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## Toward an effective global green economy: The Critical Minerals Mapping Initiative (CMMI)

Karen D. Kelley<sup>1\*</sup>, David. L. Huston<sup>2</sup>, Jan M. Peter<sup>3</sup>

<sup>1</sup> United States Geological Survey, Box 25046 Mail Stop 773, Denver, Colorado 80025

<sup>2</sup> Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

<sup>3</sup> Geological Survey of Canada, 601 Booth St, Ottawa, ON K1A 0E8, Canada

\* [kdkelley@usgs.gov](mailto:kdkelley@usgs.gov)

Global population growth, economic development and the accelerating pace of technological innovation are driving increased demand for non-fuel mineral commodities that are vital for emerging and low-carbon technologies. Examples of such commodities include cobalt and graphite for rechargeable batteries, tellurium in thin-film solar photovoltaics and rare earth elements (REE) in permanent magnets, electronics and medical technologies (Tab. 1). These commodities are known as critical elements and/or minerals (collectively referred to as critical minerals), with the term critical used to define not only their importance for new technologies, but also their demand and vulnerability to supply disruption. The demand for critical minerals is likely to continue to grow, but supply is not assured. Therefore, national strategies in Australia, Canada, United States and elsewhere (e.g. Europe: Wittenberg et al. 2021) are being developed to encourage exploration and production, including resolving the geological processes responsible for their enrichment into viable ore deposits.

In 2019, Geoscience Australia (GA), the Geological Survey of Canada (GSC) and the United States Geological Survey (USGS) formed the Critical Minerals Mapping Initiative (CMMI) to undertake research to develop a better understanding of critical mineral resources in known deposits (Fig. 1), determine the geological controls on critical mineral distribution for deposits currently producing by-products, and iden-

tify new sources of supply through mineral prospectivity mapping and resource assessment.

The coordination of these three geoscience organizations creates a shared foundation on which to build new research ideas (Kelley 2020). Together, the three organizations will a) promote a collective understanding of critical minerals science; b) share data; c) identify knowledge gaps; d) build upon existing datasets for use in critical mineral assessments; e) examine critical mineral abundances and distributions in different deposit types; and f) leverage strengths to enhance working relationships and share expertise.

### What are critical minerals and why are they important?

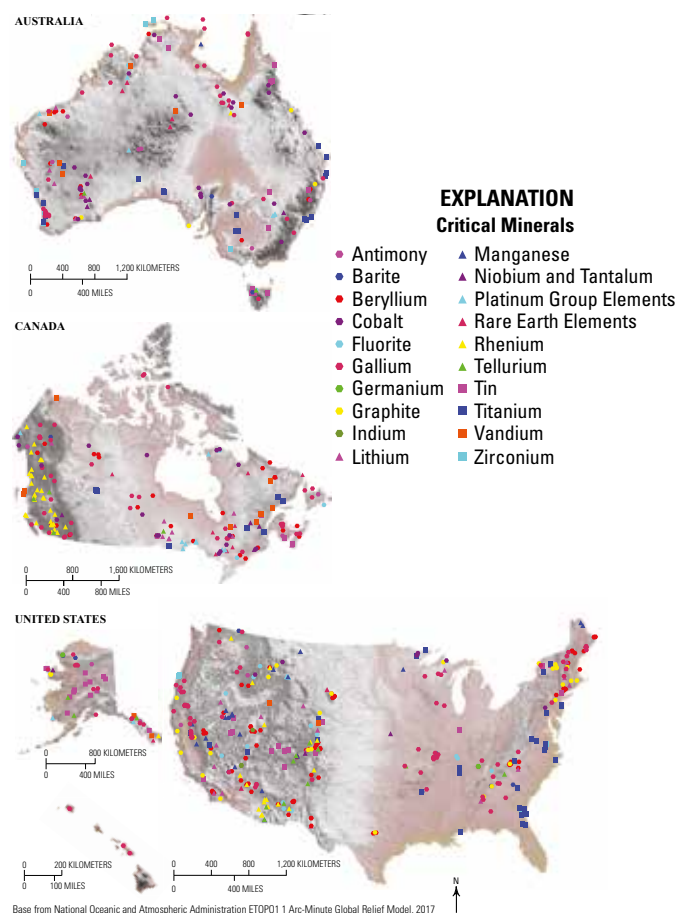
Critical minerals are natural resources that are essential to the economic and national security of nations, and may be or become scarce due to geological, technological or political factors. They are minerals that have many important uses (Tab. 1) and few effective substitutes. A mineral that may have been considered critical 25 years ago may not be critical now. Likewise, a mineral not considered critical today may become critical in the future. Many critical minerals are currently recovered as by-products of the production of other minerals, complicating the economics of their supply chain. For example, cobalt (Co) and platinum group elements (PGE) are recoverable from some magmatic nickel-

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**Table 1. Primary uses of select critical minerals (modified from Fortier et al. 2018)**

Mineral	Primary Use
Aluminium (bauxite)	Aircraft, power transmission lines, lightweight alloys
Antimony	Lead-acid batteries
Arsenic	Microwave communications (gallium arsenide)
Barite	Oil and gas drilling fluid
Beryllium	Satellite communications, beryllium metal for aerospace
Bismuth	Pharmaceuticals, lead-free solders
Cobalt	Jet engines (superalloys), rechargeable batteries
Gallium	Radar, light-emitting diodes (LEDs), cellular phones
Germanium	Infrared devices, fibre optics
Graphite	Rechargeable batteries, body armour
Indium	Flat-panel displays (indium-tin-oxide), specialty alloys
Lithium	Rechargeable batteries, aluminium-lithium alloys for aerospace
Niobium	High-strength steel for defence and infrastructure
Platinum Group metals	Catalysts, superalloys for jet engines
Rare Earth Elements	Batteries, electronics, magnets, communication and medical technologies
Rhenium	Jet engines (superalloys), catalysts
Tantalum	Capacitors in cellular phones, jet engines (superalloys)
Tellurium	Infrared devices (night vision), solar cells
Tin	Solder, flat-panel displays (indium-tin-oxide)
Tungsten	Cutting and drilling tools, catalysts, jet engines (superalloys)
Vanadium	Jet engines (superalloys) and airframes (titanium alloys), high-strength steel



copper deposits (e.g., Voisey's Bay; Naldrett et al. 2000), whereas tellurium is indirectly mined as a by-product of milled copper, iron and other base-metal-rich ore bodies containing trace amounts of tellurium-bearing minerals (Anderson 2015). A few critical commodities, such as graphite and tungsten, can be produced on their own, but their global production is presently dominated by only a few countries (Nassar et al. 2020).

### The many guises of criticality

There are a number of sources of criticality, that is, the degree for which the supply chain for a critical mineral can be disrupted and what is considered critical varies among countries. In a broad sense, criticality can be derived from three sources: geological, technological and political. Critical geological risk stems from the occurrence of known or developed resources in a restricted number of regions due to geological processes. For example, the vast majority of world cobalt production in 2019 (~71%) and identified resources (~55%) are from the Democratic Republic of Congo, as it contains much of the Central African Copperbelt, the world's largest cobalt province (Shedd 2020).

Technological risk relates to the ability (or inability) to recover critical minerals from resources in an economically viable and

*Fig. 1 Critical mineral resources in Australia, Canada, and the United States (Labay et al. 2017). Critical minerals support a broad range of industrial sectors and a diversity of high-tech industries that are important to global economies.*

environmentally responsible manner. As an example, the Olympic Dam deposit in South Australia contains the second largest resource of REE in the world, but this resource is not economically recoverable using current technologies (K Ehrig, pers comm, 2017).

Political risk arises mostly from geopolitical tensions that can exacerbate the geological and technological risks described above or may spring from other factors. The best example of geopolitical tensions is the REE trade dispute in the early 2010s. In response to a dispute with Japan, China imposed quotas on the export of REE in 2010 (Mancheri et al. 2019). Although China dropped these trade restrictions in 2015 in response to a ruling of the World Trade Organization, this episode illustrates that geopolitical tensions can significantly impact the trade of critical minerals, when one or a small number of countries have a near monopoly.

As described above, many critical minerals are recovered as by-products of major metals (e.g., Cu, Ni, Zn, etc), but recovery of these critical minerals is not uniform. Because of this and the fact that many concentrates are not processed in their country of origin, supply chain risk for some critical minerals may not be geological or technological, but may stem from the location of processing facilities. For example, although Belgium has no operating zinc mines, it is a major primary producer of zinc along with associated critical minerals such as germanium because of the existence of a large smelting industry in Belgium. Although China has a large zinc mining industry, it also imports and smelts zinc concentrates from other parts of the world and is the dominant producer of processed germanium and related elements. Therefore, even though mine production of critical minerals is diversified, the concentration of processing facilities in a few jurisdictions could significantly impact the criticality of some commodities.

## The most critical of the critical minerals

Although the factors that determine the degree of criticality are country dependent, recent analysis of supply risk to the manufacturing sector in the U.S. between 2007 and 2016 indicates that a subset of 23 minerals (including cobalt, niobium, REE and tungsten) are the most at risk (Fig. 2; Nassar et al. 2020). The supply risk is calculated based on three factors: 1) disruption potential caused by nature (e.g., earthquakes), or man-made events (e.g., labour disruptions); 2) trade exposure (degree of exposure to foreign supply disruptions); and 3) economic vulnerability (supply disruption inflating commodity price). The list of minerals with the greatest supply risk are primarily sourced from countries such as China, Democratic Republic of Congo, Russia or South Africa (Fig. 2; Nassar et al. 2020).

Technological change is also driving Australia's need for critical minerals, similar to those for the United States, Japan, Europe and other major developed manufacturing economies. Although not considered critical minerals, phosphate and potash are essential due to the importance of agriculture in the Australian economy and only recently has an indigenous industry begun to provide potash to Australia's farmers. With respect to commodities viewed as critical by other countries, Australia sees opportunities for diversification to supply these commodities to other countries and, as such, are guided by lists produced by these other countries.

A key criterion for criticality for Canada is whether a product is essential to the transition to a low-carbon economy (e.g., battery and magnet manufacturing). However, Canada does not make significant use of critical minerals in its manufacturing sector (though there is the overarching goal of developing a whole value chain there). As a net exporter, the mineral resource extraction industry

is an important contributor to Canada's economy (similar to Australia). Copper, nickel, and zinc are considered critical to Canada because it has a competitive ability to supply them, whereas these metals are not considered as such by the United States and Australia, though they are by Japan. Additionally, important by-products from these metals (e.g., indium and tellurium) are considered critical. Similar to Australia, one of Canada's approaches to defining criticality is whether they are (or can be) the supplier of choice to their allies (and beyond).

## Global digital database

One of the major efforts of the CMMI is to produce an integrated global digital database of more than 65 geochemical parameters (including most of the critical elements) in rock and ore samples from major deposits/prospects. Recently obtained geochemical analyses of archived ore sample collections (Granitto et al. 2020) will be integrated with the OSNACA (Ore Samples Normalized to Average Crustal Abundance) database (<http://www.cet.edu.au/research-projects/special-projects/projects/osnaca-ore-samples-normalised-to-average-crustal-abundance>) and other GA, GSC and USGS databases and will form the beginnings of the global database. The database is considered essential to understand the controls on critical mineral distribution and to increase accuracy in mineral resource assessments. It is intended to be freely available via a web portal, and it will be open for other organizations to add to it as it develops.

As part of the program to construct the integrated global database, the CMMI is designing a deposit classification scheme that will enable the grouping of similar deposits. The classification scheme will provide internal consistency to the database such that it can be queried and analyzed. As such, it will act as a predictor of critical mineral concentrations of various deposit types, which will assist industry in identifying exploration and development opportunities. In addition, the CMMI will use the deposit classification scheme as the basis of a tectono-metallogenic classification that will allow the linking of diverse mineral systems to tectonic environment and evolution.

## Mineral systems approach

The petroleum system model (Magoon and Dow 1994) was developed in the 1980s using an Earth systems approach to understand the production and accumulation of hydrocarbons to form economic deposits of oil and gas. Following the success of the petroleum systems model, Wyborn et al. (1994) advocated a similar Earth systems framework for mineral deposits. This 'mineral systems' approach considers all geological processes involved in the generation and preservation of mineral deposits. Figure 3 illustrates one version of the mineral systems approach and conveys the premise that mineral systems evolve over much longer time periods and over much larger regions compared to individual ore deposits. Processes that eventually result in the formation of ore deposits can begin tens to hundreds of millions of years prior to the development of an ore system and can modify and upgrade the resulting ore metal accumulation well after it formed. These processes range from global to deposit-scale and therefore involve initial chemical differentiation of Earth through plate convergence and divergence, basin-formation and/or magmatism and chemical processes at the ore depositional site. In recent years, the mineral systems approach has been used for mineral potential analysis (Mernagh, 2013; McCafferty et al. 2019; Skirrow et al., 2019; Bruce et al. 2020; Lawley et al., in press) that has been used by industry to identify new ex-





Fig. 2 Heat map displaying the supply risk (SR) of the U.S. manufacturing sector for all commodities examined between 2007-2016 (Nassar et al. 2020). Leading producing countries are shown as blue bars, and the most vulnerable applications are identified.

ploration plays and make discoveries (e.g., Julimar PGE-Ni and Lake McKay potash in Australia) or have identified target areas for future exploration of critical commodities (Co, REE in IOCG and IOA deposits, southeast Missouri, USA). The CMMI seeks to improve this approach by empirically testing genetic mineral systems models using the collective datasets across the Australian and North America continents, similar to the global study of sediment-hosted base metal deposits by Hoggard et al. (2020).

Placing critical minerals into a mineral systems framework represents one of the most important outcomes of knowledge and data sharing between the three geological survey organizations. Critical minerals frequently occur as minor components of deposits that contain copper, zinc, nickel, aluminium or iron. Hence, understanding mineral systems that form deposits of these major commodities can also resolve system controls on critical minerals. Initial studies demonstrate that concentrations of critical minerals are more likely to be concentrated in specific mineral systems or deposit types (Yellishetty

et al. 2017), even in different mineral systems dominated by the same major metal.

Critical minerals (notably REE, tungsten and graphite) can potentially form deposits in which they are the most significant or only economic commodity. The mineral systems that form such deposits are generally poorly understood. However, progress is being made. For example, the formation of some REE deposits require the long-term presence of metasomatized mantle and/or lower crust by subduction as a metal/fluid source (Spandler et al., 2020).

## Summary and conclusions

The demand for minerals used for emerging and low-carbon technologies has led many government geoscience groups, industry and research organizations to focus on how critical minerals are enriched in mineral deposits and how we can better predict sources, which will aid exploration and development. To that end, GA, GSC and USGS have come together to initiate the Critical Minerals Mapping Initiative (CMMI) to combine expertise and provide a comprehensive, publicly available database

of critical minerals in different mineral system types and to conduct mineral potential mapping by testing genetic mineral system models using the collective datasets across the Australian and North American continents.

Australia, Canada and the United States share commonalities regarding the most important critical minerals, but there are also differences: The U.S. with its strong manufacturing sector requires resources such as cobalt or graphite for rechargeable batteries, tellurium for solar panels and REE for magnets, electronics and medical technologies. Both Australia and Canada, as net-exporting countries, define criticality by whether they can be a supplier of choice for their allies.

It is expected that the demand for critical minerals will continue to grow, but their supply is not assured. The search for and discovery of critical minerals is being advanced through the adoption of a mineral systems approach that provides a holistic integration of all geological processes, irrespective of time or space, leading to their enrichment. Placing critical minerals into such a framework represents one of the primary objectives of the knowledge and data sharing between GA, GSC and the USGS.

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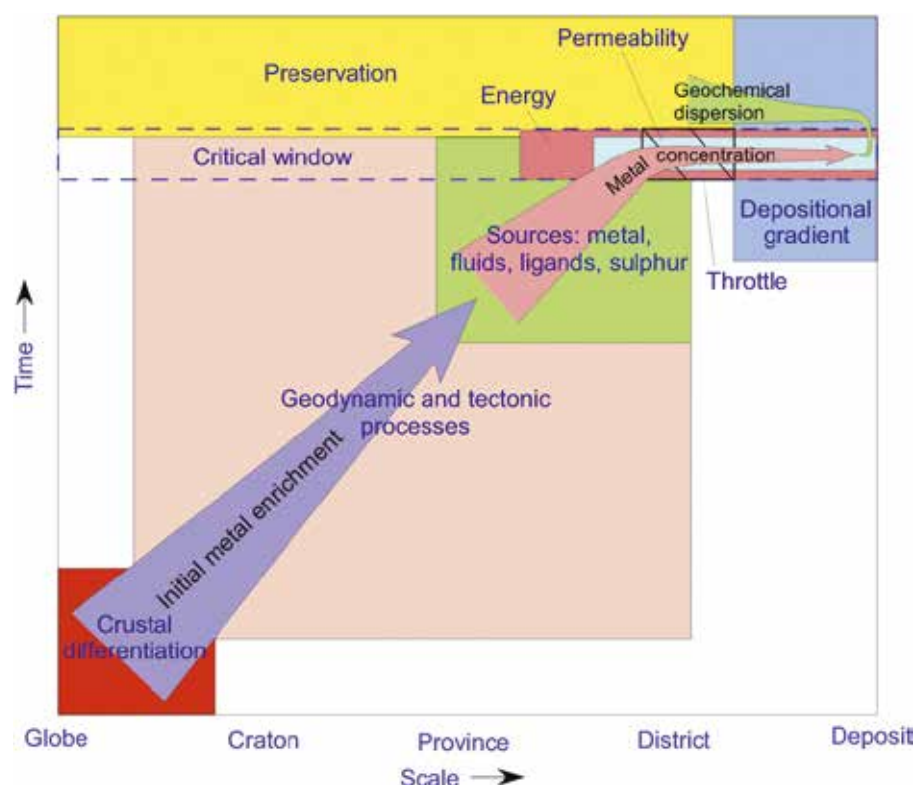


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# GeoERA Raw Materials to support Europe's resilience on raw materials

Antje Wittenberg<sup>1\*</sup>, Daniel P.S. de Oliveira<sup>2</sup>, Lisbeth Flindt Jørgensen<sup>3</sup>, F. Javier González<sup>4</sup>, Tom Haldal<sup>5</sup>

<sup>1</sup> Federal Institute for Geosciences and Natural Resources, Geozentrum Hannover, Stilleweg 2, D-30655 Hannover, Germany

<sup>2</sup> National Laboratory of Energy and Geology, Apartado 7586, Alfragide 2610-999 Amadora, Portugal

<sup>3</sup> Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark

<sup>4</sup> Geological Survey of Spain (IGME), Calle de Ríos Rosas, 23, 28003 Madrid, Spain

<sup>5</sup> Geological Survey of Norway, Postal Box 6315 Torgarden, NO-7491 Trondheim, Norway

\*antje.wittenberg@bgr.de

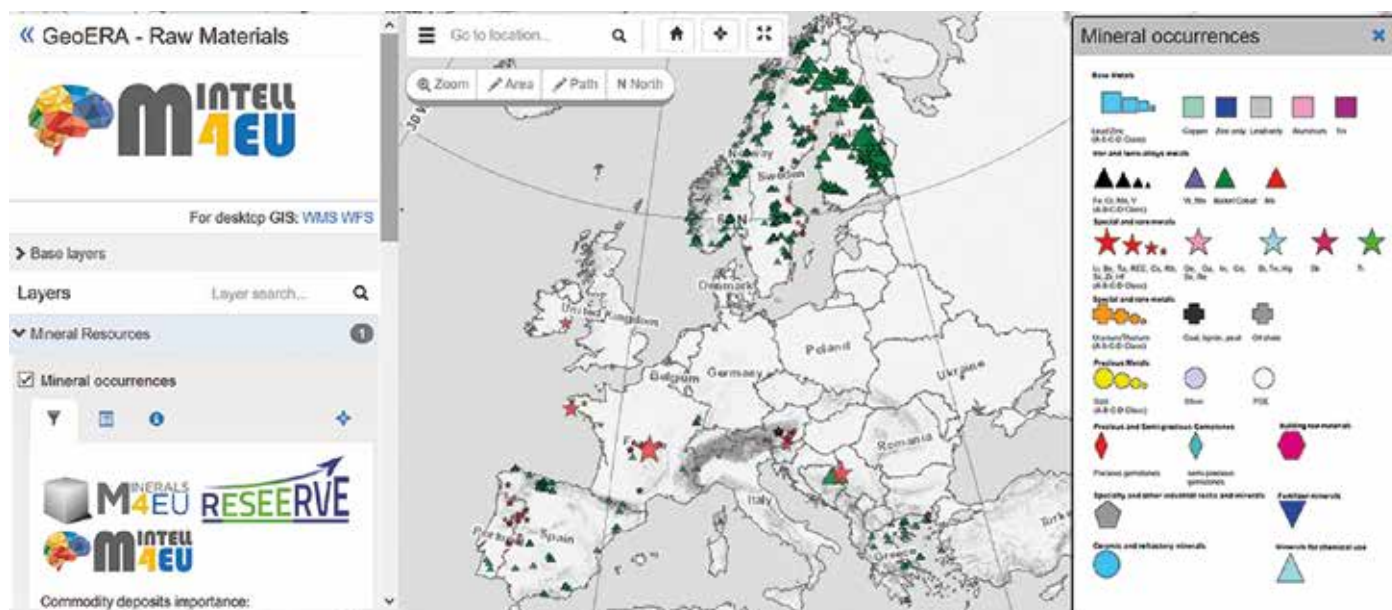


Fig. 1 Cobalt (green triangles) and lithium (red stars) occurrences in Europe (as of November 2020). Different sizes reflect the assessed amount of the commodity in question; most of the small symbols reflect non-quantified occurrences.

Europe's vision to be a climate neutral economy by 2050 has ushered in the energy transition. Carbon-neutral energy supply is based on raw materials from which energy-critical elements for rechargeable batteries like cobalt, graphite, lithium and rare earth elements can be purified. In addition to direct energy generation, other future-oriented, environmentally friendly key technologies needed for digitisation and mobility can only be engineered by using raw materials (European Commission 2019). Semiconductors, super alloys and lightweight steel, fibre optics are amongst the fundamental technical components for which scarce chemical elements like tellurium, gallium, germanium, rhenium or scandium are crucial (Marscheider-Weidemann et al. 2016). Many important raw materials can only be found in low concentrations in accessory minerals in the usually accessible upper hundred meters of the Earth's crust. Because of their low concentrations, they are rarely a primary mining target. In what geological environment and by what means such elements are enriched is still a lively scientific debate. Moreover, the mineralogy that needs to be cracked to extract the desired chemical elements is often a technological challenge. Furthermore, social, environmental, economic, political constraints have their share to limit the raw materials accessible further, but are also part of the solution towards a responsible and sustainable sourcing. These aspects must be taken into account and lead to a number of studies and policies to define critical raw materials. Among these is the sequential reviewing exercise to determine Europe's Critical Raw Materials List conducted for the European Union sets the political framework and defines what and why a raw materials are currently considered to be critical (European Commission 2020). The approach assesses various indicators from a European perspective, including economic importance, trade distortions, the import dependencies, recyclability and substitutability.

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Fig. 2 The Rock Gallery example shows the granite monolith and adjoining sculptures in the Vigeland Sculpture Park, Oslo. Numerous unique resources of ornamental stone have given a geological signature to architecture and art of Europe.

Increase the raw materials supply from domestic sources that abide the high ethical, social and ecological standards is one of the recommendations of the European Commission that has been repeatedly expressed.

Europe has a long history in mining going back for centuries. Easy targets are to a large extent already mined out. Modelling of geological enrichment processes and the use of innovative exploration tools to discover unknown raw materials are techniques and methods that build on comparable, high quality and reliable data including geochemical and mineralogical analyses. It calls for a coordinated database, which uses harmonized vocabulary and cross-border validation schemes. A task most of the Geological Survey Organisations (GSO) of Europe already committed to in earlier European projects.

### GeoERA Raw Materials: a joint Programme towards Europe's raw materials intelligence

Europe represents great cultural variety echoed by more than 100 different languages spoken in an area about half the size of Australia. As such, many of the GSO in Europe have developed their own reporting on their national resources. The standards and vocabulary used have grown over time and only some are understood in the same way across national borders. This calls for concerted actions to which more than 50 individual regional and national European Geological Survey Organisations of 30 countries respond with the GeoERA as a joint programme supported by the European Commission. The overarching objective of GeoERA is to contribute to the optimal use and management of the subsurface. Underpinned by fifteen research projects in the four themes GeoEnergy, Groundwater, Information Platform and Raw Materials it supports 1) a more integrated and efficient management and 2) more responsible and publicly accepted, exploitation and use of the subsurface. The GeoERA Raw Materials

comprises four projects ranging from dimension stone (EuroLithos) to seabed (MINDeSEA) and land-based (FRAME) minerals supported by a data management project (Mintell4EU).

The joint programme GeoERA takes advantage of the optimised network of the Regional and National Geological Survey Organisations of the European States, Europe's long tradition in mining and quarrying and on new methods, models and data to unlock domestic resource potential. Based on the respective national databases on sites and commodities, specific issues along with a more general perspective across national borders aim at compiling and unifying the geoscientific knowledge on Europe's resource potential. The scientific projects establish the first stepping-stone to secure reliable and responsible sourcing from domestic sources by

- providing a common and harmonised minerals inventory of known mineral resources and their development status' (Figs. 1 and 2);
- establishing harmonized vocabularies and cross-border validation schemes;
- identifying new sources of supply through critical mineral potential mapping and quantitative mineral assessment on land and in the European seabed, with focus on the CRM needed in the course of the Energy transition (Fig. 3);
- identifying and mapping principal metallogenic areas defining models for different types of mineralisation (Fig. 4);
- developing new methods and technologies to unlock Europe's Raw Materials potential;
- providing test cases on the operability and applicability of the UNFC for Geological Surveys tasks.

### Common digital database

Site-specific detailed data and information required in the context of mining activities are usually a task for the industry. The regional and national Geological Survey Organizations of Europe are the counterpart that provides decision-makers from government and the public with comprehensive and unbiased information. The United Nations Framework Classification of Resources (UNFC) integrated into the United Nations Resource Management System (UNRMS) could prove to be a suitable instrument to communicate complex issues in a simplified manner to the society. The strength of the classification system is to combine scientifically sound information on the level of confidence on geological knowledge in addition to the feasibility of a project as well as social-environmental considerations in a standardized way with ecological and social requirements.

MINTELL4EU is a lighthouse project that compiles knowledge and information on commodities from the data provider's national data sources. Currently 30 data providers from 29 European countries (more to come in 2021) add to the established harvesting routine that collects, validates and stores data in a central database in line with the INSPIRE regulations of the European Commission (European Commission n. d). The common data structure builds on former projects and data are exposed at the EGDI infrastructure. Through EGDI, Europe's Mining Inventory is visualised in different maps, e.g. a map showing historical mine sites with touristic interest will be made accessible via EGDI (Fig. 5). The map includes international important sites as UNESCO Global Geoparks, UNESCO World Heritage sites and much more.

### Where is the benefit?

The cooperation in GeoERA improves mutual understanding in the multilingual community by enhancing a common language and knowledge. Mineral deposits are temporally or spatially connected and do not stop at national borders. Therefore, common charac-



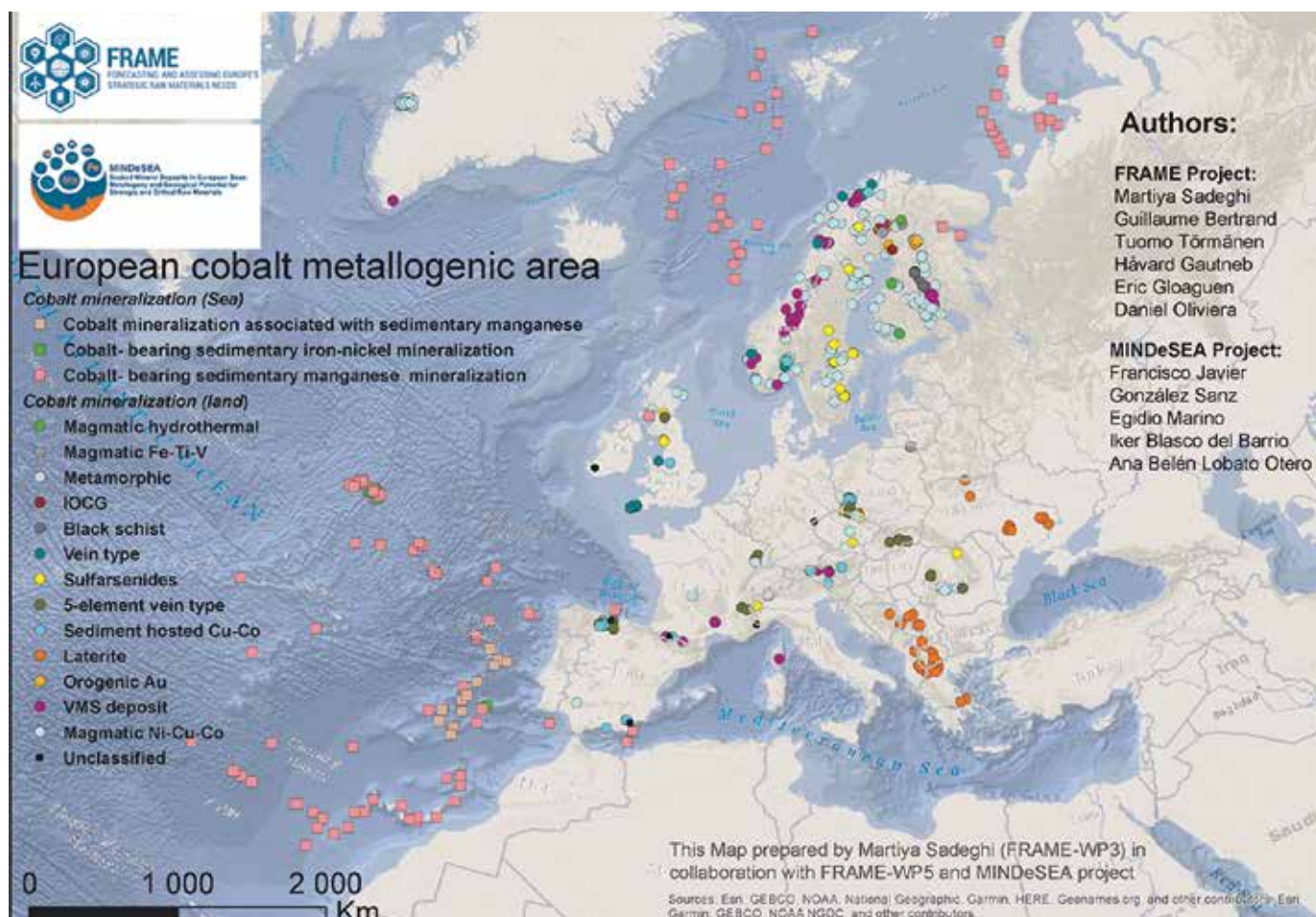


Fig. 3 European cobalt metallogenic areas classified by style of mineralization, status October 2020

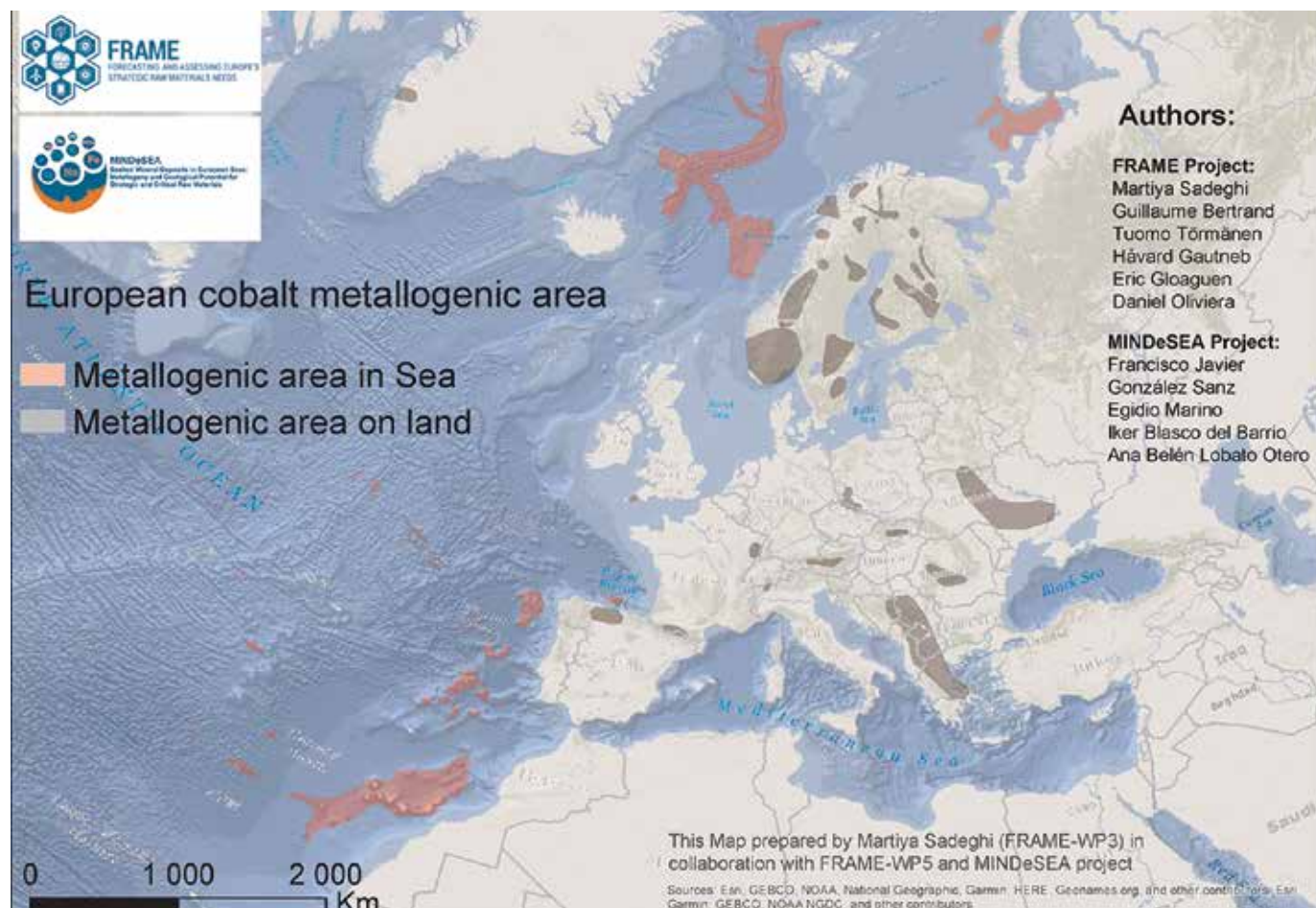


Fig. 4 European cobalt metallogenic principal areas, status October 2020



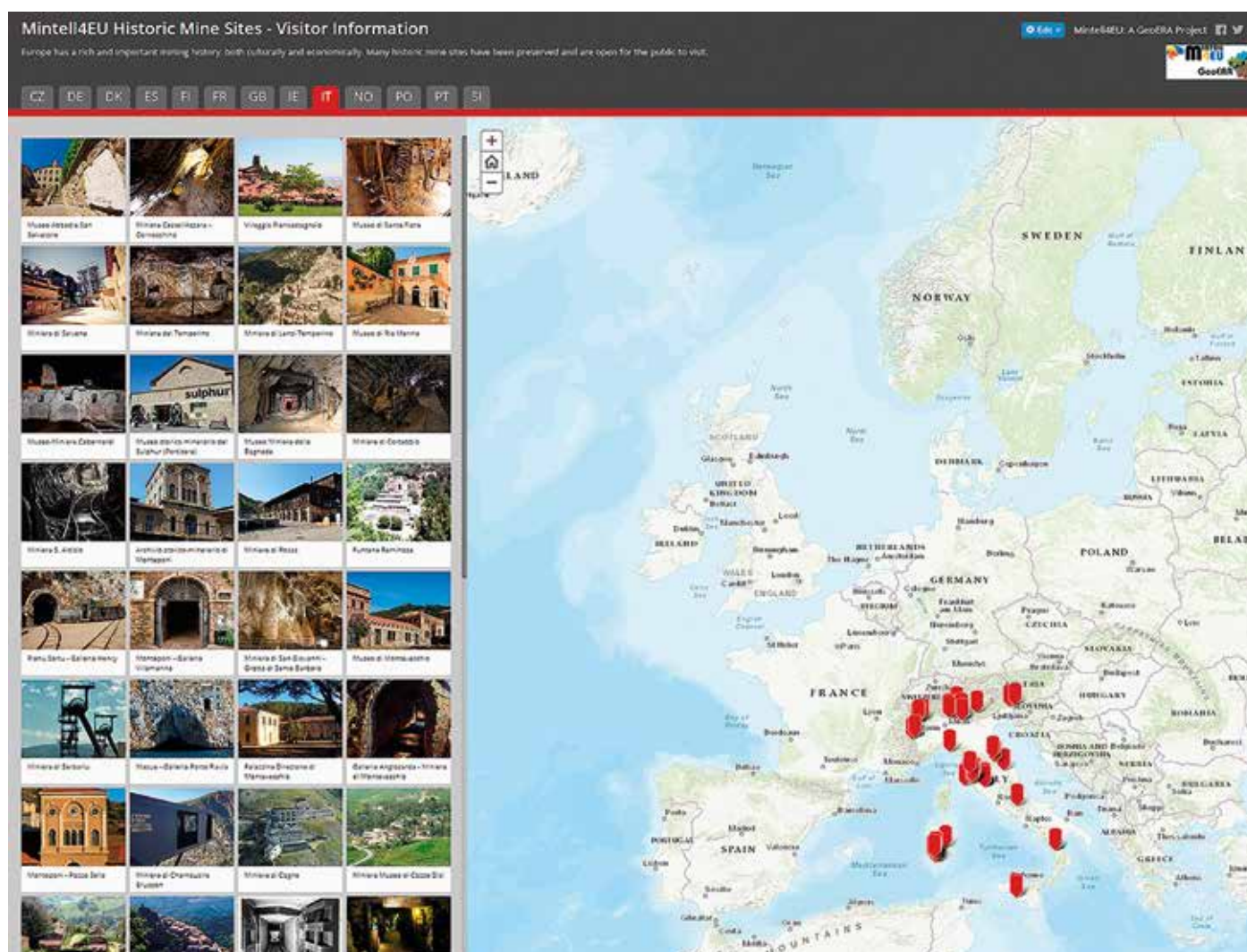


Fig. 5 Historical mining sites minerals inventory includes tourist information for visitors listed by country. The example shows Italy with status October 2020

teristics, signatures and structures across political borders must be considered. This is only possible with a mutual understanding of the output and a common set of reliable and validated data. GeoERA Raw Materials builds on existing data sets, adds to these and mutually improves quality and reliability. With the GeoERA Raw Materials scientific projects, the community promotes a collective understanding of science about critical minerals in relation to their environment, their European distribution and the likelihood of discovering unknown potentials through the exchange of data, knowledge, information and creating solid networks of expertise. By recognizing knowledge gaps and using individual strengths to improve working relationships and exchange specialist knowledge, further improvements are approached and considered to be continued in later collaboration. With GeoERA, the community of Geological Survey Organisations of Europe provides neutral and unbiased information to the public.

### GeoERA – a joint programme of the Geological Surveys in Europe

Europe is a continent of 51 sovereign states of which 27 are part of the European Union. GeoERA is a joint programme of more than 50 individual Survey Organisations of 30 countries. The GeoERA covers the applied geosciences, addressing the following themes: Raw Materials, GeoEnergy, Groundwater and Information Platform.

The importance of raw materials to our society today and to become carbon-neutral by 2050 are underlined by terms like Critical Raw Materials, Energy Critical Elements, Battery Minerals, Strategic Raw Materials.

GeoERA Raw Materials provides unbiased and science-based knowledge and information to the public. GeoERA Raw Materials focuses on strategic and critical raw materials in Europe on land (FRAME) and in the seabed of Europe's territories (MINDeSEA). With information on the raw material occurrence (known and potential) GeoERA Raw Materials provides a common raw materials inventory (MINTELL4EU), improved vocabulary and codes also on dimension stones (EuroLITHOS). GeoERA Raw Materials is a step forward to publicly available reliable pan-European database based on scientific knowledge and information through The European Geological Data Infrastructure of the EuroGeoSurveys (EGDI) as the hosting data infrastructure.

For more information visit <https://geoera.eu> and specific homepages of the scientific projects FRAME ([www.frame.lneg.pt](http://www.frame.lneg.pt)), MINDeSEA (<https://geoeramindesea.wixsite.com/mindesea>) and EuroLithos (<https://www.eurolithos.org>).

### Acknowledgements

The authors like to thank the entire GeoERA Raw Materials Team from more than 30 individual Geological Survey Organizations. GeoERA has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166.

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European Commission (2020) Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. Publications Office of the European Union, COM(2020) 474 final.

European Commission (n. d) INSPIRE Knowledge Base. Retrieved 18.11.2020, from <https://inspire.ec.europa.eu/inspire-legislation/26>

## Disclaimer

The information given here is given to the best of our knowledge and belief in accordance with the current project status. The data will continue to be checked and supplemented. They are therefore neither to be regarded as complete nor as conclusive.

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# News of the Society

Jan Pašava<sup>1</sup> (SGA Executive Secretary)

*<sup>1</sup> Czech Geological Survey, Geologická 6, 152 00 Praha 5, Czech Republic, [jan.pasava@geology.cz](mailto:jan.pasava@geology.cz)*

Due to the COVID-19 pandemic, the e-Council Meeting was organized on October 22, 2020 from 12,00 to 14,30 CET via Zoom. After welcome by D. Huston (SGA President), the Agenda was handled by J. Pašava (SGA Executive Secretary). Council members received all reports in advance and only items that needed council vote were discussed. At the end of the e-meeting all submitted reports were approved with great thanks.

## Roll Call and Apologies

**Present:** G. Beaudoin (for part of the meeting), G. Bozkaya, T. Christie (Chair LOC SGA 2021), H. Frimmel, D. Huston (SGA President), C. McCuaig, P. Garofalo, G. Graham, D. Holwell, P. Mercier-Langevin, E. Naumov, J. Kolb, S. Mikulski, J. Pašava, S. Petersen, R. Skirrow, J. Slack, G. Tourigny (for part of the meeting) and A. Vymazalová.

**Apology:** D. Banks, S. Bouhlef, C. Conde, S. Decree, E. Ferrari, A. Idrus, B. Lehmann, B. Orberger, I. Pitcairn, N. Saintilan, Y. Song, X. Sun.

1. Summary of previous e-Council Meeting (March 30, 2020) – J. Pašava

Council decision not needed

2. Reports of officers on Council:

2.1 Report from President (D. HUSTON)

Council decision not needed

2.2 Report from Executive Secretary (J. Pašava)

Council decision not needed

2.3 Report from Treasurer (H. FRIMMEL)

Council decision not needed

2.4 Report from Promotion Manager (S. DECREÉE)

Council decision needed on selection newly proposed promotional items and quantity

Neon Safety Jacket : >1.74€

Camera cover for laptop : >0.10€

Magnet: >0.09€

Neon armband: >0.23€

Armband (for the Biennial meeting?): >0.11€

Tag for luggage: >0.43€

**Action:** After discussion, the council approved the presented reports with great thanks and the following motions:

D. HUSTON to send a letter to Newmont Company, asking for continued support for the production of new SGA-Newmont Gold medals.

H. FRIMMEL to contact the Zürich Insurance Company regarding SGA 2020 insurance payment.

S. DECREÉE to negotiate best deals for the purchase of newly proposed promotional items except of masks with producing companies (quantities in range from 500 to 1000 pcs, depending on best offer).

J. PAŠAVA to contact IUGS Secretary General to find out how to manage IUGS financial contribution towards African Metallogeny Course.

2.5. Report from Chief Editor, SGA News (J. KOLB)

Council decision needed on widening the editorial team (one or two associate editors for the student chapter submissions and a paid student for importing into the Adobe InDesign program). Present Chief Editor would do the final editing in the program.

**Action:** After discussion, the council approved widening the editorial team and asked J. KOLB to look for suitable persons to help with technical editing with a remuneration of up to 500 Euro per year (to be arranged through H. FRIMMEL as SGA Treasurer).

2.6 Report from Chief Editors, MD (B. LEHMANN)

Council decision not needed

2.7 Report from Chief Editor SGA Special Publications

(J. SLACK)

Council decision not needed

2.8 Report from the Chief Editor SGA website (I. PITCAIRN)

Council decision needed on prioritization of the following website development projects:

- Setting up a storage place for SGA documents at SGA website for Council members (access via password).
- Update the SGA membership application on-line forms to enable members to donate to SGA EF.
- Adapt SGA website for e-submission of contributions to SGA News.

**Action:** After discussion, the council recommended to ask Iain Pitcairn to update the SGA membership application on-line forms in collaboration with Blueways to enable members to donate to SGA EF.

2.9 SGA Educational Fund (D. BANKS)

2.10 to 2.16 Reports from Regional Vice Presidents (Asia, Australia/Oceania, Europe, North Africa and Middle East, Sub-Saharan Africa, North America, South America)



## 3. SGA 2021 – update (T. CHRISTIE)

Council decision needed on the following items:

Contingency plans are being developed for various COVID-19 scenarios, impacting international travel. In addition to the November 2021 dates, the conference venue has also been ‘pencil’ booked for March and November 2022 should postponement be required.

The LOC would appreciate some guidance on the SGA Council’s preference if international travel is likely to be significantly restricted in late 2021?

- Postponement to March or November 2022;
- Run a hybrid in-person and virtual meeting;
- Run a fully virtual meeting; and
- Other options suggested by SGA Council.

Some virtual options are described in an accompanying document “SGA 2021 hybrid and virtual conference options”.

Postponement by 4 months to March 2022 is probably acceptable, but postponement by 1 year to November 2022 would result in only a 9-month gap before the 17<sup>th</sup> SGA Biennial Meeting in August 2023, unless it was also shifted by 1 year, i.e. SGA would change to having their annual meetings on even years (2022, 2024, 2026, etc). Please let us know your preferences.

Ideally, the LOC would like to make a decision on the conference format by March 2021.

**Action:** After intensive discussion with the chair of the LOC, it was agreed that the postponement of the 16th SGA Biennial Meeting to March 2022 would be acceptable and that this will be finally decided in July 2021. If March 2022 would become a new date for the meeting, Council will decide on the mode (in person/hybrid/fully virtual meeting) in early January 2022 at the latest.

## 4. SGA 2023 – update (N. SAINTILAN)

Council decision not needed

At the moment two possibilities: (1) keeping the SGA meeting between August 20-25, 2023 or (2) moving the SGA meeting to the first week of September 2023

**Action:** P. GAROFALO recommended sticking with the originally proposed dates in August because Italian Universities start term already in September.

## 5. Progress report on membership drive from the last SG Council Meeting (S. DECRÉE et al.)

Council decision not needed

## 6. Status of development of SGA Student and Young Scientist network (A. VYMAZALOVÁ)

Council decision needed on request for EUR 300 from La Salle SGA-SEG Chapter (established only this year without asking for seed money) to support a field trip.

**Action:** After introduction by A. VYMAZALOVÁ, the council discussed and approved requested financial support (EUR 300) for La Salle Chapter. A. VYMAZALOVÁ will inform the president of the chapter about the council decision.

## 7. Requests for sponsorship

- Ore deposits hub (e-initiative) – T. BELGRANO et al. – SGA sponsorship approved - EUR 963
- Second Annual Meeting of the SGA Peru Student Chapter (November 20 and 21, 2020) – requested USD 1,150 – SGA sponsorship not approved but proponents encouraged to incorporate council comments provided by E. FERRARI (RVP South America) and submit a new proposal.

## 8. Any other business

Council decisions not needed

- SGA future activities with respect to COVID-19 (D. HUSTON et al.)
- SGA new initiatives – update on SGA Sub-committee on New Initiatives (D. BANKS et al.)
- The 7<sup>th</sup> Short Course on African Metallogeny – Namibia – postponed to late 2021 - update (B. ORBERGER)
- Virtual seminar on “Green metals” (proposed by SGA and IUGS in collaboration with the University of Namibia, the Geological Survey of Namibia and the Namibian Uranium Association).
- SGA Mobility Grant – status of implementation (T. AIGLSPERGER)

Extended abstracts from future SGA Biennial Meetings (request for shortening to X00 words)

**Action:** After introduction by J. PAŠAVA and H. FRIMMEL, which was followed by council discussion, it was agreed to keep extent of abstracts submitted to SGA Biennial Meetings up to 4 pages (the precise number of pages is up to the authors – SGA recommends to stick with 4 pages).

Council also approved that published e-Books of extended abstracts from future SGA Biennial Meetings will be freely accessible for SGA membership for the period of 1 year and then will become open access.

## 9. Date and place of the next SGA Council meeting (spring 2021, Warsaw or e-Meeting – to be decided).

## 10. Informative list of past activities

- 38<sup>th</sup> IGC (March 2-8, 2020 New Delhi, India) – SGA sponsors the Theme 28: “Ore Forming Processes and Systems” – J. Pašava/A. Vymazalová - SGA link – postponed to August 2021
- Short Course “From Concept to Oil - The E&P Lifecycle” (May 2020, Würzburg) – H. Frimmel – SGA in-kind sponsorship approved by SGA Council - postponed
- III. Symposium on Precambrian geology and metallogeny (May 25 to 29, 2020 in San Ignacio de Velasco, Bolivia) – USD 2,500 approved by SGA Council to support SGA keynote speakers - postponed
- QUARTZ2020 International Symposium (June 7-12, 2020 Tonsberg, Norway) – SGA sponsored – a budget of up to 1,000 EUR approved by SGA Council for SGA student membership support - postponed
- Inaugural SGA Field Conference Mount Isa and Cloncurry, Queensland (20-24 July 2020) – D. Huston and. V. Lisitsin – postponed
- SEG 2020 (September 12-19, 2020 - Whistler, Canada) – postponed

## 11. Informative list of future activities

- 16<sup>th</sup> SGA Biennial Meeting (November 14-18, 2021 Rotorua, New Zealand) – T. Christie et al.

# PRESIDENT'S CORNER

Like many other scientific and other societies, SGA continues to contend with problems generated by the COVID pandemic. This has been the main concern of Council over the past year and will continue to be a major concern over the next few years, even if vaccines currently being developed in many countries across the world provide protection against the virus. A post-COVID world will have some important differences, possibly one of the important being changes in our travel patterns. At present Council and the Local Committee for the 16<sup>th</sup> Biennial SGA Meeting in New Zealand are considering these effects and making contingency plans. Other workshops and meetings, including the 7th Short Course on Africa Metallogeny and the inaugural SGA field workshop in Mount Isa, Australia, have been delayed pending resolution of COVID. We will keep you informed, as the timing of these meetings is resolved.

To support the pending 7<sup>th</sup> Short Course on African Metallogeny, Beate Orberger and Ismahen Chaouche, with assistance from many others, organised the SGA Virtual Green Metals Seminar, which involved virtual student presentations from across Africa and some European countries. University students networked and formed groups of two or three and then chose a topic from a list provided by the organizers to present talks on the opportunities and challenges of green metals to Africa and the world in general. The seminar series was completed in November, with many high quality presentations. The Council and I thank Beate, her co-organisers and, most importantly, the students for their efforts in this highly successful initiative.

Following the theme of green metals, this issue of SGA Newsletter includes two separate articles on the importance of green and other critical minerals to the economies of developed countries. The first, from European Geological Surveys, presents four unified European projects to address the challenges of making Europe climate neutral by 2050 as part of the GeoERA raw material program. The second, on behalf of geological surveys from the United States, Canada and Australia introduces the Critical Minerals Mapping Initiative, a joint program to ensure the supply of critical minerals to the world's economy. GeoEra and CMMI have similar goals, although, in detail, the programs differ. As the world economy changes, such international collaborations will become more and more important. We will continue to keep our members informed of these and other developments that change the role of resource geologists into the future.

David Huston  
President

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Vice-President (Student Affairs)  
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South America	E. Ferrari (Peru)

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T. Aiglsperger (Sweden)
G. Bozkaya (Turkey)
R. E. de Barrio (Argentina)
T. Christie (New Zealand)

### Councillors through December 31, 2023

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P. Ledru (France/Canada)
C. McCuaig (Australia)
E. Naumov (Russia)
B. Orberger (France)
N. Saintilan (Switzerland)

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President	Sean Mc Clenaghan (Ireland)
Secretary General	J. Xian (China)



# SGA – Green Metal Virtual Seminar 2020: Green Metals for a Sustainable Society

Eudes Sati Tegan<sup>1</sup>, and Faye Malick<sup>2</sup>

*1 Institut National Polytechnique, Yamoussoukro, Côte d'Ivoire*

*2 Cheikh anta Diop Université of Dakar, Sénégal*

Held from 3 to 6 November 2020, the SGA virtual seminar entitled: Green Minerals for a Sustainable Society was attended by students from eight countries including seven from Africa (Namibia, Algeria, Senegal, Cameroon, Nigeria and Côte d'Ivoire) and 1 from the Middle East (Iran).

In collaboration with the organizing committee, we set up effective communication networks (what's app) to share information and help participants setting up working groups. In addition to this, some tasks such as the realization of the trombinoscope of the seminar have been appreciated and validated by the committee.

This virtual seminar was a great success, which allowed an international collaboration between the participants, demonstrated

once again the interdisciplinarity of science in one major topic and, above all, rising enthusiasm among all colleagues and country managers.

This was made possible thanks to the dynamism, professionalism and leadership of the organizing committee in particular Mrs. BEATE ORBERGER and Mrs. ISMAHANE CHAUCHE. They have been the pillars of this seminar, from whom we, the section representatives should be inspired to enlarge the SGA community through the establishment of a vast network of student chapters already identified during the seminar.





## SGA – Green Metal Virtual Seminar 2020: preparation to the 7<sup>th</sup> Short course on African Metallogeny: Energy Metals for a Sustainable Society

Beate Orberger and Ismahene Chaouche

1 GEOPS Université Paris Saclay, Bât 504, 91405 Orsay, Cedex; beate.orberger@universite-paris-saclay.fr

2 Geology departement, FSTGAT, University of Sciences and Technology, Houari Boumediene (USTHB), Algeria, chasane@gmail.com

According to the global sanitary situation and the uncertainty of the evolution of the corona virus infections and related travel restrictions, the 7<sup>th</sup> short course on African Metallogeny was postponed to the 4<sup>th</sup> quarter of 2021 on the same topic in Windhoek, Namibia. Many students registered and 12 students from outside Namibia obtained scholarships from UNESCO, after an evaluation process, to travel next year to Namibia. SGA-IUGS in cooperation with the University of Namibia, the Geological Survey of Namibia and the Namibian Uranium Association, and the student chapters of Senegal and Ivory Coast, proposed, for the registered MSc and PhD students, a seminar on the topic “Green metals” in preparation to the short course in 2021. The objective of this seminar was to work in international groups (cross-country) on a topic concerning ‘Green Metals’. The topics were proposed by the organizing committee.

The tasks were:

1. Preparing a common power point presentation (members of the organizing committee will interact and guide);
2. 30 min. presentation of the topic and the outcomes by skype/zoom/teams for all including the organizing committee, followed by 20 min. discussion;
3. Writing a ½ page abstract in English.

The committee will deliver a SGA certificate after evaluation.

Many students met at the short course held in Ivory Coast in

November 2019 thanks to UNESCO scholarships. This networking was now extended and collaboration will improve in the future. Seventeen MSc and PhD students from 9 countries (Senegal, Ivory Coast, Ghana, Namibia, Cameroon, Iran, Ireland, Nigeria and Algeria) registered to participate in this seminar. They formed quickly groups of three and selected a topic. The UNESCO scholarships provided in 2019 to students from outside Ivory Coast (short course place) was a great help to create this international student network.

The introduction, a ZOOM meeting, was held on Thursday 1<sup>st</sup> October. Zoom meetings were also held with the individual groups to advise and guide through the work. Presentations and abstract need to be sent until 30th October. Public presentations were held in the first two weeks of October. A common WhatsApp group was established to easily exchange information and photos. The first advisory meeting was held with “BAUXITE” group the 24<sup>th</sup> October (Fig. 1).

Advisers:

Beate Orberger (Associate Professor, Université Paris Saclay, France);

Ismahene Chaouche (Associate Professor, University of Alger, Algeria)

Mary Barton (Associate Professor, University of Namibia, Namibia)



# REPORTS FROM THE SGA STUDENT CHAPTERS

SGA chapter	President	E-mail	Website/Facebook/Twitter	Chapter e-mail	Foundation
<b>Prague</b>	Štěpán Jaroměřský	jaromers@natur.cuni.cz	<a href="http://sga.cuni.cz/">http://sga.cuni.cz/</a> <a href="http://www.facebook.com/SGA-Student-Chapter-Prague-155355499351/">www.facebook.com/SGA-Student-Chapter-Prague-155355499351/</a>	chapter_prague-user-group@natur.cuni.cz	2002
<b>Baltic</b>	Krzysztof Foltyn	krzyfoltyn@gmail.com	<a href="http://www.sga.agh.edu.pl/">www.sga.agh.edu.pl/</a> <a href="http://www.facebook.com/groups/balticsga/">www.facebook.com/groups/balticsga/</a>		2009
<b>Siberia</b>	Anna Devyatiyarova	anna13502@gmail.com	<a href="http://www.sib-sga.com">www.sib-sga.com</a> <a href="http://www.facebook.com/groups/184671754223118">www.facebook.com/groups/184671754223118</a>	SiberianChapter@yandex.ru	2011
<b>Barcelona</b>	Malena Cazorla	malecama.97@gmail.com	<a href="http://www.bcn-sga-seg.cat/index.php">www.bcn-sga-seg.cat/index.php</a> <a href="http://www.facebook.com/Bcn-SGA-SEG-Student-Chapter-520047141415889/">www.facebook.com/Bcn-SGA-SEG-Student-Chapter-520047141415889/</a>	student.chapter.ub.sga@gmail.com	2012
<b>Colombia-Bucaramanga</b>	Juan Pablo Jaimes Bermudez	juanjaimesb21@gmail.com	<a href="http://www.facebook.com/capitulosgaus/">www.facebook.com/capitulosgaus/</a>	sga.uis.bucaramanga@gmail.com	2012
<b>Nancy</b>	Alix Hauteville	alix.hauteville@etu.univ-lorraine.fr	<a href="http://sganancy.wordpress.com">sganancy.wordpress.com</a> <a href="http://www.facebook.com/groups/449029751879224">www.facebook.com/groups/449029751879224</a>	sga.nancy@gmail.com	2013
<b>Peru</b>	Silvana Janeth Stipetich Santillán	stipetich.s@pucp.pe	<a href="http://www.facebook.com/SGAPeruStudentChapter/">www.facebook.com/SGAPeruStudentChapter/</a>	sgastudentchapter.peru@gmail.com	2013
<b>Colombia-Bogota</b>	Daniel Felipe Solano Gil	dfsolanog@unal.edu.co	<a href="http://www.sgabogota.org/">www.sgabogota.org/</a> <a href="http://www.facebook.com/capitulosgaus">www.facebook.com/capitulosgaus</a>	sga.unalbogota@gmail.com	2015
<b>Morocco</b>	Said Ilmen	said.ilmen@edu.uca.ma	<a href="http://www.facebook.com/SGA-Moroccan-Student-Chapter-1561030220797534">www.facebook.com/SGA-Moroccan-Student-Chapter-1561030220797534</a>	sgachapter.marrakech@gmail.com	2015
<b>Laval</b>	Emile Boily-Auclair	Emile.boily-auclair@ete-inrs.ca	<a href="http://segulaval.ca">http://segulaval.ca</a>		2016
<b>North-West Russia</b>	Evgenyi Eremenko	st013196@student.spbu.ru	<a href="https://nw-sga.com">https://nw-sga.com</a> <a href="http://www.facebook.com/groups/NWRussian.Student.SGA">www.facebook.com/groups/NWRussian.Student.SGA</a>		2017
<b>Turkey</b>	Fatih Ozbas	fatih.ozbas@istanbul.edu.tr	<a href="http://www.pau.edu.tr/sgatrstudent">www.pau.edu.tr/sgatrstudent</a> <a href="http://www.facebook.com/groups/1312678395490904">www.facebook.com/groups/1312678395490904</a>	sga.turkey@gmail.com	2017
<b>Black Forest-Alpine</b>	Alannah Brett	alannah.brett@geo.unibe.ch	<a href="http://bfa2sga.wordpress.com">bfa2sga.wordpress.com</a> <a href="http://www.facebook.com/groups/849362358568835">www.facebook.com/groups/849362358568835</a>		2017
<b>Brazil</b>	Julia de Souza Pimenta	juliaspim@gmail.com	<a href="http://fdeabreu4.wixsite.com/website-1">fdeabreu4.wixsite.com/website-1</a>		2018



SGA chapter	President	E-mail	Website/Facebook/Twitter	Chapter e-mail	Foundation
<b>United Kingdom</b>	Jo Miles	amyles86@bgs.ac.uk	twitter.com/uk_sga		2018
<b>Ivory Coast</b>	Sahy Anthelme Veh	vehsahy@gmail.com	www.facebook.com/sga.civ		2019
<b>Moscow</b>	Maria Komarova	ivanchenko.marija@gmail.com	www.facebook.com/student chapter moscow		2019
<b>Urals</b>	Daria Kiselova	podarenka@mail.ru	https://sga-ural.com/		2019
<b>Colombia-Areandina</b>	Juan Carlos Vargas	jvargas71@estudiantes.areandina.edu.co	www.facebook.com/CapituloSGA.Valledupar		2019
<b>La Plata</b>	Diego Sebastian Palma	diegopalma90@yahoo.com			2020
<b>La Salle</b>	Théo Hénaut	Theo.HENAUT@etu.unisalle.fr	www.facebook.com/lasallefrancestudentchapter		2020
<b>Senegal</b>	Malick Faye	fayepapmalick@gmail.com			2020



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# Moldavites of South Bohemia

Štěpán Jaroměřský<sup>1</sup>; Karolína Fízková<sup>1</sup>; Jan Šulc<sup>1</sup>; Štěpán Dvořák<sup>1</sup>; Marek Tuhý<sup>1</sup>

<sup>1</sup> Faculty of Science, Charles University, 128 43 Praha 2, Czech Republic

\*Corresponding author: E-mail address: jaromers@natur.cuni.cz



Fig. 1 Lecture; Photo by Štěpán Jaroměřský

Despite the restrictions caused by the pandemic, an excursion to South Bohemia was realized on July 30 with 15 chapter members. The field trip was led by the local expert Dr. Miloš Faltus (Fig. 1), and the main aim was to focus on moldavite, a world-class Czech tectite. We visited the open-pit (Fig. 2), which is located between the villages Chlum and Ločnice of the Bohemia region. Sand is the major product, moldavite is byproduct of the local production (Fig. 3). This is the only mine in the Czech Republic that has permission to officially produce and sell this outstanding stone. The sand pit, which we visited as a part of our excursion, belongs geologically to the South Bohemian basin, where sedimentation had begun during the Cretaceous and continued until the Tertiary. The basin is composed primarily of fluvial and lake sediments. In the open-pit, we got the opportunity to find moldavite in the Domanín formation (Fig. 4), in the Korosec series, in sand to gravel with clay intercalation.

Moldavite was discovered by Dr. Josef Mayer from Charles University in Prague in 1787. He believed them to be a form of volcanic glass and named them after the Moldau (Vltava) river, where the first occurrences were described. In general, moldavite is vitreous, usually not exceeding several centimetres and has a weight of several grams. Even though tectites can be found all over the world, the Czech moldavites from South

Bohemia, unlike others, are transparent with a light or dark green colour. Their hardness varies between 6 and 7 on the Mohs scale. Moravian moldavites tend to have brown colours. However, bicoloured moldavites, probably caused by the combination of two distinct melts, were rarely discovered.

According to the current state of knowledge, moldavites are considered to be formed by a meteorite impact ca. 14.5 million years ago in the Ries crater between Nuremberg, Stuttgart and Munich. The Ries crater is 24 km in diameter, and nowadays the city of Nördlingen lies in its centre. Due to the meteorite impact at a speed of approximately 20 km/s and an impact angle of 30-50°, a huge amount of energy was transferred during the collision with the surface. The collision resulted in crushing, melting and evaporation of surrounding rocks. Moreover, there was a cloud containing gaseous, liquid and solid particles transported to the East (approx. 240-450 km away from the crater). After the initial high temperature and pressure conditions, the molten silicate solidified so quickly that the individual mineral components did not fully crystallize but formed silicate glass, which was deposited in southern Bohemia/Moravia. It has been estimated that the total weight of all fallen moldavites might be at around 3000 tons.

Macroscopically, there is a variety of shapes and textures in moldavite, such as sticks, droplets and rarely heart or “hedge-

hog” shapes (Fig. 5). One of the unique properties of Czech moldavites is their texture, which is quite heterogeneous, caused by long exposure to weak acids after the deposition. These processes resulted in a certain wrinkling of the surface, which is therefore quite valued. Moldavites may also contain several types of inclusions, including gas bubbles. Because the moldavite is chemically very close to glass, it is sometimes difficult to distinguish cut moldavite from cut green glass.

Moldavites are valuable minerals and they have often been illegally mined, which caused environmental problems. In most cases, illegal miners dig up to a few meters deep pits (Fig. 6) to reach the moldavite-bearing layers and therefore, soil, tree roots and the overall landscape are destroyed. Even though there is a high risk of fining, illegal mining still occurs in South Bohemia.

The whole excursion was a great success, and we would like to thank the owner of the open pit Ing. Viktor Weiss, who allowed us to enter an area that is normally inaccessible. We would also like to thank Dr. Miloš Faltus who gave us a lecture and last but not least, thank the SGA for their long-standing support and favour.

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Fig. 2 The open pit; Photo by Jan Šulc



Fig. 3 Active treatment plant; Photo by Jan Šulc



Fig. 4 Currently found moldavite; Photo by Jan Šulc

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Figure 5: Rare “hedgehog” moldavite; Photo by Jakub Malý



Fig. 6 Consequences of illegal mining; Photo by Jan Šulc

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# Field trip to Ural Mountains, September 12–20<sup>th</sup> 2019

Borisova E.<sup>1,2\*</sup>, Shpakovich L.<sup>2</sup>, Kalashnikova S.<sup>1</sup>, Yakubovich O.<sup>1,2</sup>

<sup>1</sup> Saint-Petersburg State University, Universitetskaya emb., 7/9, 199034, Saint Petersburg

<sup>2</sup> Institute of Precambrian Geology and Geochronology RAS, Makarova emb., 2, 199034, Saint Petersburg

\*Corresponding author: jenyaborisova98@gmail.com



Fig. 1 View from the Serebryanskiy Stone Mountain.



Fig. 2 Students examine ore-bearing rocks.



Fig. 3 SGA members against the Vorontsovskiy quarry.

The North-West Russian Student Chapter organized a field trip to Middle Urals to be acquainted with geology of noble metals ore deposits. Most of these deposits are platinum bearing and located along the Main Ural Overthrust, forming the Ural platinum belt. Students from the Baltic and Australian chapters joined us, so the group consisted of 18 people. During the field trip, we observed different types of mineralization (predominantly, platinum and gold) in mafic and ultramafic rocks. In addition, we had a great opportunity to explore placers on the first stages of their formation. We visited eight deposits and two museums. At the end of the trip, we took part in XXV All-Russian Scientific Youth Conference with international participation "Ural Mineralogy School - 2019" in Yekaterinburg.

September 12<sup>th</sup>, we started our field trip with an excursion to the Serebryanskiy Stone, which is a mountain located 50 km from Karpinsk (Fig. 1). The Serebryanskiy Stone massif is a part of the Kytlym pluton and consists of gabbro, anorthosite and gabbro-pegmatite dykes. The Ural platinum belt is characterized by titanomagnetite and copper-sulfide-titanomagnetite mineralization and Au-Pt-Pd ores (Fig. 2). Noble metals are coupled with sulfide mineralization

there. Our aim was to reach the old mines and find representative ore samples in the outcrops.

September 13<sup>th</sup>, we visited the Vorontsovskoye gold deposit located in the Tagil zone of the Northern Urals and is developed by Polymetal Company. This deposit is hosted by porphyrite and tuff of andesite composition, tuffite and limestone of early Devonian age, which were altered into skarn under the influence of nearby gabbro-diorite-granodiorite of the Auerbakh massif. Ore bodies are mineralized breccia of limestone subjected to the process of skarn-formation, sericite-silicification, jasperoidization and other alterations. In the carbonate breccia, gold-realgars-stibnite (+ Ti-bearing minerals) mineralization was observed, due to which the Vorontsovskoye deposit is classified as Carlin style. The visitors were allowed to select representative samples of ores and host rocks from the quarry. Also during the excursion, we were introduced to mining



Fig. 4 SGA members examine ore.

operations at the quarry and noted the modern equipment of the enterprise (Fig. 3).

In the evening, we visited the Fedorovsky Geological Museum founded in Turinsky mines (now the Krasnoturinsk town) in 1894 by the famous crystallographer and geologist E. Fedorov. We observed the original items of his office, which were saved in museum halls as well as the collection of the Ural gems and rare minerals.

September 14<sup>th</sup>, we visited the Iovskoye dunite-clinopyroxenite body located high in the Northern Ural Mountains. The massif is





Fig. 5 Students on their way to see the placer formation.



Fig. 6 SGA members washed placer to mine platinum.

well exposed, and we were able to observe relationships between different types of rocks, specifically dunite, clinopyroxenite and chromites (Fig. 4). Also during the route along the streams of the first and second orders descending into the valley, we had a great opportunity to observe the first stages of placer formation (Fig. 5).

September 15<sup>th</sup>, we observed objects of geological interest on the river Kamenyushka. Firstly, we saw a karst failure served as a natural enrichment facility for Quaternary platinum placer formation. Then, we had an opportunity to observe a dredge on the river Kamenyushka, still working since 1937. At the end of a day, we visited another platinum placer, where 300 tons of rare metal were developed (Fig. 6). This deposit was formed as a weathering crust of a dunite-clinopyroxenite body, as the one we have seen on the slopes of the Iovskoye dunite-clinopyroxenite body the day before.

September 16<sup>th</sup>, we had an excursion to the Volkovskoye deposit, located near the Nizhniy Tagil city in the Middle Urals. This deposit is a complex of different rocks from ultrabasite to syenite and quartz-diorite. The most common rocks are gabbros containing copper-sulfide ores with gold and PGE mineralization in the upper part of the massif. Copper mineralization is represented by chalcopyrite-bornite-titanomagnetite ores with dispersed native gold. PGE are found in tellurides of palladium (merenskyite, kotulskite and keithconnite) in the form of small inclusions (0.001-0.025 mm) in sulfides (bornite, chalcopyrite), titanomagnetite and clinopyroxene.

September 17<sup>th</sup>, we observed the Vysokogorskoye Fe-skarn deposit, which is

located in the Nizhniy Tagil area. The deposit is confined to the contact zone of syenite and limestone. It is assumed that this deposit was a part of a large copper-porphyry system. There are two types of ore-bearing skarns separated by the main effusive formation. Thick layers of magnetite and titanomagnetite ores represent the ore. They contain vanadium and tungsten, which are used to increase the strength of the steel alloy, and no harmful impurities, such as phosphorus. Therefore, the iron ore mined here was of great quality and was used to make military equipment. The deposit was mined from 17<sup>th</sup> century and now it is fully developed.

The old Mednorudnyanskiy deposit was developed for mining malachite, azurite and later iron ore. This deposit is a weathering crust with karst. The origin of malachite were copper- and iron-bearing sulphate rocks associated with limestone.

September 18<sup>th</sup>, we visited the famous Berezovskoye gold deposit discovered in 1745. The discovery marked the beginning of gold exploration in Russia. The ore field is part of the Ural-Tobolsk anticlinorium, which is represented by volcano-sedimentary rocks, intruded by the Sharshatskiy granite body. The contact of these rocks is highly metasomatized. During our visit to the "Northern" mine, we observed metasomatized granite rocks at a depth of 600 m. We had a great opportunity to see an old



Fig. 7 SGA members at the entrance of the Berezovskoye mine.

type of ore exploration there (Fig. 7). After returning to the surface, we visited the chief geologist's office with a small museum of all rocks that can be found in deposit.

September 19-20<sup>th</sup>, in the last days of the trip, we took part in the Ural mineralogical conference in Yekaterinburg, where we met students from other SGA chapters. Most of our participants made reports on their scientific achievements and had a great time communicating with geologists from different cities of Russia.

### Acknowledgments:

Members of North-West Russian, Australian and Baltic student chapters are grateful to the general director of ore deposit Nablulin F.M. and manager Tretyakov A.V. for the opportunity to visit the Vorontsovskoye quarry. Stepanov S.Y., Palamarchuk R.S., Mihailov V.V. and Pavlova M.A. are also thanked for leading the excursions.

# SGA Student Chapter UniLaSalle – Field trip in Alsace, France, October 2020

Léon Foucault, Alexandre Le Boulch

UniLaSalle engineering school, 19 rue Pierre Waguet, BP 30313, 60026 Beauvais, France  
 leon.foucault@etu.unilasalle.fr, alexandre.leboulch@etu.unilasalle.fr



Fig. 1 Chapter members inside the underground laboratory of the CIGEO project.

The SGA Student Chapter of UniLaSalle Beauvais organized this year a field trip in France due to COVID-19, from the 9<sup>th</sup> to the 11<sup>th</sup> of October 2020. The main objective was to discover the mining history of Alsace. It includes historic silver mines of Sainte-Marie-aux-Mines and former potash mines near Mulhouse. On our way, we made a stop on Friday to visit the CIGEO project. It is an underground laboratory made to study the feasibility of storing radioactive waste in depth. The second day was dedicated to the visit of two old mines at Saint-Marie-aux-mines. The first one was organized with the Tellure mining centre and the afternoon the Gabe Gottes mine with the ASEPAM association. Then, we were able to see the granite quarry of Saint-Pierre-Bois. The last day of the field trip was centred on the potash industry with the visit of the “Carreau Rodolphe” and the Kalivie museum with two former miners.

## Day 1: GIGEO project

Near the little city of Bure (Meuse, France), the French national radioactive waste management agency (ANDRA) is experimenting deep reversible storage of highly radioactive long-lived waste (HRLW) from

nuclear power plants for more than twenty years. An underground laboratory has been built at 490 m depth, before building the Industrial Centre for Geological disposal named CIGEO. Galleries are dug in a thick homogenous layer of Callovo-Oxfordian mudstone of the Paris Basin, which has the best properties for HRLW storage. After the project presentation at the surface, we visited the lab galleries (Fig. 1) with a guide showing all surveys like galleries convergence due to alpine stress on several kinds of arches and roof bricks. We also saw the digging methods and the different cell designs for HRLW storage. Finally, we discovered the technologic showroom of the project gathering all survey results, goals and the innovating methods especially created for this project.

## Day 2. Historical silver mines of Sainte-Marie-aux-Mines (Haut-Rhin, France)

Located in the Eastern part of the Vosges mountains, Sainte-Marie-aux-Mines valley was a famous mining district, which reached its peak in the 16<sup>th</sup> and 18<sup>th</sup> century. Deposits are mainly copper-lead-silver (tetrahedrite, argentiferous galena), cobalt-

silver and antimony, and are distributed in veins hosted in gneiss. These veins were deposited during Rhine graben collapse in the Tertiary, which allowed the circulation of hydrothermal fluids in the gneiss formations.

In the morning, we did mining speleology with a guide of the Tellure mining centre. The objective was to explore an old mine, named Armée Céleste, and its ores. We saw galleries (Fig. 2) with different shapes depending on the digging techniques like hammer and pick in the 16<sup>th</sup> century or explosives in the 18<sup>th</sup> century. We were able to observe metre-scale mineralized veins with barite, fluorite (Fig. 3), azurite, malachite and chrysocolla. In the afternoon, we visited the Gabe Gottes mine with a guide of the ASEPAM association (Speleological Association for the Study and Protection of Former Mines). In the mine, we saw different ores than in the morning, such as tetrahedrite (Fig. 4), known as grey copper in this region, chalcocopyrite (Fig. 5) and erythrite (Fig. 6). This mine was the last to close in the entire district. Its antimony exploitation stopped in 1940.

The last activity of the day concerned the quarry of Saint-Pierre-Bois owned by





Fig. 2 Gallery from the 18th century along a fault in Armée Céleste mine.

the local company Sablières J. LEON-HART. We met the quarry manager, who explained the activity of extracting granite for the aggregate industry. He showed us the new permanent crushing and screening installation and some geological points. The quarry is known for its old eastern face showing the best outcrop of the Hercynian unconformity between the granite and the Permian sedimentary rocks in the Vosges massif (Fig. 7).

### Day 3. The Potash mines of Mulhouse (Bas-Rhin, France)

The southern part of Alsace is known for its Potash industry. The potash deposit in the Mulhouse basin was discovered in 1904 by Joseph Vogt at a depth of 694 m. Operations started in 1908 with the opening of a first shaft named Amélie I. When operations ceased in 2002, more than twenty shafts had been built and the maximum depth reached was 1033 m. Two layers of potash were mined, the lower one was 4 m thick and the upper one was 1 m thick. As the basin has an average dip toward the southeast, the shafts are deeper in this zone.

During our field trip, we were able to visit two former mines with guides from two potash mine associations which maintain sites and welcome tourists. The first one was

named “The Carreau Rodolphe”, containing two shafts, Rodolphe I (1911) and Rodolphe II (1928) (Fig. 8). Around 1600 miners used to work there until 1976. Some rooms have been restored, such as the “hanging room” (Fig. 9) or the machine room with a 5 m diameter wheel operating the elevator. There was also a set of mining equipment used for potash mining such as a “Continuous Miner” (Fig. 10) or a “Mining Cutter” (Fig. 11). These machines are exceptional because most of them are still underground, trapped by mining subsidence.

In the afternoon, we visited the Kalivie museum (Potash is translated by Kali in German). It was created by a former miner, who worked in this mine for more than 40 years (Fig. 12). Concerned about preserving the region's mining heritage, he has brought together in the museum all the objects linked to the exploitation of potash in Alsace, as well as a large collection of

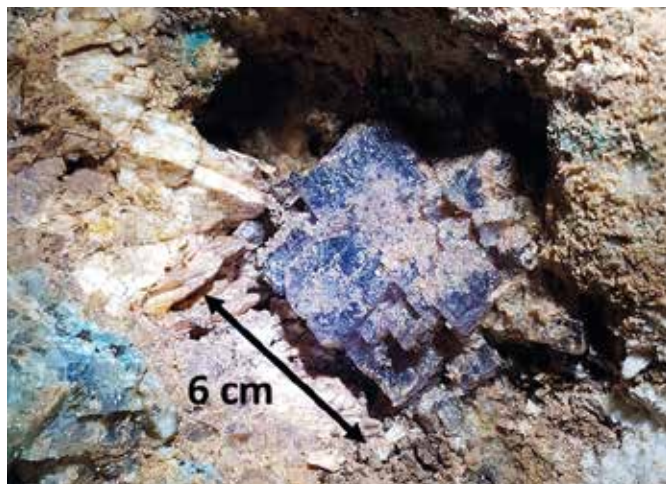


Fig. 3 Fluorite with barite and chrysocolla.



Fig. 4 Tetrahedrite in the Gabe Gottes mine.

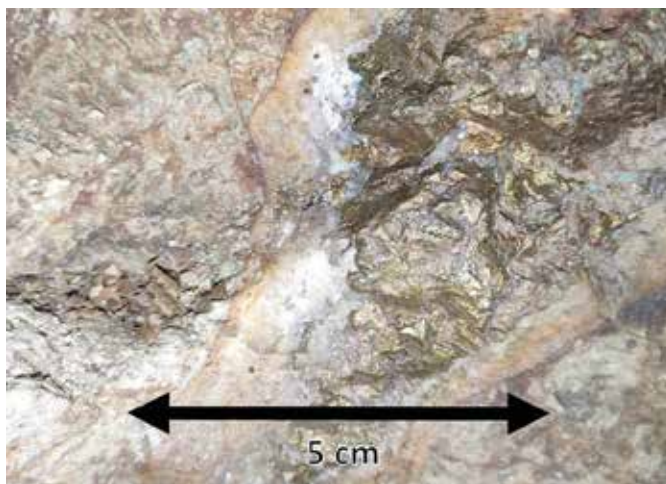


Fig. 5 Chalcopyrite ore in the Gabe Gottes mine.

potash samples from all over the world. This former miner was able to bear witness to his daily life, his living conditions in the mine, the heat that reigned there (almost 50°C), and the cohesion between the miners underground. The museum also included several displays, notably with medical and rescue equipment which were indispensable underground. This last visit ended our field trip in Alsace, but before leaving, we were able to take with us a sample of potash to remember this adventure.





Fig. 6 Erythrite and barite ore in the Gabe Gottes mine.

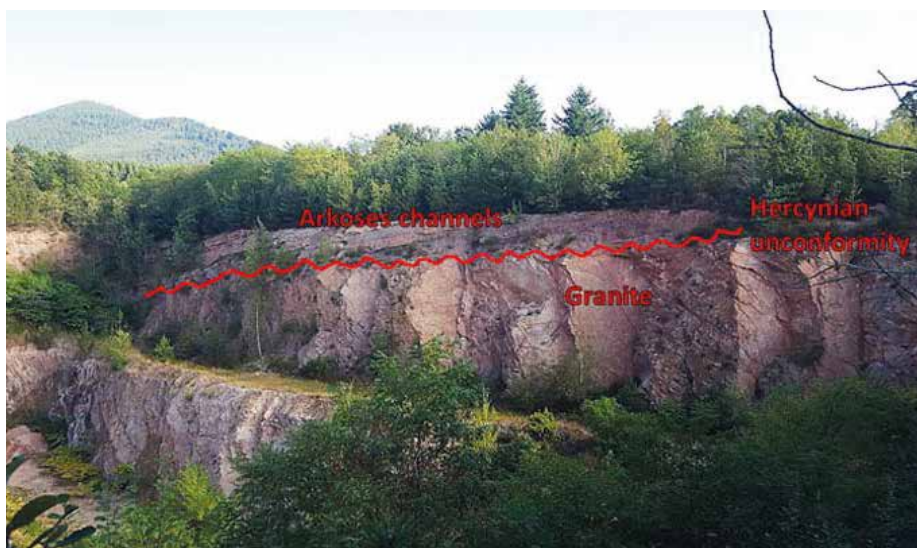


Fig. 7 Hercynian unconformity in Saint-Pierre-Bois quarry.



Fig. 8 The Rodolphe 2 shaft and factory.



Fig. 10 The Continuous Miner from the Carreau Rodolphe.



Fig. 9 The "hanging room".



Fig. 11 The "Mining Cutter" from the Carreau Rodolphe.



Fig. 12 Chapter members with the former miner "Pauli" (on the right) at the Kalivie museum.

## PEOPLE

## Prof. Dr. hab. eng. Henryk Kucha

Adam Piestrzynski<sup>1</sup><sup>1</sup> University of Mining and Metallurgy, al. Mickiewicza 30, 30-059 Kraków, Poland, piestrz@agh.edu.pl

It is with the saddest regret that we announce the death of Professor Henryk Kucha (AGH University of Science and Technology in Kraków, Faculty of Geology, Geophysics and Environmental Protection), on July 11, 2020. Prof. Kucha was an outstanding specialist in geology of ore deposits, geochemistry, mineralogy, crystallography, X-ray spectroscopy, natural organometallic compounds, ore deposits exploration and environmental protection. Prof. Kucha discovered four minerals: eugenite, hibbingite, viaeneite and Thningyoite which were approved by the International Mineralogical Association. In our community, he is known for the discovery of gold and platinum in Zechstein sediment-hosted Cu-Ag deposits and also as an investigator of natural gold silicates.

Prof. Kucha was a lecturer in mineralogy and geochemistry of ore deposits at the AGH University of Science and Technology in Krakow for many years. He also gave lectures at many foreign universities: the National University of Ireland Galway, Trinity College Dublin at the University of Dublin (Ireland), the Catholic University of Leuven (Belgium), the University of Leoben (Austria), School of Earth Sciences at the University of Melbourne, the University of Newcastle, the University of Ballarat (Australia). He has been collaborating with many exploration and mining companies, such as KGHM Polska Miedź SA, Equatorial Mining (gold depos-

its in the Andes - Chile, Peru, Panama), Navan (Tara) Mine, Ireland (Zn-Pb deposits), El Tesoro Mine, Chile (Cu deposits), Hard Creek Nickel Corporation, BC, Canada (Ni, Cu, Co, Pt, Pd, Rh, Os, Ir and Ru ore deposits in mafic rocks), Outokumpu Oy, Finland (polymetallic ores), Rio Tinto Zinc RTZ (Zechstein sediment-hosted copper deposits), Phelps Dodge (Zechstein sediment-hosted copper deposits in Europe and Congo), Irish Base Metals (Zn, Pb and Cu deposits) and Marathon Mining, Australia (uranium deposits).

Prof. Kucha was the laureate of numerous prestigious national and international awards for his achievements as a researcher (i.e. Polish Geological Society in 1976, South Africa Gold Fields Premium in 1994, Van den Broek Medal from the Belgian Geological Society for his achievements in scientific activity in 1985 – 1995). He was a long-time member of SGA (between 1989 and 2013) and several other societies (Polish Mineralogical Society, Geological Society of Poland, Royal Geological Society of Ireland, and Society of Economic Geology).

Our community lost a devoted scientist, dedicated teacher and supportive colleague. Professor Henryk Kucha will stay in our memory as a modest and kind man who was always generous with his time for everyone and cheerful in the face of adversity.

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# Professor Richard Stanton, geologist (1926–2020)

Ross Large<sup>1</sup>

<sup>1</sup>University of Tasmania, Private Bag 79, Hobart TAS 7001, Australia, Ross.Large@utas.edu.au

Professor Richard (Dick) Stanton was born in 1926 Sydney and died in Canberra, Australia on 25 August 2020. He studied geology and mathematics at the New England University College of the University of Sydney at Armidale, which later became the University of New England (UNE). From a very early age, Dick Stanton was interested in the natural world, and amongst other things, he was a keen collector of minerals. When he entered first year geology at UNE, it was his fourth subject choice in the hope of doing something on minerals and crystals. As it turned out, he proceeded on to a double major in geology and mathematics. During his undergraduate years, he learnt to appreciate the elegance of science; and in his future career Dick Stanton achieved some beautiful solutions about how mineral deposits form in the Earth's crust.

Dick Stanton graduated at the end of WWII, when there was a surge in mineral exploration activity and the challenge of an exciting career. He joined Broken Hill South starting in Broken Hill and then moved to Far North Queensland to work up along the spine of Cape York Peninsula, followed by a mapping stint at an old copper mine at Burruga, about 50 miles south of Bathurst, NSW. This was the start of Stanton's most important contribution to economic geology: the theory that massive sulfide deposits of zinc, lead and copper form on the seafloor associated with volcanism in regional volcanic island arc settings.

Stanton quickly realised that on a larger scale than Burruga, the old mines and workings south of Bathurst occurred in a distinct pattern related to the geological features of the area, a particular association of volcanic rocks, shale and coralline reef limestone. Subsequently, this became the topic of his PhD started at the University of Sydney in 1950 and completed in early 1954. In 1956, Stanton won a National Research Council of Canada post doctorate fellowship at Queen's University, in Ontario researching the copper and zinc massive sulfides in New Brunswick. This subsequently led to three publications in the CIMM in 1959 and 60, which had a major impact on mas-

sive sulfide mineral exploration. The last of these, 'General features of the conformable pyritic orebodies', laid out the model for massive sulfide mineralisation and the key parameters for exploration.

Dick Stanton returned to Australia to accept a post in the University of New England, where he rose to become the pre-eminent academic economic geologist in Australia and spent 29 years contributing very significant research in a number of aspects of ore deposit genesis. Probably his best recognised achievement in this period was his 1972 book *Ore Petrology*. This was the first publication to consider ore deposits as a natural part of geological evolution and to recognise that classes of deposits were controlled by their geological environment. The book was an immediate success and over 18 000 copies were sold worldwide. It was the basic text on ore deposits in many western universities for over 30 years.

Dick Stanton retired from the University of New England in 1986 but continued to be active in research. His last publication was written in 2015 in his 90th year! Dick Stanton was a quietly spoken, thoughtful and highly intelligent man who was greatly admired and respected by his students and colleagues. Dick Stanton received many awards during his career, including the 1956 Olle Prize Royal Society of NSW; 1966 Fulbright Award; 1972 David Syme Prize, University of Melbourne; 1974 President's Award, AusIMM; 1975 elected to Australian Academy of Science; 1976 Goldfields Medal IMM; 1990 William Smith Medal, Geological Society London; 1990 Browne Medal Geol. Soc. Aust; 1993 Distinguished Alumni Award UNE; 1998 SEG Penrose Gold Medal; 1998 Haddon Forester King Medal AAS; 1998 Clarke Medal Royal Society of NSW; and 2003 Centenary Medal. He was awarded an Order of Australia in 1996 for service to economic geology and geological research.

## SGA News

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### CHIEF EDITOR

Jochen Kolb  
Institute of Applied Geosciences  
Karlsruhe Institute of Technology (KIT)  
Adenauerring 20b  
D- 76131 Karlsruhe  
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Prof. Dr. Jochen Kolb  
Institute of Applied Geosciences  
Karlsruhe Institute of Technology (KIT)  
Adenauerring 20b  
D- 76131 Karlsruhe  
GERMANY  
e-mail: [editor-sga-news@e-sga.org](mailto:editor-sga-news@e-sga.org)  
[jochen.kolb@kit.edu](mailto:jochen.kolb@kit.edu)

# Dietrich D. Klemm in memoriam

Bernd Lehmann<sup>1</sup>

*<sup>1</sup> Mineral Resources, Technical University of Clausthal, 38678 Clausthal-Zellerfeld, Germany; bernd.lehmann@tu-clausthal.de*

Professor Dietrich Dankwart Klemm (DD) died on 2 October 2020 at the age of 87. We have lost an eminent scientist and good friend, economic geologist and mineralogist, past Editor of *Mineralium Deposita* and Honorary Member of SGA.

DD studied geology in Frankfurt and Heidelberg, and did his PhD in 1959 on the skarn-style iron ore deposits of Divrik (Divriği) in Turkey, under the supervision of Paul Ramdohr. He then moved to Ludwig-Maximilian University of Munich (LMU), where he worked on experimental mineralogy of Fe-Co-Ni-As sulfide systems and applied the electron microprobe technique, still in its infancy, for his habilitation thesis in 1964. He then was a lecturer and associate professor in applied mineralogy at LMU, a CNRS guest lecturer at Sorbonne University in Paris and in 1973 became the Head of the Geochemistry and Geology of Mineral Deposits section at LMU, until he retired in 1998.

He was a brilliant teacher and inspired several student generations. His research projects were focussed on petrology and economic geology of chromite and titanomagnetite deposits in the Bushveld layered intrusion, banded iron and manganese ore deposits in South Africa and Nigeria, epithermal systems in Tuscany and elsewhere, and experimental mineralogy of solid-solution equilibria in various sulfide and oxide mineral systems. From 1980-1992, he was Editor of *Mineralium Deposita*, the first 10 years together with Hans-Jochen Schneider and then with David Rickard and Ian Plimer.

DD worked very close with his wife Rosemarie Klemm, an egyptologist, also from the University of Munich. They did many field campaigns in Egypt and Sudan together, with systematic investigations on ancient Egyptian quarry areas and sampling of antique monuments for petrographical and geochemical provenance determinations. They also studied ancient mining activities for gold, copper and tin in the Eastern Desert of Egypt and in Sudan. They published together two important books: *Steine und Steinbrüche im Alten Ägypten* (1993, Springer)/*Stones and Quarries in Ancient Egypt* (2008, British Museum Press) and *Gold and Gold Mining in Ancient Egypt and Nubia/Sudan* (2013, Springer). The thousands of rock samples from these 30 years of research are deposited in the British Museum in London, the Rosemarie and Dietrich Klemm Collection. Comparison with these rock samples allowed in 2003 to identify the origin of one of the most visited objects in the British Museum, the Rosetta Stone, which is made of fine-grained biotite-hornblende granodiorite/tonalite with close similarities to Panafri- can granitic rocks near Aswan.

The breadth of DD's research work reflects his humble open-mindedness and intellectual elegance combined with the good-humoured and generous personality of a gentleman. We will miss an excellent scientist, talented teacher and dear friend.



*Dietrich D. Klemm (1933-2020)*





16TH BIENNIAL MEETING

**SGA 2021**Rotorua, New Zealand • November 15 - 18 • [www.sga2021.org](http://www.sga2021.org)**CALL FOR ABSTRACTS**

The Organising Committee invites submissions for oral and poster presentations. The main theme for the conference is *The Critical Role of Minerals in the Carbon Neutral Future*. Submissions are encouraged on topics related to mineral deposit research, exploration, sustainable development and environmental and social aspects related to mineral deposits.

Abstracts must be submitted via the official website link at [www.sga2021.org.nz](http://www.sga2021.org.nz) where a full list of themes and guidelines for submission can be found.

**FAST FACTS****WHEN**

15 – 18 November 2021, plus pre- and post- conference field trips and short courses.

**WHERE**

Rotorua Energy Events Centre in Rotorua, New Zealand.

**WHO SHOULD ATTEND?**

Delegate representation includes academia, industry, government research organisations, consultants and service providers.

**KEY DATES**

**CALL FOR ABSTRACTS - OPENS 2 NOVEMBER 2020**

**EARLY EARLY-BIRD REGISTRATION - DEADLINE END DECEMBER 2020**

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**CALL FOR ABSTRACTS - DEADLINE 3 MAY 2021**

**PROGRAMME HIGHLIGHTS**

The Technical Programme will consist of four days of oral and poster presentations with themes including:

- Ore forming processes
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- New research and exploration developments
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- Sustainable mining and environmental issues
- Social license

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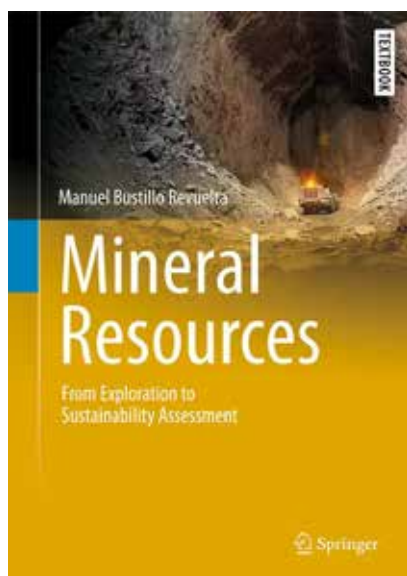
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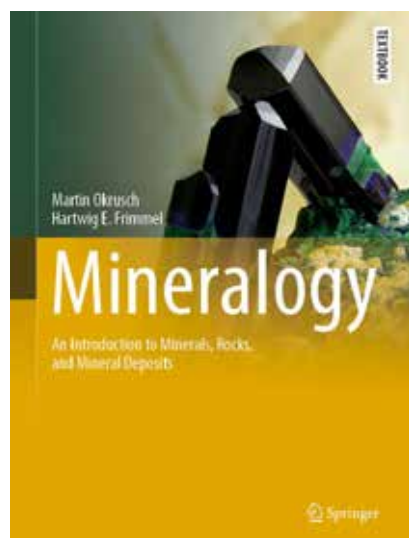
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# Guide to authors for the SGA News

Jochen Kolb; chief editor SGA News

*Institute of Applied Geosciences, Karlsruhe Institute of Technology, Adenauerring 20b, 76131, Karlsruhe, Germany; editor-sga-news@e-sga.org*

There are three types of submission: (1) regular article; (2) reports of SGA student chapters; and (3) reports related to SGA. Regular articles should present scientific studies of the geology, mineralogy and geochemistry of mineral deposits or other topics related to mineral deposits. Reports of SGA student chapters should represent detailed description of activities. They must be reviewed by the scientific supervisor of the respective chapter prior to submission. Make sure that the field reports include the exact location (coordinates if available) of each station described. There is no restriction to the length of a contribution, but it should be concise and informative. All figures should be informative and of good quality. The language of SGA News is British English and all contributions need to be formatted as such. When submitting a text, do not include figures or tables and their captions. Present the latter at the end of the Word file and submit the figures separately, instead.

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Every submission needs to provide: (1) a concise and informative title; (2) the name(s) of the author(s); (3) the affiliation(s) and address(es) of the author(s); and (4) the e-mail address of the corresponding author.

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SGA Executive Secretary  
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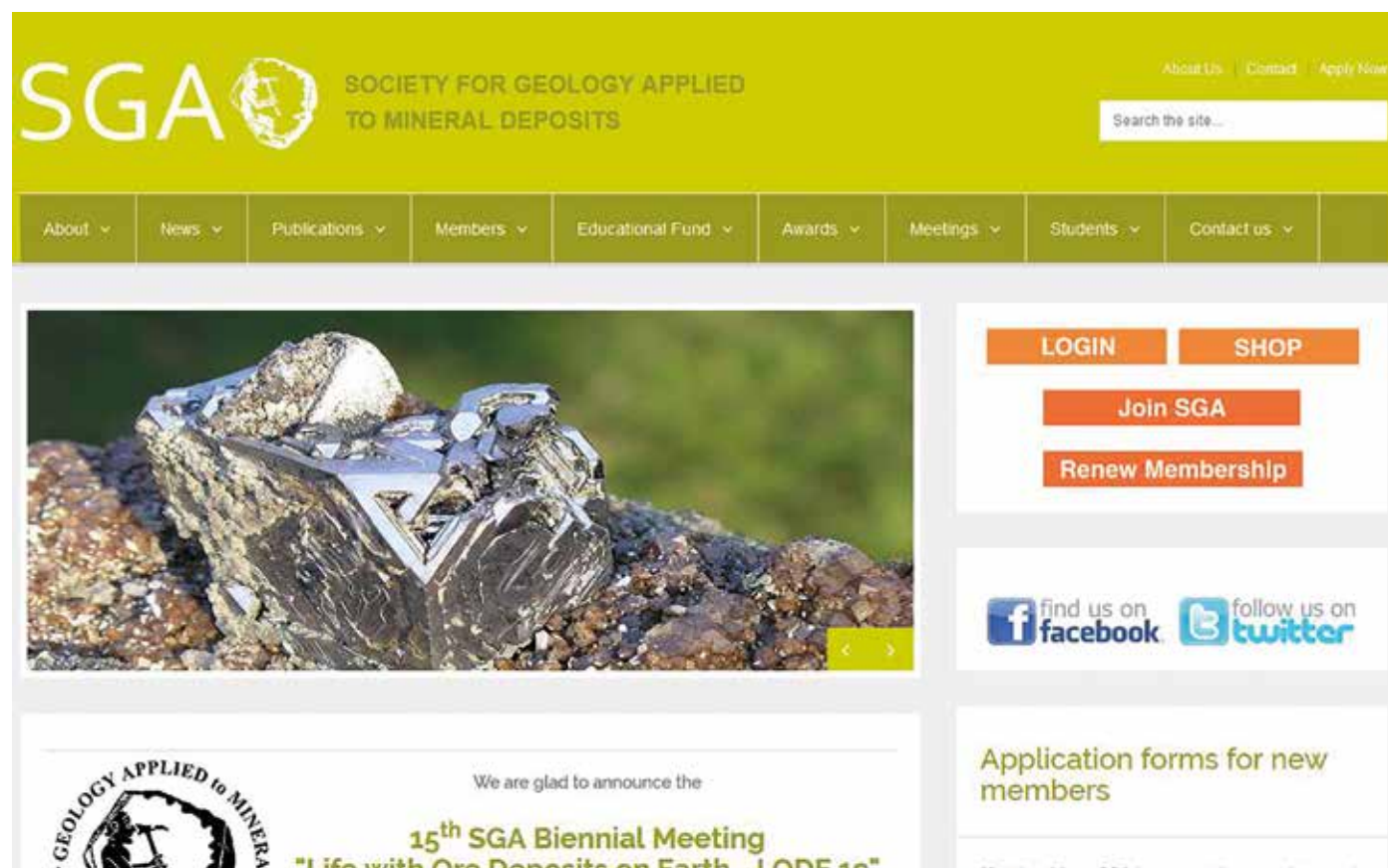
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Iain Pitcairn , Chief Editor SGA website

Department of Geological Sciences, Stockholm University, Stockholm, Sweden

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