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OF THE MINERALOGICAL SOCIETY

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From our editors...

Welcome to the April 2026 issue of the Applied Mineralogist! After a brief break in our newletter publications, we are back to sharing the stories of early career geoscientists who used the AMG bursary to have amazing experiences!

In this issue, we begin with an exciting special feature from Dr. John MacDonald, of the University of Glasgow. He shares how anthropogenic materials are integrated into natural processes and sediments, and what resulting mineralogy is observed. We then have bursary reports from Daniel Kwizera and Robin Hilderman. Daniel shares his experience completing fieldwork in Eastern Rwanda as part of his MSc thesis. Robin tells us about their experience at the European Mineralogical Conference (EMC) in Dublin in 2024.

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

Highlights

Edited by
Michaela (Kay) Turanski

SPECIAL FEATURE

by John M. MacDonald (University of Glasgow), Amanda Owen, David J. Brown

The Mineralogy of Anthropogenic Rocks

Human activity results in the erosion, transportation and deposition of tens to hundreds of gigatonnes of clastic sediment on Earth's surface each year [1]. Some of this material is natural in origin, e.g. sand mining, mine tailings, or aggregate deposited to make embankments/foundations. However, much of it is anthropogenically-created and does not occur in nature. Ferrous slags (the by-product from iron and steelmaking), for example, are dominated by minerals which are very rare in natural systems, such as gehlenite, merwinite, larnite [2], and various other phases that nine out of ten mineralogists have never heard of!

When materials such as these, with their unnatural mineralogies, are deposited (dumped) at the Earth's surface, natural processes act upon them, and they become incorporated into natural sediment systems. One outcome of this is the formation of new anthropogenic 'rocks' composed of anthropogenic mineral materials such as slags.

Anthropogenic geomaterials are diverse in their origins and mineralogies, so let's focus on one of the better studied examples – slags – and see how deposits of slag turn into rock. Pure iron, and steel, do not occur in nature, and the iron needs to be smelted out of ore minerals. This is done in furnaces at >1000 °C, with the addition of limestone flux and some other additives.

The pure iron is tapped off leaving a molten residue of all other elements from the ore minerals (e.g. silicon) and the calcium from the limestone flux [2]. This residual molten material is cooled and granulated to leave a grey solid gravelly material – slag.

Until the past few decades, slag was not reused – it was deposited in large heaps or banks and forgotten about. If you visit any historical iron or steelmaking areas of the world, you can often find these large landforms – a legacy of past industry. In the UK, the slag banks of West Cumbria, e.g. around Workington and Barrow-in-Furness, are among the biggest examples. These legacy slag heaps are subject to natural erosion, introducing particles of slag into Earth's sediment cycles. After being dumped and undergoing erosion, these slag deposits can undergo geologically rapid lithification – conversion of a loose gravelly deposit to larger rock-like masses – which is all down to their mineralogy.

Scanning electron microscopy chemical mapping of samples of these slag-dominated anthropogenic rocks shows relative depletion of calcium from around the edges of slag particles, and the presence of calcium-rich cements around and between the slag particles [3, 4] (Fig. 1). The minerals that make up slag, like gehlenite, merwinite and larnite are quite reactive at Earth surface conditions, so when discarded slags come into contact with rainwater, they start to break down, resulting in leaching of calcium from particle edges. X-Ray Diffraction analysis [3] and Raman Spectroscopy confirm the mineralogy of these calcium-rich cements to be calcite. Isotopic analysis suggests ingassing of atmospheric CO_2 into the porewaters between the slag particles contributes the carbonate to combine with the leached calcium to form these calcite cements [3, 4]. The calcite cement that rims the slag particles also binds them together, resulting in a sandstone- or conglomerate-type rock (Fig. 2). While calcite is the dominant cement mineral in these slag-dominated anthropogenic rocks, goethite, pyrochroite and brucite cements have also been documented [5] although more work is needed to understand their formation mechanisms. The resulting rocks form sedimentary strata (Fig. 3).

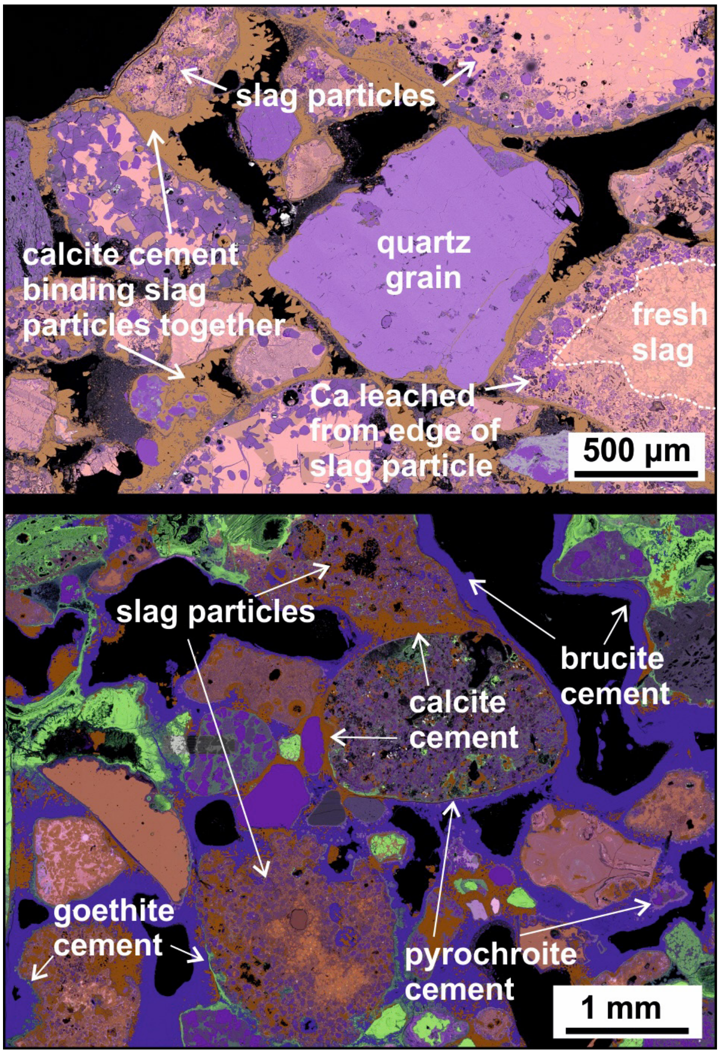

***Figure 1**: Scanning Electron Microscopy Electron Dispersive X-Ray false colour maps of slag-dominated anthropogenic rocks. Top panel shows calcium leached from edge of slag particle, with calcite cement (orange) binding particles together. Bottom panel shows other mineral cements: goethite (green); pyrochroite (purple); brucite (blue).*

***Figure 2:** Anthropogenic rock with conglomeratic texture, where clast composition is dominated by slag; 10 cm-long compass clinometer for scale.*

Figure 3: *Bed top of a stratum of slag-dominated anthropogenic rock, Workington, UK. The whole foreshore in this photograph is cemented.*

Anthropogenic rocks are a relatively new topic but their formation has a range of practical implications, from civil engineering to biodiversity to flood management. The change from a loose sediment to a cemented rock changes the geotechnical properties of the deposit, increasing its strength, but reducing water filtration, which may increase surface run-off and flood risk in certain settings. The change in physical properties may also control the biota which can colonise these evolving deposits. In this short feature we've focused on anthropogenic rocks formed from slags, but examples from other anthropogenic geomaterials have been documented, such as concrete [6] and paper mill sludge [7]. They also serve as a reminder of how human activity is being recorded in geological systems, and act as a potential marker of an 'Anthropocene'. Their formation is all down to the mineralogy!

References

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BURSARY REPORT

By Daniel Kwizera (Ghent University)

Mineralogical, petrographic and geochemical study of the Musha-Ntunga pegmatite mineralisation in Eastern Rwanda

In July 2023, I conducted fieldwork in the Musha-Ntunga area in Rwanda as part of my MSc thesis project at Ghent University, Belgium. I am grateful to the Applied Mineralogy Group for granting me a bursary which was used to cover transportation and logistical expenses. The fieldwork aimed to collect unweathered pegmatite and surrounding host rock, mainly from drill cores (Figs. 1, 2).

The results of my MSc thesis project were presented in the Geological Belgica Congress held in September 2024 at the University of Liège. Additionally, the abstract of my MSc thesis is set to be published in the journal Geologica Belgica.

Figure 1. *Conducting fieldwork in the Musha-Ntunga area in Rwanda.*

Figure 2. *Sawing drill core into collectable samples.*

Introduction

Pegmatites are coarse-grained, intrusive magmatic rocks that formed during the final stages of a solidifying magmatic melt. They sometimes contain critical metals such as lithium, tin, tantalum, and niobium (London, 2018). The increasing need for these metals, especially lithium, is fuelled by the ongoing energy transition towards achieving net-zero carbon emissions by 2050 (IPCC, 2023). Therefore, studying pegmatites is essential to ensure a sustainable supply of these critical elements. The main objective of my thesis was to characterise a Li-mineralised pegmatite intrusion and its interaction with the host rock from Musha-Ntunga in Rwanda.

Methods

A total of 40 quarter-core samples, each ranging 10- to 15 cm in length, were collected from a drill core. The drill core included a 20 m pegmatite section observed at depths between 205 m and 225 m, and surrounding host rock. 20 polished thin sections were prepared for analysis. Firstly, optical- and cold cathodoluminescence (cold-CL) microscopy, Raman spectroscopy, and X-ray diffraction (XRD) techniques were applied to identify the mineralogy of paragenetic sequences. Secondly, geochemical analysis of major-, minor- and trace elements was performed using inductively coupled plasma optical emission spectrometry (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) to investigate the interaction of the pegmatite intrusion and its surrounding host.

Result and implications

Petrographic and mineralogical studies enabled the identification of two distinct mineralisation stages in the selected pegmatite intrusion and a minor third late stage. The first stage consists of primary minerals, including microcline, albite, quartz, muscovite, spodumene, columbite-tantalite, cassiterite, monazite and fluorapatite.

Phase / Minerals	Initial stage	Second stage	Third stage
Microcline	- - ———— - - - -		
Albite	- - ———— - - - -	- - ———— - - - -	
Quartz	- - ———— - - - -	- - ———— - - - -	
Muscovite	- - ———— - - - -	- - ———— - - - -	
Spodumene	- - ———— - - - -		
Columbite-tantalite	- - ———— - - - -		
Cassiterite	- - ———— - - - -	- - ———— - - - -	
Monazite	- - ———— - - - -		
Fluorapatite	- - ———— - - - -		
Goethite			- - ———— - - - -
Kaolinite			- - ———— - - - -
Chlorite			- - ———— - - - -

Table 1. *Paragenesis of pegmatite crystallization.*

The second mineralisation stage is characterised by minerals replacing primary phases such as quartz, albite and muscovite, along with cassiterite crystallisation. These results were subsequently used to construct the paragenesis of the selected pegmatite intrusion (Table 1).

The first stage is thus characterised by the crystallisation of primary minerals, corresponding to the magmatic phase of pegmatite crystallisation. The second stage includes the formation of secondary minerals during the (magmatic-)hydrothermal alteration stage of pegmatite crystallisation. The final, third stage involves the formation of late secondary minerals during (hydrothermal-)supergene alteration.

The metasedimentary host rock is composed of quartz, muscovite, tourmaline, biotite and opaque minerals. Tourmaline and muscovite are the only minerals that are proposed to be related to pegmatite-host rock interaction. Additional geochemical analysis of the host rock samples showed enrichment in incompatible elements such as Cs, Rb, Sn and Zn extending for at least 5 meters from the pegmatite boundary into the host rock. These observations suggest the migration of pegmatitic fluids into the surrounding host rock. Such fluids rich in incompatible elements are indicative of the extreme fractionation of the pegmatite melt.

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BURSARY REPORT

By Robin Hilderman (University of Glasgow)

Attending the European Mineralogical Conference, Dublin 2024

From August 18th to 23rd, I attended and presented at the European Mineralogical Conference (EMC) 2024 in Dublin. A diverse range of sessions was organised with ‘Platinum group elements and minerals’, ‘Mineralogy and circular economy,’ and ‘Innovation and challenges in process mineralogy, geometallurgy and supporting analytical techniques,’ especially piquing my interest. I presented my research that characterise legacy industrial waste to inform opportunities for resource recovery and atmospheric carbon dioxide (CO2) storage, in the ‘Crystallisation of carbonates: Mechanisms, kinetics, methods, case studies, and novel applications’ session.

My oral presentation included my research that revealed variable mineralogy and metal content between five stratigraphic horizons of a slag deposit. By utilising a semi-automated approach as a turnkey operation for processing numerous large datasets, the machine learning algorithms we used located hidden and non-statistically significant regions. This new approach for finding trace metal content in industrial waste can be applied to enhancing microstructural analysis and documenting the evolution of metallurgical processing methods, which can ultimately inform environmentally sensitive CRM recovery.

My poster presentation on the mechanisms lithifying a legacy coastal artificial ground deposit, comprising by-products of legacy iron and steel workings, sparked wonderful conversations with other researchers in the field. As a result of the UK’s industrial history that peaked in the early twentieth century, there are estimates of over 190 Mt of legacy iron and steel slag at current and former workings. Whereas, in Germany, where slag is currently being produced, much of the research focuses on reusing the more modern waste. Nonetheless, is important to understand the natural processes altering these waste sites as they could pose opportunities for CO2 storage, or challenges such as ecotoxic metal leaching. My findings that compositionally diverse slag and various external environmental parameters influence slag lithification, suggest the opportunities for atmospheric CO2 storage and reuse for ‘hard protection’ and coastal defence applications.

On the top of the deposit, rainfall dissolved gehlenite and åkermanite, promoting Ca leaching and atmospheric CO_2 mineralised into calcite cement that lithifies this region. Comparatively, where there are more Ca-rich phases that are washed by seawater on the seaward side of the deposit above the mean high-water mark, there is less calcite which records lower $\delta^{13}C$ values and calcium-silicate-hydrate cement lithified this region.

I want to thank the Applied Mineralogy Group of the Mineralogical Society for awarding me the Postgraduate Student Bursary and supporting my attendance at the EMC 2024. I also want to extend my deepest appreciation to my University of Glasgow research group, who provided support throughout my Master's.

Upcoming Events!

The **Mineralogical Society's 150th Anniversary Conference** is coming up soon from June 23-25, 2026 at the University of Manchester.

The conference theme is 'Past Discoveries and Future Frontiers'. Everyone is welcome, from early-career researchers to those with a lifetime of membership to the Mineralogical Society, and registration continues at the following link!

Learn more about this event here: **https://minsoc-150.org/**

WORD SEARCH

C N N E W Q O Y K J N X M I R Y I J R K M U M J P

A S X M F P O N B M V K Q Q T J A B K I A H L E A

Q I E S C Q G Y H K J A L S U J X R I V N B F F G

O M O S A N T H R O P O G E N I C B J B C D D I E

W U F C Q D P P E G M A T I T E S W H E H S Q H O

C G L C J U X X T U F E G I A B G K N N E S B I C

C G W I Q W I R J G G E A S M J L S W U S I N V H

G R R T I T A C I N G N J R F K F L B Q T V K P E

S F I Y V O D W E U D S C D T X M B N O E S M U M

T D U T R O R A M N X S O Q P H G O C J R R Q I I

D A J D I F W E F I T B F U I R S Z C M D O M J S

J N F A H C R Y D U N E G O O U G C Z D X C I Y T

R N U S I P A X N E I E N V S L D O I T N K N O R

E I K C B E H L D N P U R N U S C R C E Z S I B Y

A V M G J V B D M B F O C A I A R G D B N Z N D Z

S E C U C Q N K F I W E S R L A H P X A J C G G V

B R L N O G S P L R N H C I C O L Y N N L D E M H

F S U W W R I X F T O E O X T C G N B Z F F N B Z

M A L L C I Y T C H C N R J D E W Y G E G N C V J

X R Z A E D L M N P B A T A U R T G M R L X Z U J

B Y G M S N M Z E T N O K I L U T I J W G O Z G I

F E N X H R L L L P G N Y Y E S S T O Y C M X Z Y

I M E X P L O R A T I O N T Q R M M T K W L S I Q

D I S C O V E R I E S K T T B F S Y M G H F L K K

U P M V H Q J Y Q V C V Y R R N X J Z R W D C M I

Words to Find:

- Discoveries
- Frontiers
- Mineralogy
- Sesquicentennial
- Anniversary
- Earth Science
- Exploration
- Geochemistry
- Mining
- Ore Deposit
- Manchester
- Anthropogenic
- Rocks
- Pegmatites
- Critical Minerals

This issue's word search is inspired by the upcoming Mineralogical Society 150 Conference, the special feature, and the bursary reports!

GET INVOLVED!

If you are looking to get more involved with the Applied Mineralogical Society (AMG), then keep reading! We are looking for an **EDI Representative** and 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.

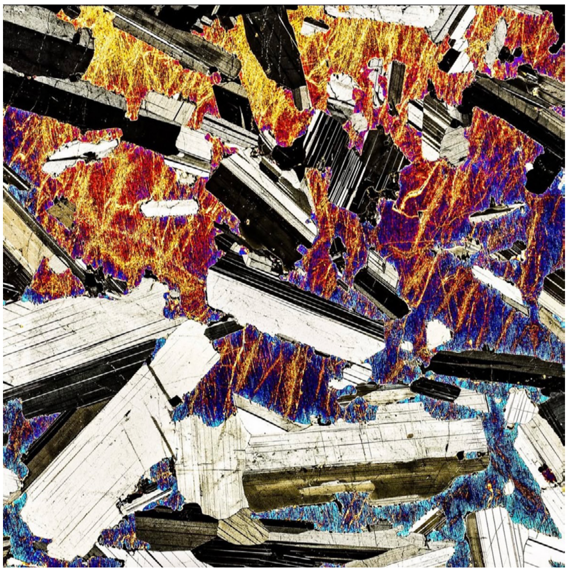
More information and contact details if interested can be found here: **https://www.minersoc.org/amg.html**

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

#ThinSectionThursday



Congratulations to Robert Puckett, with the image contributed via @minsocam on Instagram, for being our Thin Section Thursday winner!
This section is described as 'Ophitic texture of plagioclase laths encased in clinopyroxene in a gabbro from the Glen Mtns Layered Complex in southwestern Oklahoma.'

If you want a chance at winning, post with the tag **#ThinSectionThursday !**

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:

EGU General Assembly
Vienna, Austria - 3-8 May 2026

EAGE Annual 2026
Aberdeen, UK - 8-11 June 2026

Mineralogical Society 150th Anniversary Conference
Manchester, UK - 23-25 June 2026

Goldschmidt Conference
Montreal, Canada - 12-17 July 2026

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

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