The Applied Mineralogist
The Bulletin of the Applied Mineralogy Group
Edited by: Holly Andrews, Charlie Compton-Jones, Adam Eskdale
Web: www.minersoc.org/amg.html
Twitter: www.twitter.com/amg_min
Email: amgminsoc@gmail.com

March. 2021
Volume 6
Number 1

From the AMG Committee
Hello and welcome to the March edition of The Applied Mineralogist! We present a special feature on South African eclogites, a summary of a Rare Earth Elements workshop by the AMG, and the latest updates on upcoming Ore Deposit Hub talks. Finally, test your mineralogical mettle on our latest wordsearch!

In this issue:
- REE Workshop Summary (p. 1)
- Eclogite Xenoliths and Their Precious Metal Budget, Charlie Compton-Jones (p. 2—4)
- Geological Wordsearch (p. 5)
- Summary of Ore Deposits Hub Talks (p. 5)
- Twitter contest winner #AppliedMineralogy (p. 6)

REE Workshop Summary, Eimear Deady
The AMG was delighted to host a workshop on the geochemistry of the rare earth elements (REE) in February 2021. The workshop opened with a refresher on the REE by Dr Marc-Alban Millet (University of Cardiff and Secretary of the Geochemistry Group). Dr Michael Anenburg (ANU) discussed a new method and interactive online app to quantitatively describe rare earth elements patterns using lambda coefficients. He discussed the tetrad effect, and showed some applications of the method. Michael is currently working on various magmatic-hydrothermal processes that led to the formation of ore deposits of rare metals, including the REE (La-Lu), Y, PGE (platinum group elements), etc. He is particularly interested in the behaviour of these metals in carbonatites and related systems. Finally, the workshop closed with a presentation on the pyrolite python package developed by Dr Morgan Williams (CSIRO) this package can be used to work with big geochemical data sets. All the software and python packages discussed here are open source. The AMG was delighted with the community engagement with the workshop. It was attended by 250 participants from 27+ countries and the talks have been watched hundreds of times already!

For more information and links to the presentations (available through the Society’s Youtube channel) and to the software discussed by the speakers go to: https://www.minersoc.org/REE-software-workshop.html

Figure 7 from Anenburg, M. (2020). Rare earth mineral diversity controlled by REE pattern shapes. Mineralogical Magazine, 84 (5), 629-639. doi:10.1180/mgm.2020.70
Background

The precious metal abundances of the Earth’s mantle are primarily investigated by analysis of sulphide in the form of inclusions within diamonds or silicate minerals, or as discrete grains located at the boundaries of the primary assemblage within mantle xenoliths. Historically this work has sought to establish the base metal sulphide (BMS) and chalcophile element (including platinum-group elements; PGE) budget of the peridotitic mantle with less attention in the literature paid to the less volumetrically significant eclogitic mantle (1-4% of the mantle by volume; Shultze, 1989), especially with respect to the PGE.

Over the last 50 years, the Roberts Victor kimberlite in South Africa has produced one of the most extensively studied suites of cratonic eclogite xenoliths, up to 80% of the collected Robert Victor xenolith population, while other pipes in the Kimberley region generally contain abundant peridotitic xenoliths with only a minor (~5%) contribution of the eclogitic variety (Macgregor and Carter, 1970).

The Bushveld Complex, located north east of the Roberts Victor pipe, is one of the most studied ore deposits on Earth and requires little introduction (but for those less tuned in to the wonderful world of layered igneous intrusions and associated PGE mineralisation, the Bushveld large igneous province is the most voluminous of its kind on Earth and contains a staggering 90% of the world’s platinum resources, in addition to significant quantities of the other PGE, V and Cr). Despite this, the provenance of the PGE riches of the Bushveld Complex is still contentious. Some authors have linked the formation of the Bushveld Complex to varying components of partially melted eclogite in the subcontinental lithospheric mantle (SCLM) underlying the Complex (e.g., Richardson and Shirey, 2008) - but the precious metal composition of BMS in eclogitic mantle remains poorly understood, and so we may ask from a basic ‘mass balance’ approach: does the PGE budget of sulphides from eclogite xenoliths comply with such a model?

Robert Victor eclogite petrology

The Roberts Victor eclogite xenoliths range in size from 3 to 5 cm and are coarse-grained, bimineralic rocks with omphacitic clinopyroxene and pyrope-almandine garnet as the modal primary minerals (Fig. 1). The groundmass is predominantly composed of fine chlorite and albite, which exists interstitially to the primary assemblage. Minor oxides (e.g., ilmenite and rutile) and BMS form the most common accessory minerals and range in size from 100 μm to > 1 mm. Almost all of the studied eclogite xenoliths contain BMS and they primarily form as interstitial phases with fewer BMS forming as inclusions within the primary silicate assemblage (in both garnet and clinopyroxene).

The BMS form as irregular to semi-rounded grains that lie in melt channels at the grain boundaries of clinopyroxene and garnet and as well rounded droplet-like grains that are enclosed within the silicates (either fully included or as ‘embayments’ within the grain; Fig. 1). These interstitial BMS are associated with channels of ‘spongy’ Na-poor clinopyroxene (diopside), chlorite, biotite, and albite and often exhibit the effects of mobilisation in the form of sulphide ‘strings’ that trail from the BMS through the surrounding melt channel (Fig. 2a). Pyrite-bearing assemblages dominate the eclogites in conjunction with minor pentlandite that forms as ‘lamellae-like’ internal features (displayed clearly by the QEMSCAN false colour images; Fig. 1c). Pentlandite also forms with chalcopyrite as a rim. Pyrrhotite, which is the most common BMS-forming mineral in peridotites, is sparse but is present in the eclogite BMS assemblages (e.g., Fig. 1b).
Platinum-group element geochemistry

We used LA-ICP-MS to assess the precious and semi-metal compositions of the BMS revealing 4 end-member compositions (Types i to iv). The majority of the ablated BMS conform to Types i to iii, which are distinguished by their total PGE abundance, and Pt/Pd and Au/Pd ratios, while exhibiting ubiquitously low Os, Ir and Ru abundances (generally < 1 ppm per element). These BMS contain < 100 ppm total PGE (Fig. 3), with Pt and Pd as the main contributors. This is in line with those of other eclogite xenoliths of the Kaapvaal craton and associated eclogitic diamond inclusions. In contrast, Type iv BMS (which consist of two discrete BMS from a single xenolith) are significantly enriched in all PGE compared to other eclogitic BMS (> 100 ppm total PGE) and are more comparable in their trace element composition to BMS from peridotite xenoliths and associated diamond inclusions (Fig. 3). This group is characterised by a pervasive enrichment in Os, Ir and Ru and consistently high abundances of Pt and Pd compared to Types i to iii (and other eclogitic BMS in the literature). We also observed discrete, nano- and micron-scale platinum group minerals (PGM) in the eclogite xenoliths spatially associated with the BMS, including Pd–Pt antimonides, tellurides and arsenides (Fig. 2b). To our knowledge, these PGM are the first described in eclogite xenoliths and their presence may be significant to the precious metal budget of eclogitic mantle. These PGM account for the discrete peaks in Pt and Pd often associated with grain boundaries between the Ni-Fe sulphides in BMS of Type i and ii.
So why do we care?

This work has demonstrated that there are multiple populations of BMS existing within eclogite xenoliths, categorised by their petrographic siting (i.e., interstitial or enclosed) and by their PGE systematics (Types i to iv). Type iv BMS are more PGE-rich than any other eclogitic BMS studied previously and, despite their apparent rare occurrence, may be enriched enough to greatly affect the PGE concentrations of a hypothetical melt derived from mantle eclogite. In addition, the presence of discrete PGM associated with eclogite BMS also serves to increase the precious metal potential of these mantle rocks. Accordingly, SCLM eclogites may be more capable than previously thought of enhancing the metal basket of asthenosphere-derived parental magmas, like those contributing towards the formation of the Bushveld large igneous province.

References


Read the full paper here.


Corresponding author address: cc715@exeter.ac.uk
For this bulletin’s puzzle, here is a wordsearch covering different ore deposit classifications. Many of these have featured in the Ore Deposits Hub talks so the more you’ve tuned in, the better!

<table>
<thead>
<tr>
<th>LODE</th>
<th>EPITHERMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCHAEOAN</td>
<td>SKARN</td>
</tr>
<tr>
<td>PORPHYRY</td>
<td>KOMATITE</td>
</tr>
<tr>
<td>LATERITE</td>
<td>VHMS</td>
</tr>
<tr>
<td>CARBONATITE</td>
<td>SEDEX</td>
</tr>
<tr>
<td>BIF</td>
<td>MVT</td>
</tr>
<tr>
<td>IOCG</td>
<td>ALLUVIAL</td>
</tr>
<tr>
<td>ASTROBLEME</td>
<td></td>
</tr>
</tbody>
</table>

THE ORE DEPOSITS HUB

The Ore Deposits Hub is an open talks platform hosted online. Started in response to the COVID-19 pandemic as a virtual meeting facilitating science communication when in-person conferences were not viable. Ore Deposits Hub has grown and continued to provide this platform into 2021. 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:

**Upcoming talks include:**

(Wed, 21st April, 8:00am) **Stuart Smith** – Geological Punctuation Marks: The Importance of Time in the Porphyry Model

(Wed, 21st April, 5:00pm) **Krebchov Haimbodi** – Unravelling some of the scientific riddles of one of the world’s oldest porphyry Cu-Mo deposits

(Wed, 5th May, 8:00am) **Koen Torremans, David Selley, Bubile Nhataka** – Sediment-hosted copper deposits – Research Exchange Session 1/2

(Wed, 5th May, 5:00pm) **Nic Saintilan, Philippe Muchez, James Davey** – Sediment-hosted copper deposits – Research Exchange Session 2/2

Find out more information and sign up at: [https://oredepositshub.com/](https://oredepositshub.com/).
Interested in joining the Mineralogical Society and Applied Mineralogy Group?

Go to: https://www.minersoc.org/ for membership details.