A T H F E R A Y
M H D P E T R O G R A P H Y I L W E Y L
P E G M A T I T E L C F A P E O P K A Z
G X D A E C R P A P A O L V L I N X I F
G I C R J X M K F D D Q N S K A R N N T

Words to Find:

- Quartz
- Garnet
- Zircon
- Pyrite
- Feldspar
- Magnetite
- Orebody
- Vein
- Skarn
- Porphyry
- Pegmatite
- Alteration
- Pathfinder
- Prospect
- Core
- Assay
- Drill
- Outcrop
- Petrography
- Mineralogy

This issue's word search is inspired by the MinSoc 150 Conference!

GET INVOLVED!

If you are looking to get more involved with the Applied Mineralogical Society (AMG), then keep reading! We are looking for one or more **Industry Representatives**. The Industry Representative must research mineralogy applied to ores. We have 4 committee meetings per year where we help decide on group activities, funding allocation, and suggestions for events.

We are also pleased to have welcomed student representatives Matthew Cundell and Hector Skipworth (University of Exeter), joining Michaela Turanski (University of Edinburgh), for this issue of the Applied Mineralogist.

More information and contact details if interested can be found here:
https://www.minersoc.org/amg.html

BURSARIES/FUNDING:

The next AMG bursary application deadline is **October 15th, 2026**. This bursary is meant to support Postgraduate students (MSci or PhD) in the disciplines of Applied Mineralogy, Crystallography, Petrology and/or Geochemistry with travel costs to events such as conferences. You must be researching in one of the following 'applied' areas: ore mineralogy and petrology, ore genesis, mineral processing and metallurgy, industrial mineralogy, archaeology, environmental mineralogy, nuclear-waste disposal, medical and forensic mineralogy and analytical techniques. You must also be a member of the Mineralogical Society. Application guidelines and form can be found at the following link:

www.minersoc.org/amg-bursaries

Group picture from the MinSoc 150 Conference (Credit: MinSoc)

Please forward any articles, comments, or notices or events and conferences to: **amgminsoc@gmail.com**.

Find all previous issues of the Applied Mineralogist at:
www.minersoc.org/amg-applied-mineralogist

Word Search Answers:

Interested in joining the Mineralogical Society and Applied Mineralogy Group?

Learn more here:
https://www.minersoc.org/

More Upcoming Events:

EIG Conference 2026
Liverpool, UK - 8-11 September 2026

SEG 2026 Conference
Salt Lake City, Utah, USA - 30 September - 3 October 2026

GSA Connects
Denver, Colorado, USA - 11-14 October 2026

AGU 26
San Francisco, California, USA - 7-11 December 2026

MDSG 2027 Conference
Belfast, Northern Ireland - 5-8 January 2027