



**SGA Anniversary
(1965–2020)**

SGA News

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Hub & speak: the story of Ore Deposits Hub

Tom Belgrano¹ & The Ore Deposits Hub Team

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Towards the end of March, having already been cooped up in the home office for a few weeks, a surprising realization dawned on us about those departmental seminars we tend to skip and complain about — we actually quite missed them. Fuelled with the kind of enthusiasm that is exclusive to the hopelessly naïve, we set about to replace those cancelled seminars with an online alternative. The name ‘Ore Deposits Hub’ was chosen after narrowly dodging a few disastrous suggestions from the author and within a few days, we had a concept, time slots, some high-profile speakers and a rickety but functional website — which is actually more than can be said for quite a few physical conferences!

Our general concept is simple: free, open talks and discussion on ore deposit geoscience hosted weekly in an online ‘meeting room’. We send the meeting details out via our mailing list and people can tune in to a ~45 minutes talk. Afterwards, we discuss the topic for as long as we like, from the comfort of anywhere our WiFi reaches. This open-ended discussion would be impossible in a physical setting, and it is one of the greatest advantages of the platform. However, some of the emergent strengths of our online format are more far-reaching (literally). We are delivering cutting-edge research into the living rooms of people who, for whatever reason, expense, care responsibilities, time, disability etc., could not normally attend international conferences. Likewise, we built a platform on which these brilliant geologists can share their work with an international audience.

We have now hosted 29 talks, consistently getting 100–250 people tuning in, and by the time you read this, we will have ex-

ceeded 4500 email subscribers. For the most part, we reached this stage by piggybacking on the fame and competence of our early speakers: Simon Jowitt, John Thompson, Ali Sholeh, Steve Barnes and Dave Lentz (there, we’re doing it again), to whom we owe our unending gratitude. This has all been made easier by our now far-less rickety and far-more functional website, developed by Aaron Hantsche, Alannah Brett and myself and paid for by the SGA, IAGOD, and SEG.

Thankfully, with eight team members to run the show, we now have a moment to reflect on where we might be going in the post-pandemic future. Online meetings are quick to organize, almost free, basically carbon-neutral and accessible to all. However, if being locked down has taught us anything, it is that face-to-face catch-up and discussion are incredibly important — life happens at greater than 1024 kb/s! Online platforms cannot replace that experience, but can act as an accessible, parallel or integrated platform to physical meetings. We hope to work together with the SGA and other community sponsors to create a permanent cross-society platform for this newly prevalent avenue of science communication, and we look forward to seeing a 1024 kb/s version of yourself in a meeting soon!

Ore Deposits Hub is an online open platform for talks and discussions on Ore Deposit Geoscience. The Hub is currently run by Aaron Hantsche, Alannah Brett, Tom Belgrano, Marion Grosjean, Wren Bruce, Chris Voisey, Jamie Kelly and Neil Fernandes, and is jointly sponsored by the SGA, SEG and IAGOD. For more details, including a schedule of talks and the sign-up form, check our website at <https://oredepositshub.com/>

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News of the Society

Jan Pašava¹ (SGA Executive Secretary)

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The SGA Ordinary Council Meeting was planned to be held in Warsaw, Poland on March 31, 2020. Due to the unfortunate COVID-19 situation, the meeting had to be cancelled and postponed to October 2020. Great thanks are due to Prof. Stanislaw Mikulski from the Polish Geological Institute and his team for their efforts related to the preparation of the meeting in Poland during this difficult time.

Instead, the SGA management decided to ask the SGA Executive Secretary to address SGA Council members via email with a revised agenda and relevant supporting documents. Council members were asked on March 30, 2020 to go through the agenda and attached items and provide the Executive Secretary with brief response (for/against with a one-two sentence explanation for proposals) by Monday, April 6, 2020. David Huston (SGA President) suggested that the other items not covered by the present agenda can be handled by the initiators with help from the Executive as needed.

Based on responses by Council members to the recent SGA e-Council Meeting (March 30), here is a summary of results:

1. Minutes of previous Council Meeting (August 26, 2019 Glasgow, Scotland) – approved.
2. Determining successful bid for SGA2023 – after a tight vote on two very high quality bids, the Council decided that the 17th SGA Biennial Meeting will be held in Zürich, Switzerland in August 2023 (official letter from SGA President to both bidding teams sent).
3. Report from SGA2021 - noted - suggested creation of a new category for retired members at SGA2021 - newly put to a vote and approved.
4. Determining if the Mt. Isa field conference should be postponed until July 2021 - approved postponement to July 2021.
5. Springer Nature issue/Membership fee - a mild increase in membership fee between 10-20 EUR without impacting on students approved - newly revised and approved to refrain

from raising the membership fees at this stage until a better prediction can be made about the extent and kind of activities SGA can offer in post-COVID19 times.

6. Financial reporting – SGA – Treasurer's Report approved.
7. Financial reporting – SGA2019 - noted (in the meantime, SGA received the financial report and the first payment).
8. Status of development of SGA Student and Young Scientist network - approved providing budgets to all chapters that submitted their reports and new chapters, and hold the payment for chapter, which did not provide any reports. SGA Vice President for Student Affairs to inform individual chapters.
9. Coordination between SGA2021 and SGA Educational Fund for soliciting support - noted and recommended that fund-raising should be coordinated between Tony Christie and his team and one SGA Council representative (D. Huston/D. Banks).
10. SGA Sub-committee on New Initiatives - confirmed for an initial period of 1 year; a clear Terms of Reference document needed, D. Banks to continue in identifying Sub-committee members.
11. The 7th Short Course on African Metallogeny on "Energy transition metals" (November 23-27, 2020 Windhoek, Namibia) – B. Orberger et al. - noted - important to make a decision on if the course will be organized by July 1, 2020.
12. III. Symposium on Precambrian geology and metallogeny (May 25 to 29, 2020 in San Ignacio de Velasco, Bolivia) – M. Biste et al. - approved postponement to May 2021.
13. SGA Ordinary Council Meeting - 12-15 October 2020, Warsaw, Poland - approved.

PRESIDENT'S CORNER

Like most other organisations around the world, SGA has been wrestling with how we deal with Coronavirus (COVID19). The pandemic, which became a major problem for the world earlier this year, has forced significant changes upon the society. The first effect was that the biannual Council meeting scheduled for April was held digitally and included e-mail responses to a series of issues and then some discussions via video conferencing. It is possible (likely) that future Council meetings will be held in this manner at least until the COVID19 pandemic recedes.

The COVID19 pandemic has also affected (or has potential to affect) some of the Society's other activities. The inaugural SGA field conference in Mount Isa, Australia, which was scheduled for this month, has been postponed until July 2022. Although the 7th SGA-IUGS-SEG-UNESCO

Short Course on African Metallogeny is currently scheduled to occur on 23rd - 27th November 2020 in Windhoek, Namibia, the organisers are keeping a watching brief on the development of COVID19 in Africa to make sure that the conference can be held safely. The 16th Biennial Conference is on track to be held in Rotorua, New Zealand on 15th – 18th November 2021, but, again, the organisers are keeping a watching brief on COVID19. The Society wants to maintain the health and safety of its members and other persons who attend these conferences.

On a more positive note, *Mineralium Deposita*, the Society's flagship publication has the highest impact factor among economic geology journals in 2019, higher than both *Economic Geology* and *Ore Geology Reviews*. The two-year impact factor of 4.323 in 2019 is significantly higher than that of 3.397 for 2018. Congratulations to our co-Chief Editors Georges Beaudoin and Bernd Lehmann and all of the Associate Editors who have ensured the quality of the journal, which is reflected in the impact factor.

In addition, SGA, along with SEG and IAGOD, are financially supporting the *Ore Deposits Hub* (<https://oredepositshub.com>), which is a student-based organisation promoting ore deposit science and collaboration between academia, government and industry. The SGA Council recommends that our membership attend the weekly digital seminars – registration is simple. Thanks to Tom Belgrano and Alannah Brett for founding this initiative, the SGA is proud to support.

Finally, I would like to thank the outgoing council members, particularly ex-Presidents Karen Kelley and Jorge Relvas, who have both made long-term contributions to SGA. At present, there are a number of challenges that our society is facing. We will ensure that our society continues to provide services to our members in a safe and timely manner.

David Huston
President

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Secretary General	J. Xian (China)



Mineralium Deposita: 2019 bibliometric data

Georges Beaudoin¹ and Bernd Lehmann² (Editors-in-Cief)

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2 Technical University of Clausthal, Adolph-Roemer-Str. 2A, 38678 Clausthal-Zellerfeld, Germany, lehmann@min.tu-clausthal.de

Mineralium Deposita is the official journal of the SGA. The 2019 bibliometric data indicates the journal is doing well, with its highest 2-year Impact Factor (IF) ever at 4.32. The IF compares the number of citations for a reference year to the number of citable items of the two previous years. Since introduction of the IF in 1997, *Mineralium Deposita* has shown a steady increase of this metric (Figure 1). *Mineralium Deposita* has an IF higher than its competitor journals. Similarly, the 5-year IF shows an increasing trend with the highest value in the field of economic geology (Figure 2). Other metrics show similarly high values for *Mineralium Deposita*. The journal publishes

about 65-70 citable items per year, a steady number. As a reflection of the high IF and other metrics, the journal is highly regarded by the community, and attracts an increasing number of submissions (284 in 2019), which necessarily results in a high rate of rejection (>2/3). We are continuously looking for high quality papers from around the world to maintain and increase *Mineralium Deposita*'s status as the premier journal in the field. We thank the authors for their excellent research, the many referees and members of the Editorial Board for their insights steering submissions through the peer-review process.

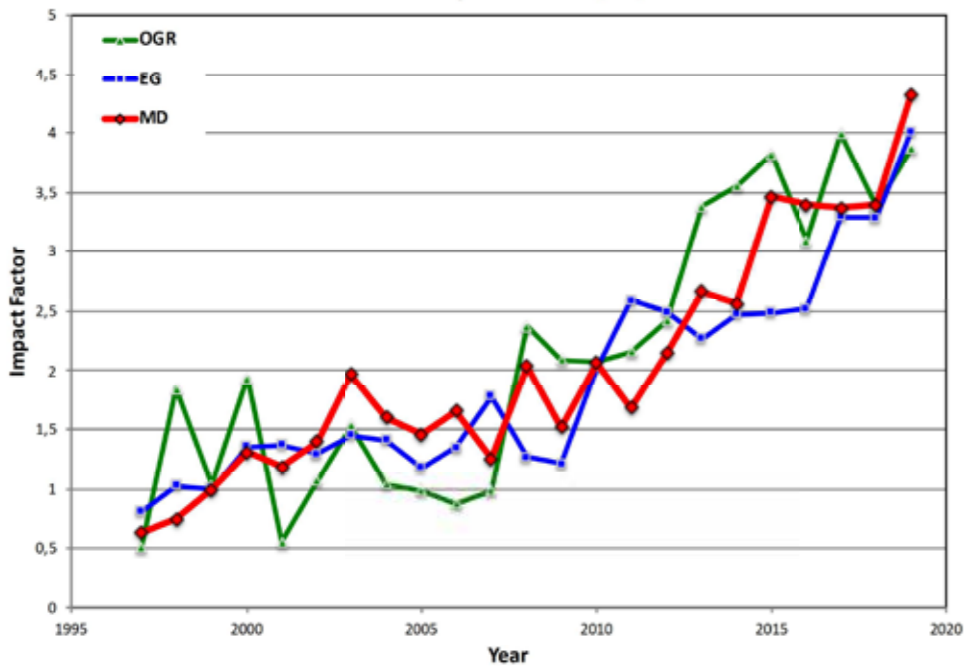


Fig. 1: The 2-year Impact Factor of *Mineralium Deposita* (MD), *Economic Geology* (EG) and *Ore Geology Reviews* since 1997.

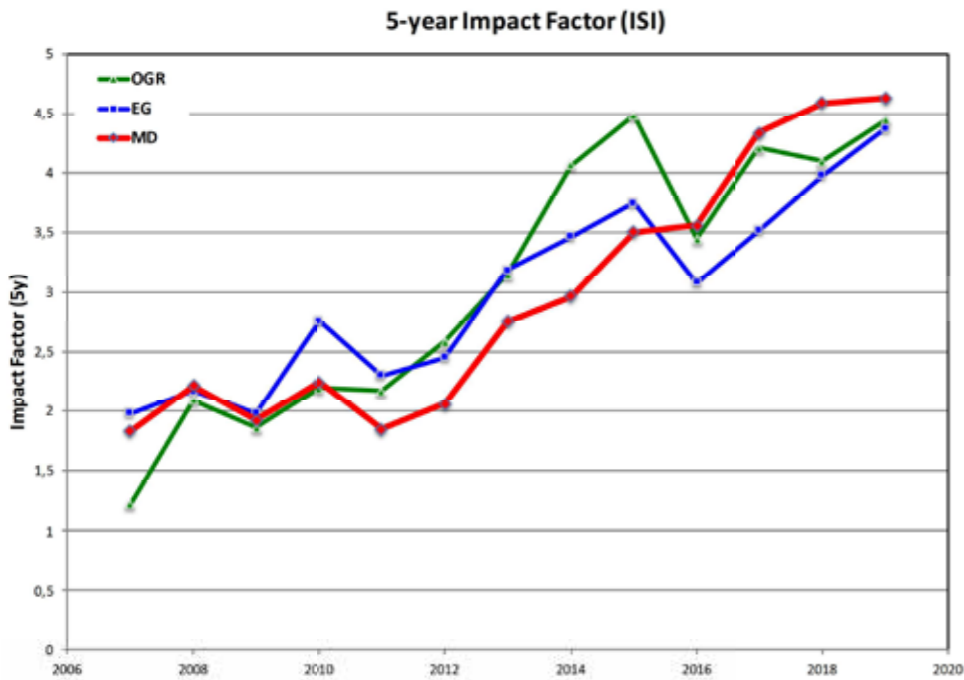


Fig. 2: The 5-year Impact Factor of *Mineralium Deposita* (MD), *Economic Geology* (EG) and *Ore Geology Reviews* since 1997.

REPORTS FROM THE SGA STUDENT CHAPTERS

SGA chapter	President	E-mail	Website/Facebook/Twitter	Chapter e-mail	Founda-tion
Prague	Štěpán Jaroměřský	jaromers@natur.cuni.cz	http://sga.cuni.cz/ www.facebook.com/SGA-Student-Chapter-Prague-155355499351/	chapter_prague-user-group@natur.cuni.cz	2002
Baltic	Krzysztof Foltyn	krzyfoltyn@gmail.com	www.sga.agh.edu.pl/ www.facebook.com/groups/balticsga/		2009
Siberia	Anna Devyatiyarova	anna13502@gmail.com	www.sib-sga.com www.facebook.com/groups/1846717542233118	SiberianChapter@yandex.ru	2011
Barcelona	Malena Ca-zorla	malecama.97@gmail.com	www.bcn-sga-seg.cat/index.php www.facebook.com/Bcn-SGA-SEG-Student-Chapter-520047141415889/	student.chapter.ub.sga@gmail.com	2012
Colombia-Bucaramanga	Juan Pablo Jaimes Bermudez	juanjaimesb21@gmail.com	www.facebook.com/capitulosgauis/	sga.uis.bucaramanga@gmail.com	2012
Nancy	Margarita Melfou	margarita.melfou7@etu.univ-lorraine.fr	sganancy.wordpress.com www.facebook.com/groups/449029751879224	sga.nancy@gmail.com	2013
Peru	Silvana Janeth Stipetich Santillán	stipetich.s@pucp.pe	www.facebook.com/SGAPeruStudent-Chapter/	sgastudentchapter.peru@gmail.com	2013
Colombia-Bogota	Juan Pablo Jaimes Bermudez	juanjaimesb21@gmail.com	www.sgabogota.org/ www.facebook.com/capitulosgauis	sga.unalbogota@gmail.com	2015
Morocco	Said Ilmen	said.ilmen@edu.uca.ma	www.facebook.com/SGA-Moroccan-Student-Chapter-1561030220797534	sgachapter.marrakech@gmail.com	2015
Laval	Emile Boily-Auclair	Emile.boily-auclair@ete-inrs.ca	http://segulaval.ca		2016
Western Cape	Jorgina Akushika	jorginaakushika@gmail.com			2017
North-West Russia	Evgenyi Ere-menko	st013196@student.spbu.ru	https://nw-sga.com www.facebook.com/groups/NWRussian.Student.SGA		2017
Turkey	Fatih Ozbas	fatih.ozbas@istanbul.edu.tr	www.pau.edu.tr/sgatrstudent www.facebook.com/groups/1312678395490904	sga.turkey@gmail.com	2017
Black Forest-Alpine	Alannah Brett	alannah.brett@geo.unibe.ch	bfa2sga.wordpress.com www.facebook.com/groups/849362358568835		2017

Ore geology workshop by SGA Baltic Student Chapter: Scandinavian exploration geology applied to younger terrains

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Fig. 1: Participants mingle with Swedish fika during the intermission.



Fig 2: Group photo of all the participants who joined for the workshop.

Open for Application The SGA Mobility Grant

Get ready for SGA networking! Do you know about a SGA member who runs a laboratory that could answer open questions of your research? Then the SGA Mobility Grant can help to bring you together! The SGA Mobility Grant offers an opportunity for regular SGA members to apply for money to travel to a facility with SGA background.

Applicants have to be in good standing for at least 3 continuous years (i.e. paid up membership fees; up to 2 years of student membership count) and apply by sending their request following a template to the SGA Mobility Grant coordinator (thomas.aiglsperger@ltu.se).

The application template is available at <https://e-sga.org/home/>.

Learning and sharing! That's the spirit of the SGA Mobility Grant.



Last fall, the SGA Baltic Student Chapter at Luleå University of Technology (LTU) organized a collaborative, guest speaker oriented workshop with a unique theme: Scandinavian exploration geology applied to younger terrains. While geologists are trained in the fundamental principle of uniformitarianism: “the present is the key to the past,” the Baltic Student Chapter invited students, researchers and professionals to a workshop on how exploration geology in older and tectonically more complex terrains could be beneficial to exploring in younger terrains. In order to gather pre-

sen- ters from a variety of fields and perspectives, the SGA Baltic Student Chapter welcomed two external speakers and two in-house speakers to present on the theme including Dr. Stefan Luth from the Swedish Geological Survey (SGU), Marcello Imaña, chief consultant of Scandic Peruana Minerals, Assoc. Prof. Dr. Tobias Bauer and Senior Lecturer Dr. Nils Jansson of LTU.

The event was sponsored by Boliden, Luossavaara-Kiirunavaara Aktiebolag (LKAB) and SGU, and was held on November 21, 2019 at LTU. It gathered over 60 participants including representatives

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from LKAB, Boliden, Agnico Eagle, Björkdalsgruvan, EMX Royalty Corp., SGU and researchers in academia and students from a variety of levels.

The workshop was given in a four-part lecture series covering a range of topics and included engaging discussion sessions. Dr. Nils Jansson discussed the need of synthesizing models tailored for understanding ore deposits within specific districts. He used case studies of stratabound limestone-skarn-associated Zn-Pb-Ag-Cu (SVALS) and stratiform ash-siltstone-hosted Zn-Pb-Ag (SAS) deposits in the Bergslagen district as examples of how the application of deposit-scale geochemical, structural and mineralogical data can be used to modify general ore genetic models into explicit ones. Dr. Tobias Bauer gave a synthesis of the tectonic history of the Fennoscandian Shield and drew comparisons to modern analogues such as the South Aegean Arc and the Papuan Fold Belt. He spoke about how understanding the tectonics of the region can lead to advanced mineral exploration. Dr. Stefan Luth presented ongoing

work using core-scanning technologies and illustrated the utilization of 3D modelling applications in Scandinavia, Bulgaria and Greece. Marcello Imaña finished the workshop by discussing the role of carbonates in both old and young terrains and the geochemical interplay carbonates have in forming ore deposits. In addition to the lecture series, Dr. Laura Lauri, specialist from the LKAB exploration department, gave a presentation about LKAB's geology department and their ongoing exploration activities in Kiruna, Gällivare and Svappavaara in Northern Sweden. The lectures were punctuated with student-industry networking opportunities including enjoying a traditional Swedish fika (coffee and cakes; Figure 1), as well as an after-workshop mingling session. The SGA Baltic Student Chapter at LTU are grateful for our sponsors, speakers and for all of the people who participated in this event (Figure 2)!

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1st SGA Brazillian Student Chapter Workshop: gold mineralisation in the Ouro Preto region

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Fig. 1: Participants of the underground-mapping short course.

The Quadrilátero Ferrífero of Minas Gerais, Brazil, is a famous, world-class mineral province. On its inaugural workshop, the SGA Brazilian Student Chapter focused on the gold mineralisation in the historically most important gold-mining centre of the Quadrilátero Ferrífero: Ouro Preto. The workshop took place on September 9-12, 2019, in Ouro Preto, amid its colonial houses of baroque architecture and narrow streets, a scenario built on hills sustained by rocks of the Minas Supergroup. Numerous underground workings, currently inaccessible, are distributed over the hilly landscape. Some of them have become tourist attractions.

The Workshop was sponsored by SGA and AngloGold Ashanti and held at the School of Mines of the Universidade Federal de Ouro Preto (UFOP). This is the most traditional School of Mines in Brazil. The event gathered 30 participants, from undergraduate students of geology to mine geologists. The event was a good opportunity to present the SGA Brazilian Student Chapter to the geological community. The workshop was divided into three parts: lectures, field trips and a short course of underground mapping (Figure 1), distributed over a four-day schedule. The theoretical part consisted

of one day of lectures given by experts from academy and industry, sharing insights about mapping techniques, regional geology of the Quadrilátero Ferrífero and styles of gold mineralisation in the Ouro Preto region. Lectures were interspersed with coffee breaks, when participants could interact with the lecturers and the organization.

The field trips were guided by two professors, Alexandre Raphael Cabral, from Universidade Federal de Minas Gerais and Maximiliano Martins, from UFOP. They conducted a two-day excursion to localities in and around Ouro Preto (Figure 2), from outcrop and adit geology to gold panning (Figure 3).

The highlight of the workshop was the short course of underground mapping, which combined a theoretical introduction with two days of four-hour practice of underground mapping. We had the privilege of counting on the 20-year expertise of Diógenes Vial (Alkmíne), who voluntarily taught the course (Figures 1, 4), the practical part took place at the historical Veloso mine, currently a tourist attraction in Ouro Preto.



Fig. 2: Field-trip participants contemplating historical open-cast remains and the Itacolomi peak in the background.



Fig. 3: Participants and mosquitoes at work: gold panning and bloodsucking, respectively.



Fig. 4: Practise of underground mapping at Veloso.

SGA Student Chapter Colombia-Bucaramanga

Juan Pablo Jaimes & Luis Fernando Paez¹

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The Industrial University of Santander SGA-UIS Student Chapter, formed by 32 student members from different levels, carried out all the activities proposed for 2019. The activities included different lectures, geological meetings, courses and field trips.

Regular meetings

Throughout the year, lectures and meetings were developed by students of the last semester. These were developed twice per week and were about general topics like basic geology and specific and complex topics like configuration and development of the Colombian mineral deposits. Initially, these activities were planned for first semester students; nevertheless, students of different semesters joined and, with their help and interest, multiple topics were debated in the mineral deposits area.

Geological modelling fundamentals applied to exploratory projects course

A two-day theoretical-practical course was conducted, carried out by Ariana Montoya, M.Sc. The topics were the stages of an exploratory project, quality assurance and quality control (QA/QC), data bases and building a geological model using real data.



Fig. 1: Meeting run by Juan Pablo Jaimes, ninth semester student.

Geofair

This activity was inside a bigger event called U18, organized by the Industrial University of Santander (UIS). During the Geofair, all the active geological chapters of the Industrial University of Santander, including the SGA-UIS, worked together to bring geology to the society. A few regional schools were invited and students from

other faculties and departments attended too. There were talks, meetings, games and activities with the aim of teaching students the importance of geology in our daily life. The SGA-UIS chapter participated with a stand of different minerals and rocks in order to explain the formation processes of each sample and their importance in the society.



Fig. 2: All the SGA-UIS chapter members that were part of the modelling course.



Fig. 3: SGA-UIS chapter members in the booth talking to the public



Fig. 4: SGA-UIS chapter members on their way to Umpala, through the Chicamocha Canyon..

Regional field trip – Minesa

The SGA – UIS Student Chapter made a field trip to the mining project called “Soto Norte”, which is still in its exploration stage and which is owned by the company called Minesa. We had the opportunity to see samples from the deposit and their mineralogy, textural and structural characteristics and were explained how it formed and how it will be mined. Two field trips were carried out and each of them lasted one day.

Regional field trip – Umpalá

The SGA–UIS chapter made a field trip to a small town called Umpala, located approximately two hours away by car from Bucaramanga. The main purpose of this activity was to identify fluorite veins that

have been artisanally mined for over 30 years. Additionally, we treated topics related to igneous and metamorphic petrology, given the fact that these fluorite veins were emplaced in granite and paragneiss, and talked about other minerals being mined, to a lesser extent, for industrial purposes such as vermiculite, muscovite and K-feldspar.

Introduction to rock deformation mechanisms course

A one-day theoretical-practical course was conducted, carried out by Leonardo Palmera, M.Sc. The treated topics were the characteristics of each deformation mechanism, the relation between deformation, temperature and minerals, and deformation in gneisses from the Guiana Shield in Bra-

zil. We also had the opportunity to take the treated topics into action and identified the mechanisms in thin sections.

Science school fair

During this science school fair, the SGA-UIS Student Chapter worked together to bring geology to high school students from the Colegio Integrado Nuestra Señora del Divino Amor. Students from the 9th, 10th and 11th grades were invited with the aim of teaching them the importance of geology in our daily life. Different topics such as the impact of mining projects near Bucaramanga, the origin of earthquakes and the Bucaramanga nest, and the energy future in Colombia.

SGA Nancy Student Chapter – Field Trip in Morocco, February 2020

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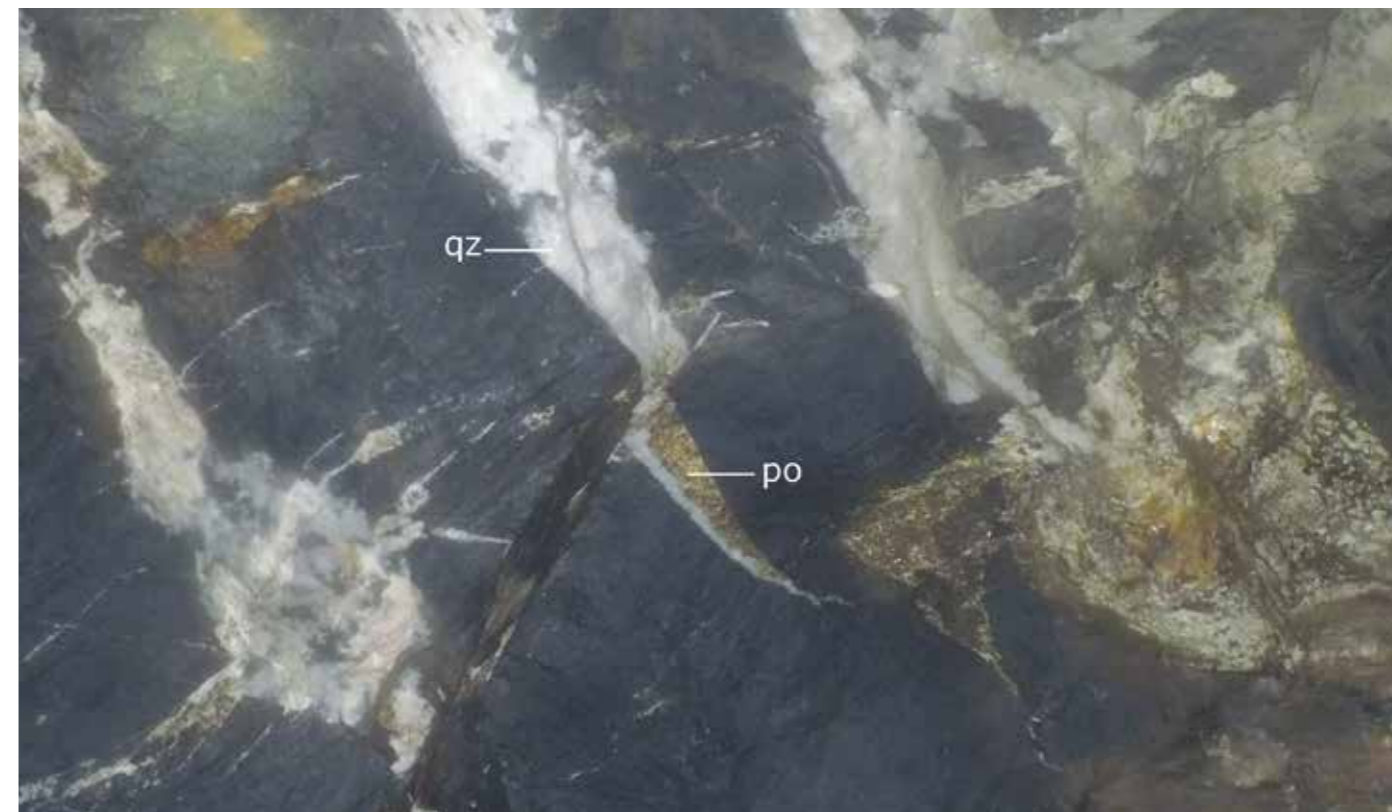


Fig. 1: Black shale hosting quartz veins (qz) and related mineralization mainly consisting of pyrrhotite (po), linked to tension gash structures.

The annual field trip of the SGA Nancy Student Chapter took place from the 16th to 21st February 2020. Six student members (5 MSc students and 1 PhD student) accompanied by the Assistant Professor Jean Cauzid (GeoRessources laboratory, University of Lorraine, France), visited various Precambrian, Paleozoic and Mesozoic base metals, PGE and phosphate deposits in central and south Morocco. The group had the chance to interact with two mining companies, the Managem group and the OCP (“Office Chérifien des Phosphates”) group and to be guided in the Anti-Atlas Mountain by Professor Amina Wafic (Cadi Ayyad University, Marrakesh, Morocco).

Visits started on Monday, February 17 2020 at the Draa Sfar mine operated by the Managem group. Mr. Bamoussa and Mr. Outouhounjit, chiefs of the exploration department, welcomed us with the traditional Moroccan tea and coffee and introduced us to the local geological framework and the current exploration project carried out at the Draa Sfar mine. The Draa Sfar de-

posit belongs to the southern part of the Jebilet massif. It is a volcanogenic massive sulfide (VMS) deposit hosted by a Hercynian volcano-sedimentary succession consisting mainly of black shale, siltstone and sandstone with subordinate volcanic and volcanoclastic rocks (Belkabar et al. 2008). The deposit contains 10 Mt @ 5.3 wt % Zn, 2 wt % Pb and 0.3 wt % Cu (Marcoux et al. 2008).

With a depth of >1 kilometer, Draa Sfar is the deepest mine in North Africa. Mineralization is dated at 331.7 ± 7.9 Ma (Ar-Ar in hydrothermal sericite) and is related to a sub-marine volcanism episode. A pyrrhotite-sphalerite-chalcocopyrite-galena assemblage forms most of the ore (Macha et al. 2015). The group visited the underground mine down to the -300 to -400 m levels, guided by Mr. Outouhounjit and observed the pyrrhotite-dominated, subparallel semi-massive sulfide ore spatially associated with quartz tension gashes crosscutting the black shale host rock (Figure 1). The visit of the mine was followed by a drill core logging

session. We had the opportunity to discuss about the host rock nature, hydrothermal alteration features and ore textures with the company exploration team.

The second day was dedicated to a field trip within the Anti-Atlas region. Professor Amina Wafic guided us through the mountains and shared with us the complex tectonic history of the Atlas Belt and details about the formation of the Bou Azzer inlier. The latter is a NW-SE anticline composed of serpentinite, gabbro, basalt, dykes and arc-type volcanic rocks. The Bou Azzer Cu-Co-Cr district and related Co-Ni-Fe-As (\pm Au \pm Ag) occurrences are located at the center of the inlier and are mostly hosted by a Precambrian ophiolitic sequence.

A world-class outcrop of the ophiolitic sequence was observed. It is a 100-m-long section that represents a cross-section through the mantle to the oceanic crust. The intrusion age of the gabbro is estimated at 697 ± 8 Ma (U-Pb in zircons; El Hadi et al., 2010). Cu occurrences were observed in the mafic rocks. We stood on the Moho

discontinuity and observed the mafic dykes that crosscut the gabbro (Figure 2) close to an old inactive Co-Ni artisanal mining operation with skutterudite, arsenopyrite and gersdorffite (Figure 3).

We headed to the Bleida Cu mine on Wednesday, February 19, 320 km SE of Marrakesh. Somifier, a daughter company of Managem, operates the mine. After the traditional safety induction, the exploration supervisor, Mr. Bajdi, presented the local geological framework, the ongoing exploration projects and the plans for pit extension. Besides, we have been told about the ore processing procedures. The mine is located in the upper part of the Bou Azzer ophiolitic sequence at the core of the inlier. The host rocks comprise metamorphosed and deformed mafic to intermediate volcanic rocks. The Cu mineralization is mainly associated with the deformed secondary quartz veins. The main ore mineral is chalcopyrite and the hydrothermal alteration is dominated by silicification and sericitization. Under the guidance of the mine geologists, we visited the open pit and discussed the regional geology and the ore-bearing structures (Figure 4). The road back to

Marrakesh took us through the High Atlas mountains and key geological outcrops were explained thoroughly by Prof. Wafik.

The last day started at the Mohammed VI Technical University in Ben Guerir, where we met Prof. Youssef Daafi. The university is in direct cooperation with the OCP group that holds the phosphate-rich prospects in the Gantour basin. Prof. Daafi welcomed us with a very informative presentation about the late Cretaceous-Early Eocene marine chemical sedimentary rocks that host the phosphate ores (Daafi et al. 2014). Phosphate extraction in the Benguerir mine has been active since 1980, with an annual production exceeding 6.3 Mt P₂O₅. We had the opportunity to observe phosphate samples from the different sedimentary horizons directly in the open pit. The field trip ended with a delicious traditional Moroccan dinner, when we discussed and summed up everything we learned about Moroccan metallogeny.

We would like to acknowledge and thank everybody who contributed to the smooth and successful outcome of this field trip. Special thanks are due to Prof. Jean Cauzid who accompanied us in Morocco and Prof.

Amina Wafic who guided us for two days in the Anti-Atlas Mountains. The SGA financial contribution to this field trip is more than appreciated. We are also very grateful to Mr. Lhou Maacha and Ms. Quechai Aicha from Managem group and OCP group who very kindly welcomed us in their facilities and shared their knowledge with us.

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Fig. 2: Gabbro crosscut by mafic dykes in the Bou Azzer district.

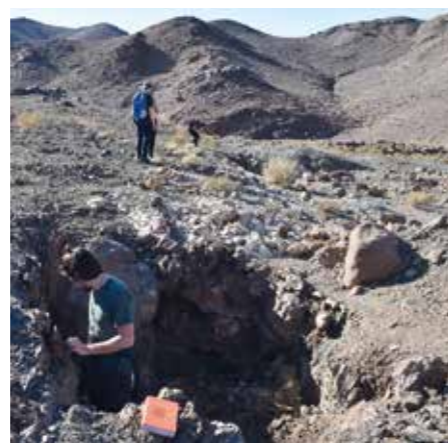


Fig. 3: Remnants of artisanal mining in Bou Azzer.



Fig. 4: The group with the exploration department of Somifier company and Prof. Wafik at the Bleida open pit.

Fieldtrip to the various deposits of the Czech site of Krušné hory Mts. (Erzgebirge)

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Fig. 1: Participants of the fieldtrip; Photo by Lukáš Vavřich.

The traditional autumn fieldtrip of the SGA Student Chapter Prague was this year dedicated to the various deposits (heritage stones, metal and non-metal mineral deposits) on the Czech side of the Krušné hory Mts. (Erzgebirge) during 24 – 27 October 2019. Fifteen members attended the course (Figure 1). The Krušné hory Mts. are situated in the NW of the Bohemian Massif and belong to the Saxothuringian zone of the Variscan orogen. Ore deposits are hosted in the Neoproterozoic and Lower Paleozoic volcano-sedimentary and intrusive sequences, which are metamorphosed to mainly phyllite, para- and orthogneiss and migmatite. This nappe complex is shaped into an anticlinorium, with its axis oriented in a NE-SW direction. The Variscan post-collisional igneous activity (327–290 Ma) is characterized by the emplacement of large granite plutons, silicic dykes and rhyolites. The silicic magmatic activity produced highly fractionated, Li–Sn–F-rich magmas and their associated hydrothermal systems. Additional hydrothermal and ore-forming stages are related to brittle deformation in the foreland of the Alpine Orogen. The Erzgebirge domain has been richly endowed in iron, base metals, tin-tungsten, molybdenum, silver-bismuth-cobalt-nickel-uranium, hematite-quartz and fluorite-barite deposits.

Day 1. Krupka polymetallic deposit

On the first day, we visited the famous historical Krupka mining district where Mo, Sn, W, Cu, etc. were extracted. Since medieval ages, heavy minerals from placers were extracted and afterwards quartz-rich hydrothermal veins were mined. Right after a geological and historical introduction, we started to explore nearby dumps.

The whole mining district (also called Knöttl) consists mainly of orthogneiss. The deposit is rich in quartz and aplite veins. The main ore body lies in the central part of the mining district in albite-zinnwaldite granite. The body consists of greisen with diverse assemblages, forming minerals such as molybdenite, zinnwaldite, malachite, azurite, apatite and cassiterite. Fortunately, we were able to find and examine the majority of the mentioned minerals. However, larger and unfortunately too-heavy-to-handle samples often show interesting relationship between minerals in hydrothermal veins, (e.g. zinnwaldite situated on the vein selvage and molybdenite in quartz matrix) or complex breccia structures (e.g. fluorite on feldspar cracks; numerous gneiss fragments in the vein).

Day 2. Mýtinka hematite and Horní Halže silica specimens

On the second day, we proceeded to the area close to the German-Czech border to explore hydrothermal iron ore and silica varieties. The Mýtinka dumps are known for world-class samples of botryoidal hematite and euhedral crystals developed in quartz-rich veins (Figure 2). On the stops nearby Horní Halže, we found specimens of a rare variety of agate, the so called 'lightning agate' and amethyst aggregates.

Day 3. Horní Blatná pyrolusite and Svornost mine in Jáchymov

In the morning, we visited the Horní Blatná region. We managed to explore numerous dumps scattered on the hill's slope, finding nicely developed pyrolusite aggregates and even rare, fully



Fig. 2: Mýtinka hematite ore; Photo by Jan Šulc.



Fig. 4: Exposed uraninite in the Svornost mine; Photo by Lukáš Vavřích.



Fig. 3: Shaft tower of the Svornost mine; Photo by Lukáš Vavřích.

developed crystals. Afterwards, we were friendly welcomed in Jáchymov (Figure 3) by the Svornost mine employees. The ancient mining town Jáchymov is situated 14 km north-east of Karlovy Vary (Carlsbad). In the first half of the 16th century, this deposit is considered the most famous silver ore deposit in the world. After silver ores were mined out, interest was focused on other metals and semi-metals in the veins, like cobalt and arsenic. Uraninite was mined after its discovery in 1789 (Figure 4). The elements radium and polonium were discovered in the Jáchymov uraninite by Marie Curie Skłodowska and Pierre Curie. Until the start of World War I, radium production with 1-2 grams of radium per year from the Jáchymov dominated the world's radium supply.

Typical Ag-Ni-Co-U-As ore is developed in dolomitic veins. Thanks to a friendly approach, we were able to visit the 10th and 12th level and see how deformation along two main fault directions

are associated with mineralization. Nicely exposed walls show a direct connection of structures with polymetallic mineralization, secondary mineralization and a unique, big native arsenic lens. Some of us took a bath in the mine's radon-rich 10 kBq water. Supplying the nearby spa is now the only reason why the Svornost mine is still operating. Thanks to this fact, Jáchymov has been an active mining town for half a millennium already.

Day 4. Karlovy Vary heritage stones and Loket orthoclase

The last day of our fieldtrip led us to the spa city of Karlovy Vary (Carlsbad), in which we visited the facility responsible for pumping the water used for medical treatment. High Ca-content in the water directly influences the work of the facility. Pipes are regularly blocked by newly formed aragonite and must be replaced every month. After the excursion, we had the opportunity to admire a great diversity of stone used in the city's architecture including the Mariánské Lázně serpentinite and the Krkonoše porphyritic granite. Afterwards, we visited a famous locality close to the Loket castle. At this site, large samples of orthoclase twins are found. An important fact to mention is that a feldspar twinning law is called after this specific locality - the Carlsbad twinning. Soil around the granite outcrops is rich in orthoclase, which is selectively eroded from local granite. We would like to thank the SGA for kind support and we appreciate help from our sponsors Vitana, a.s. and Severočeské doly a.s.

1st International Student Conference on Geochemistry and Mineral Deposits

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Fig. 1: Late stage of ice-breaker party. Photo by Václav Štěpánek.

At the end of 2019, the SGA Student Chapter Prague organized a student conference focused on geochemistry and mineral deposits. This conference was held at the Faculty of Science of Charles University in Prague the 7-9 November. The conference informally launched on Thursday evening during an ice-breaker party, traditionally held (as other events) at Chlupáč's Museum of Earth History. The first day was in the spirit of mineral deposits; the morning session started with a keynote lecture given by Dr. Karel Breiter, CSc called: Genetic model of the world-class Li deposit Cínovec. The afternoon session started with another keynote lecture given by the chairman (it was a short-notice substitution, because of illness of the original speaker) called: Uranium sandstone deposits of Madagascar. Student contributions focused mainly on ore deposits, mineralogy and trace elements. Because this was the first year of the conference and because of the lack of worthy mineral deposits in nearest vicinity of the Czech capital, we decided to organized a short excursion to the recently founded Radiogenic and Stable Isotope Research Laboratory (established in 2015), each participant has chance to join one of the two groups during a lunch break. After the last contribution of the day, the social part of conference continued with a guided tour starting at faculty doorstep, cruising to the city centre, pointing out classic sights as well as hidden gems, from

gothic to functionalism style. The most persistent students ended up in a cosy downtown pub and enjoyed the rest of the night.

The second day focused mainly on geochemistry, and the morning session started with a keynote lecture given by Dr. Jan Borovička, PhD, titled: Arsenic in geomycological studies. The last keynote speaker Dr. Tomáš Navrátil, PhD presented: Deciphering atmospheric releases of mercury from ore mining and processing operations. Shortly after a lunch break, the afternoon programme continued with a poster session. Each poster presenter had the chance to shortly introduced his poster during a "Two minutes of fame" oral block. After the last refreshment break, the conference reached its final moments and the best oral and poster presenters were awarded (winners are listed below), and the conference was successfully closed. The conference gathered 26 contributors from 12 countries and brought an interesting overview over eastern and southern European ore deposits as well as some interesting works from the African continent. For further information, you can visit the conference website (www.gmd-conf.com) where you can download abstracts. For those who are interested, you are welcome to join the next conference which will be held at Prague in the fall of 2021.



Fig. 2: Excursion at Radiogenic and Stable Isotope Research Laboratory. Photo by Václav Štěpánek.



Fig. 3: Future winner of best oral presentation in geochemistry in action. Photo by Václav Štěpánek.



Fig. 4: Last moments of conference and spectators are still concentrated. Photo by Václav Štěpánek.

The organizing committee would like to sincerely thank the Faculty of Science of the Charles University in Prague for providing lecture rooms, but also the Czech Geological Survey, VWR International s.r.o., Hanna Instruments Czech s.r.o. and Přírodovědci.cz for financial and material support.

Best oral presentation in mineral deposits section: Miloš Velojič - Trace elements in different veins by LA-ICP-MS in Chukaru Peki high sulphidation deposit, Serbia.

Best oral presentation in geochemistry section: Ndiye Kebonye - Zirconium suitability for normalization procedure in estimating soil contamination in treated wastewater discharge vicinity.

Best poster: Iva Jurkovič - Geochemistry of the Vršnik Cu mineralization, the Buchim deposit, Republic of North Macedonia.

SGA Student Chapter Prague traditional fieldtrip "Heritage stones of the Czech Republic" vol. V

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In November 2019, the SGA Student Chapter Prague organized its fifth excursion focused on heritage stones of the Bohemian Massif. Throughout our two-day field trip, 13 participants (two from Portugal) visited several geologically important localities in central, western and southern parts of the Czech Republic.

Tetín

Our excursion started in a historical town called Tetín, which is not so far from Prague. This city has a unique history and culture heritage. The oldest archeological findings are ca. 200 000 years old. Tetín belongs to the Barrandien unit and is formed out of biotrititic lower-Devonian limestone. Nearby, you can find Silurian limestone and schist with enclosed granular tuff, locally called "frogstones". This specific rock is green with white calcite veins and is mainly composed of volcanic glass, plagioclase needles, olivine, chlorite and, as mentioned above, calcite. Because of its optics and physical properties, it has been locally used for building and decoration.

Otmíč hill

The second field trip locality was the Otmíč hill. This protected area belongs to the Hořovice mountains and is protected by law not just because of geological reasons but also in terms of biology. You can find rare species of plants and animals typical for warm rocky ecosystems. The mountain itself is composed of the already mentioned granular tuff (Ordovician). There is an old open pit in the southern part of the hill, which provided stone predominantly for local villages.

Nehodiv open pit

In Nehodiv, the company Lipnice s.r.o. is mining marble, which belongs to the Moldanubian part of the Bohemian Massif. The rock is very popular for its physical properties and beautiful texture, and has



Fig. 1. Field trip participants in Plešovice granulite quarry.

been used in Bohemian lands since gothic ages. The marble body is surrounded by migmatitized gneiss. The marble is white, gray or layered due to graphite/phlogopite impurities. Nowadays, it is used mainly in interiors and for road construction.

Mářský hill

This hill is composed of stromatic, biotitic migmatite and amphibole-biotitic orthogneiss. In the uppermost part, it is crosscut by a syenite porphyry rock. Such veins are quite common in this area. The rock itself is pale, bluish-grey with typical zoning of feldspar and biotite grains.

Plešovice

In southern Bohemia, granulite is one of the most important rocks. Currently, the Plešovice mine is operating in the biggest granulite body in the whole region (Figure 1). The rock is mostly granitic-granodioritic, locally retrogressed to granulitic gneiss. Sometimes, granulite encloses serpentized peridotite, eclogite and pyroxene skarn. The granulite is usually white gray, locally bluish and is composed of quartz, feldspar, tourmaline, biotite, garnet or kyanite. An important accessory mineral is

zircon, which was not further transformed and was chosen as a world reference material for U/Pb dating (Janoušek et al., 2012). The granulite is a tough rock and not easy to work with. That is why it is predominantly used in road construction.

Acknowledgement

Kind financial support from both, the SGA and the Czech National Geological Committee (ČNK-IGCP, 637 – Heritage Stone Designation) is gratefully acknowledged.

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SGA Ural Student Chapter mineralogical and geological trip to the Southern Urals

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Fig. 1: Granite of Allaki and Lake Allaki. Photo by D. Khanin.



Fig. 2: Mine No. 418 with sapphire grains in micaites, Ilmen State Reserve. Photo by D. Kiseleva.



Fig. 3: Mine No. 242 with aquamarine, beryl, topaz and graphic granite, Ilmen State Reserve. Photo by D. Khanin.



Fig. 4: The view over the Taganay Range, Black Mountain ("Chernaya Skala") observation point. Photo by D. Kiseleva.

The first field trip of the SGA Ural Student Chapter was held the 30th of May – 1st of June, 2019 after the 10th Anniversary Geoscience Conference for Young Scientists "Minerals: Structure, Properties, Methods of Investigation", which was hosted by the Institute of Geology and Geochemistry, Ural Branch of Russian Academy of Sciences in Ekaterinburg, Russia. The field trip was attended by 20 students and young scientists. It included a visit to a large number of genesis-specific deposits, the Ilmenogorsky-Vishnevogorsky alkaline complex (IVC) and the Kusa-Kopan stratified intrusion of the Bashkir mega-anticlinorium, Southern Urals.

First, the field trip participants visited the Natural Science Museum of the Ilmen State Reserve (Miass), one of the few geological and mineralogical reserves in the world. The first collections of



minerals and rock specimens were started in 1925, soon after the Reserve's foundation. The Museum currently holds 30,000 items, with about 9000 of them on display. Besides mineralogical collections, the Museum possesses one of Russia's largest biological dioramas (full circle composite model scenery around a large display hall).

The beginning of the trip was marked by a visit to an archaeological site – an ancient sanctuary, inhabited since Paleolithic times, located near Lake Allaki (N 55° 57.548'; E 60° 55.222') among the granite outcrops, where fragments of parietal art were preserved as well as a number of stone and bronze and copper artifacts was found (Figure 1).

The geological part of the field trip began with a visit to the "5th versta" corundum deposit in the area of Kasli town (N 55°53'53", E 60°41'26"). Corundum in anorthosites is rarely found worldwide and is rarely of gem-quality. Blue sapphires in kyshtymites (corundum anorthosites) of the "5th versta" deposit are located at the western flank of the Vishnevogorsky nepheline syenite (miaskite)-carbonatite alkaline complex of the Southern Urals with unique REE-mineralisation (Nedosekova et al., 2009). The kyshtymites are the unique corundum-blue sapphire-bearing variety of anorthosites of debatable geological origin



Fig. 5: Zelentsovskaya mine (photo by D. Khanin); a bird's-eye view (photo by Pavel Raspopov from <https://uraloved.ru/>).

found in the Ilmenogorsky-Vishnevogorsky complex (IVC). Their mineral association includes corundum-sapphire, plagioclase (An₆₁₋₉₃), muscovite, clinocllore and clinozoisite. Zircon, churchite-(Y), monazite-(Ce) and apatite group minerals are found as accessory phases and moreover, churchite-(Y) and zircon are also identified as syngenetic solid inclusions within the sapphires (Filina et al., 2019). The "5th ver-

sta" deposit was discovered by A.P. Karpinsky in 1883. Three kyshtymite veins were discovered during exploration. Corundum was used mainly as an abrasive material, however, some of the grains were of gem-quality, not exceeding 1 carat (Filina et al., 2019). The exploration of the deposit was prosecuted until the 1930s and, currently, the occurrence is almost exhausted.



Fig. 6: Shpat mine, Kurochkin Log site. Entrance adit to the lower quarry. Photo by D. Kiseleva.

Besides the “5th versta” deposit, there are some more blue sapphire mineralisation points within the IVC, e.g. in the metasomites of meta-ultramafic host rocks on the territory of the Ilmen State Reserve (Miass), where sapphire can be found in the micaites of Mine No. 418 (N 55°10'42.4", E 60°17'33.0") (Sorokina et al., 2019, Figure 2).

The granitoid pegmatite veins cut the Ilmenogorsky alkaline massif in Mine No. 242 on the territory of the Ilmen State Reserve. They contain aquamarine and topaz. The participants were rewarded for complicated access to a site with graphic (Hebraic) granite samples from the graphic part of the vein, and small crystals of blue beryls (Figure 3).

The ancient complexes of the Bashkir mega-anticlinorium can be seen from the Black Mountain (“Chernaya Skala”) observation point (N 55°16.712'; E 59°42.444') of the world-famous Taganay National Park (Figure 4), where quartzites creep into amphibolites in the Precambrian strata along the “living” fault. The Taganay National Park with the total area of about 568 square kilometres was established in 1991, with its south-western border reaching down to the outskirts of Zlatoust and being a part of Zlatoust mining district.

Acquaintance with the early history of the Urals continued at the Urals' largest Kusa-Kopan stratified intrusion, revealing one of the riftogenic fragments of the territorial development (Fershtater et al., 2001). The formation of the Middle Riphean (~ 1380 Ma) gabbro-granite intrusions in the Bashkir mega-anticlinorium is confined to a series of deep riftogenic faults. In the largest and eastern of them (Zyuratkul fault), the layered massifs of gabbroids are situated (from the south to the north – Matkalsky, Kopansky, Medvedevsky and Kusinsky), which formed at different depth. In the north, the formation of the Kusinsky massif occurred under the conditions of the abyssal facies at pressures of 6-8 kbar and more. The discrete massifs of gabbroids are assumed merged at depth into a huge ultramafic-mafic layered massif with the colossal reserves of titanomagnetite and chromite ores (Alekseev et al., 1992).

Skarn mineral associations of the Southern Ural mines, recognised for an amazing variety of minerals, were a constant object of attention for mineralogists since old times (the very first Akhmatovskaya mine was laid in 1811). All the mines are located in the skarnised carbonate xenoliths along the western contact of massifs of the Kusinsko-Kopansky complex with Lower Riphean strata.

The famous Zelentsovskaya mine (N 55°20'16", E 59°42'27") is located on the territory of the Kusa deposit (Figure 5). It was first mentioned due to the discovery of large (up to 1 m) epidote and was discovered in 1929 during exploration for titanomagnetite. The geological section of the Kusa titanomagnetite-ilmenite mine is represented by feldspar amphibolites, in which two steeply dipping veins of titanomagnetite are explored. During geological exploration, the following minerals were described: tremolite, diopside (columnar grains of green colour), garnets (pink-red and honey-yellow), epidote (pistachio-green prismatic grains with developed head), magnetite (often in large octahedra), spinel, chlorite, perovskite, vesuvian, titanite, hornblende, apatite (sometimes short-columnar grains), calcite (white and blue) and tourmaline (blue crystals). In 1998, V.M. Gekimyants found a new mineral in the skarns of the Zelentsovskaya mine, hydroxylclinohumite. Clinochlore, epidote and garnet samples were collected from the Zelentsovskaya mine by the participants of the field trip.

The field trip ended with a visit to the alkaline pegmatites of the “Shpat” mine (Figure 6) at the Kurochkin Log site located in the middle of the Vishnevye Mountains range (N 55°57.345'; E 60°37.397') and the quarries with carbonatite veins of the Vish-

nevogorsky deposit, where rare-metal mineralisation is found. The “Shpat” mine consists of two quarries with vertical walls located one above the other with walls composed of coarse nepheline-cancrinite-feldspar, which are currently flooded. The lower quarry is particularly unusual due to a passage of 15-20 metres long represented by a horizontal adit driven through the rock. Mining for ceramic raw materials began here in 1929-1932 and lasted until 1944. Two large sublatitudinal pegmatite lenses at a distance of ~ 45 m from one another are localised in miaskites, across the strike of submeridional banding. The large veins of aegirine-augite (up to 10-50 cm) and cancrinite monoblocks (up to 20-80 cm) co-crystallised together with nepheline and potassium feldspar are characteristic of these veins. Pyroxene crystals are (100)-twins and often have syntactic growths of biotite in the marginal zones previously explained by pyroxene biotitisation. Large nepheline blocks are heterogeneous in colour – gray, greenish-gray, violet-red, yellowish-red due to the simultaneous exsolution phenomena with the release of microplatelets of hematite, magnetite, biotite and aegirine. The host leucocratic biotite miaskites contain a lot of calcite and cancrinite, sometimes analcime. Accessory minerals are magnetite, ilmenite, titanite, zircon and rarely pyrochlore. Calcite, biotite-calcite and biotite veins with titanite, fluorapatite, zircon are developed subconcordantly with banding in miaskites. Calcite-biotite submeridional secant veins are also observed in pegmatites, which contain small (up to 1 cm) unusually rich in faceting crystals of ilmenite. Pyrochlores and zircons were collected in the quarries with carbonatite veins of the Vishnevogorsky deposits with rare-metal mineralisation.

We thank Dr. Andrey Nikandrov for a guided tour across the Natural Science Museum of the Ilmen State Reserve and Mikhail Rassomakhin and Dr. Evgeny Makagonov for providing access and a guided tour to the mines of Ilmen State Reserve.

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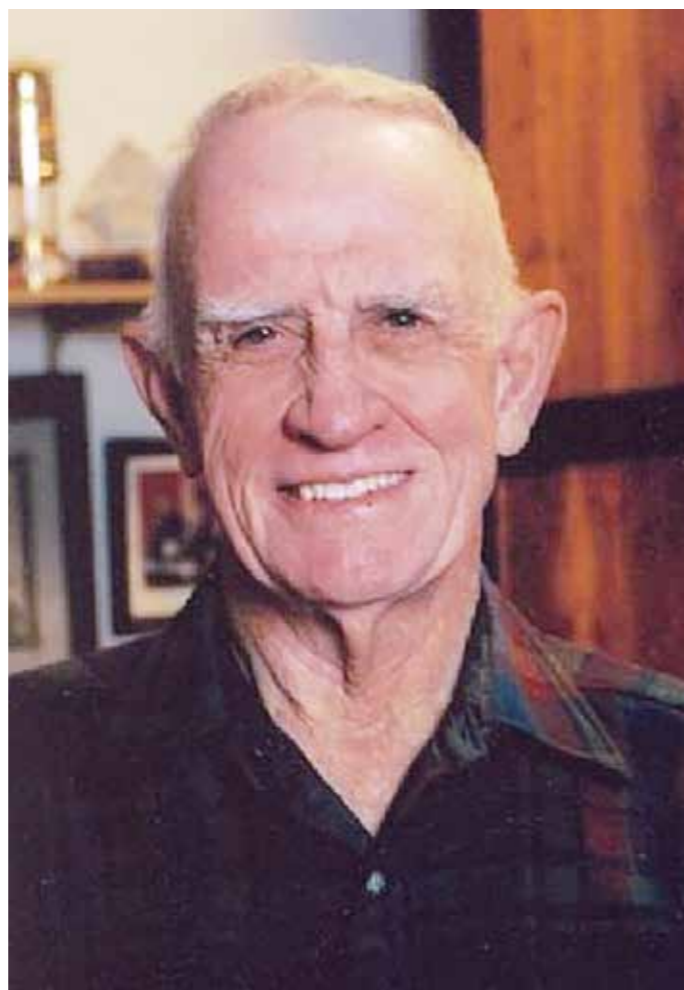
PEOPLE

James David Lowell, legendary explorationist (1928-2020)

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David Lowell, one of the greatest mineral explorers of the 20th century, died in Tucson, Arizona, in May 2020 at the age of 92. Lowell personally discovered more copper than probably any man in history and he always did it his way, innovatively, largely on his own, adventurous, and fighting both the elements and bureaucracy. In short, the opposite of what most managers in the mining industry would accept today.

Lowell became fascinated with mines at the age of 7 accompanying his father who run a number of small mines in southern Arizona and abroad. He studied mining engineering at the University of Arizona where he got a BSc in 1949 and a Professional engineer degree in 1959, with a break at Stanford University for a MSc in geology in 1957. He became an independent consultant in 1961 and in 1965 discovered his first copper ore deposits for Newmont, Kalamazoo and Vekol Hills in Arizona, where no copper mineralization was visible at surface. Field observation, particularly mapping and drillcore logging from this work led to the definition of the now classic Lowell-Guilbert porphyry copper model which was published in 1970 (Lateral and vertical alteration-mineralization zoning in porphyry ore deposits, *Economic Geology* 65: 373-408), a standard reference paper for exploration geologists worldwide. Lowell then contributed to copper porphyry discoveries in many countries. However, his main exploration ground became Chile and Peru. He discovered La Escondida and the Zaldivar/Escondida Norte satellite deposits in 1981, where five prior exploration companies had failed to recognize the extreme supergene leaching (and concomitant high-grade enrichment below); and none had drilled a hole before Lowell came along! He also discovered the Leonore mine which developed into the El Tesoro exotic copper district, and San Cristóbal, a gold deposit near Lomas Bayas. He then identified the northern Peru gold belt in a region that had generally been thought to be non-prospective. This work led him to the discovery of Pierina in 1996, which Barrick Gold bought for over 1 billion USD the same year. Lowell then turned to the under-explored Toromocho copper deposit; Morococha district, at 4,700 meters altitude in central Peru, and reinterpreted the geology. The corresponding drill programme increased the resource manifold. The project was sold in 2007 for over 800 million USD and is currently developing as a Chinese 2 billion USD project.



David Lowell was a passionate field person and personality with the combined knowledge and fervor of an economic geologist and mining engineer. This made him to one of the mining industry's most successful entrepreneurs. He received many honors, such as several honorary doctorates, the SEG Penrose gold medal, and the election to the US National Academy of Engineering. He also was a generous philanthropist, and supported the University of Arizona with multi-million dollar gifts, including the establishment of the Lowell Institute for Mineral Resources.

Anthony J. (Tony) Naldrett (1933-2020)

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Few geoscientists have left as great an impact on their field of study as Anthony J. (Tony) Naldrett, who died on June 21 this year, two days short of his 87th birthday. Tony was, indisputably, the father of magmatic sulfide research and one of the giants of modern economic geology.

Tony was born in London in June 1933 and grew up in rural southern England. He was a keen rower at school and subsequently at Trinity Hall, Cambridge, where he studied as an undergraduate. He qualified as a pilot in the RAF during his then-compulsory National Service, being fortunate that the Korean War ended before he could be sent to combat. His choice of Crystallography and Geology at Cambridge was driven by the need to schedule around his rowing, but he soon caught the geology bug to the extent that on graduating in 1957, he and three of his fellow students decided to emigrate to Canada to look for work in the field. Emigration was by ship in those days, and Tony might well have been lost to the geosciences, when he and his friends almost got on the wrong ship after a carousing layover in Montreal on the way up the St. Lawrence to Toronto. They would have ended up in the Caribbean and magmatic sulfide research might have taken a different path. But he made it to Toronto, in the middle of the field season so job opportunities were scarce. Pitching up at the Falconbridge office, has found himself in a job as a mine geologist at Sudbury, and his path was set.

After two years in the mine, he decided that he needed to further his Economic Geology education, so moved to Kingston, Ontario and started an MSc thesis on cobalt in the Sudbury Ores at Queen's University, supervised by J.E. Hawley, who was one of the first to demonstrate that the Sudbury ores were formed by immiscible sulfide magma. Continuing on to a PhD, also at Queen's, Tony worked on the now-iconic Alexo locality near Timmins, Ontario, on some strange ultramafic rocks with odd textures that had been dubbed "chicken-track". Tony was among the first to realise that these textures were skeletal olivine crystals, and he was looking at ultramafic magmas. His paper, Naldrett and Mason (1968), was published in the *Canadian Journal of Earth Sciences*, one year before the seminal work of the Viljoen twins on the Barberton Mountainland gave us the term "komatiite" for these remarkable rocks. Subsequent work by Tony on the Abitibi komatiites led to seminal papers by Pyke et al. (1973) and Arndt et al. (1977), who did his PhD with Tony in the mid 1970s.

Completing his PhD in 1964, Tony went on to a bastion of experimental petrology, the Geophysical Laboratory of the Carnegie Institute of Washington to work with Gunnar Kullerud. This period produced two of the foundation studies on magmatic sulfide petrology and mineralogy, one on the origin of the standard pyrrhotite-pentlandite-chalcopyrite assemblage in the Sudbury ores (Naldrett et al., 1967) and the other on the Fe-S-O system (Naldrett, 1969), papers that are still cited to this day.

Tony's long career at the University of Toronto began in 1967, when he joined a department that was fast building a reputation as the leading economic geology research centre in the world. Tony, Frank Beales and Greg Anderson were soon joined by Steve Scott, Steve Kessler and Ed Spooner and between them, they recruited



Picture taken by Peter Lightfoot at Norilsk in 1988.

an outstanding stable of graduate students and postdocs and built strong links with industry. At the time I arrived in Toronto in 1977, several dozen graduate students were working on a wide spectrum of different deposit types and many of them went on to highly distinguished careers in industry, academia and in some cases both. The research atmosphere at the time was incredibly stimulating. Tony's students and associates met regularly in one another's homes for meetings of the "Friends of Forsterite", a not-so-secret society that argued the finer points of magmatic ore deposits, komatiites and layered intrusions over many a beer late into the night. Out of these meetings, much of the enduring foundation of magmatic ore deposit study was built. Alumni of "FOF" include many names familiar in the economic geology and igneous petrology literature including Nick Arndt, Tony Green, Ian Campbell, Peter Lightfoot, Reid Keays, Sarah-Jane Barnes (no relation to me, although remarkably we were almost exact contemporaries at Toronto), John Thompson, Barbara Murck, Richard Ernst, Mike Leshar and Chusi Li.

The highlights of Tony's research career are too many to document in full, but two stand out. The one that Tony was most proud of was his body of work on the supergiant Norilsk-Talnakh camp. An SGA meeting in Tblisi, Georgia in 1982 led to collaborations with Nicolai Gorbachev and Valeriy Fedorenko, at the time the Norilsk ores were a closed book to western science. Samples were unobtainable and access was strictly limited. However, helped by the collapse of the Soviet empire in 1989, Tony's charm and affability paid off in his relationships with well-connected Russian scientists, and a fruitful ten years of research followed. The story involved the Sudbury-Norilsk symposium held in Sudbury in 1993, organised by Tony and Peter Lightfoot, which involved eight Russian scientists having their expenses paid to attend on the stipulation that each of them had to bring 20 kgs of Norilsk rocks in their baggage. Anybody who has ever attempted to take shiny rock samples out of Russia quails at the thought of what this involved, but it worked, and led to another series of seminal papers, and the highly influential "conduit model" for ore formation in small mafic-ultramafic intrusions. This work drew heavily on a significant breakthrough in geochemical analysis for the platinum-group elements, much of

it driven initially by PhD student Eric Hoffman in Tony's lab and subsequently applied widely to rocks and ores.

The second long-running initiative stemmed from Tony's recognition, ground-breaking at the time, that conventional magmatic Ni-Cu sulfide ores and stratiform "Reef-style" PGE deposits in layered intrusions, such as the Merensky Reef, were part of a continuum and could be reconciled by a spectrum of similar processes. This line of work began with a sabbatical visit with Prof. Gerhard von Gruenewaldt at the Bushveld Research Institute in Pretoria and continued almost until Tony's death with a long series of visits, collaborations and landmark papers on the Bushveld Complex and its ore deposits.

Along the way, Tony and his students worked at one time or other on almost all of the world's major sulfide Ni-Cu and PGE deposits, notably including Voisey's Bay, the komatiite-hosted deposits of Western Australia, the Duluth Complex deposits of the Mid-Continent Rift, Jinchuan in China, Raglan, Thompson and of course his beloved Sudbury. Much of this accumulated data and wisdom found its way into his "life's work" book (Naldrett, 2004), published by Springer, which was actually originally commissioned as a Russian-language volume translated by Valeriy Fedorenko and published in St. Petersburg. This fat volume (the English language version, that is) sits permanently on my desk, and no doubt on many others. Tony "retired" in 1998, but continued a prolific research career for another twenty years, particularly in association with Judith Kinnaird and co-workers at Wits University, only slowing down in the last few years of his life. His last major landmark contribution was a series of papers on the PGE-rich chromitites of the Bushveld Complex (Naldrett et al., 2011).

This brief account of Tony's research career leaves out a great deal about the man. He was the essence of the English gentleman scientist, full of charm, curiosity and love of life. Many a conference was enlivened by his always polite, always probing and insightful questions. None of his students forgot the time, they spent in the field with him, both on the rocks and off. His undergraduate field trips were legendary, leading many students to discover the delights not only of geology but also the camaraderie of fieldwork. He was a tireless advocate for the welfare of his students, with an unerring eye for the heart of a scientific problem and an excellent judge of the art of supervision, when and when not to micromanage. One of the skills that we all learned was to focus on the important questions and not to be side-tracked by unimportant details. He was an outstanding and dedicated teacher, continuing to teach undergraduate classes at the University of Toronto for years after his retirement. The gradu-

ate courses in ore deposit geology and geochemistry that he, Steve Scott and Ed Spooner taught were revelatory; I doubt there has been a day in my professional career that I haven't drawn on something, I learned in one of those classes. He was a generous contributor to his profession, serving as President of the Society of Economic Geologists, the Geological Society of America and the International Mineralogical Association among others. His many medals and awards include the Duncan Derry Medal of the Geological Association of Canada, the Penrose Gold Medal of the SEG and the Haddon Forrester King Medal of the Australian Academy of Sciences. He was made University Professor at the University of Toronto in 1984 (fewer than ~2% of University of Toronto Profs. are granted this honour). A full list can be found at https://en.wikipedia.org/wiki/Anthony_J._Naldrett.

Tony left an indelible legacy for his science and on all who were lucky enough to work or study with him. Many of us in the economic geology profession owe our careers to him. Tony is survived by his three daughters, Anne, Jennifer and Penelope, his two granddaughters and many grateful students, friends and colleagues who will never forget him.

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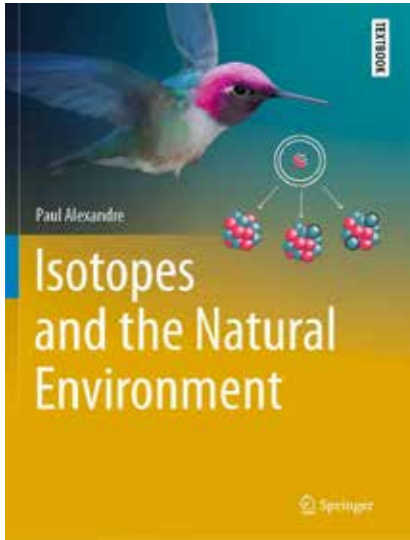
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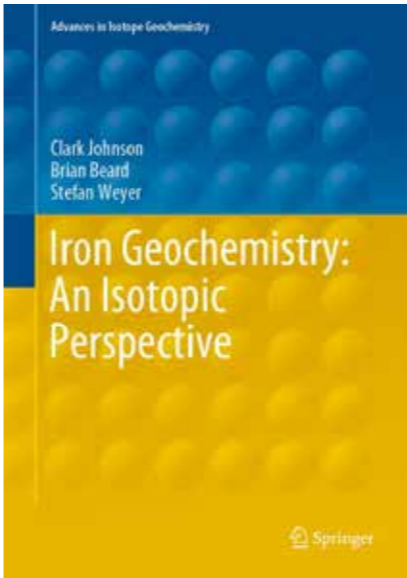
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APPLICATION FORM FOR NEW MEMBERS

I would like to become a member of the **Society for Geology Applied to Mineral Deposits** and to receive my personal access to **Mineralium Deposita**. Membership fees will be due after acceptance of the membership application.

- Note that incomplete forms and those that are not legible will NOT be processed! -

<u>Last name*</u>	
<u>First name*</u>	
Title	
<u>Postal address*</u>	
Phone	
<u>e-mail*</u>	
Academic degrees	

* mandatory fields

Select your Membership Dues*

- ☐ 75.00 EUR Regular Member (Printed copy + online access **Mineralium Deposita** and **SGA News**)
- ☐ 60.00 EUR Regular Member (Online access only **Mineralium Deposita** and **SGA News**)
- ☐ 10.00 EUR Student Member (Online access only **Mineralium Deposita** and **SGA News**, certificate required)
- ☐ 60.00 EUR Student Member (Printed copy + online access **Mineralium Deposita** and **SGA News**, certificate required)
- ☐ 60.00 EUR Senior Member (Printed copy + online access **Mineralium Deposita** and **SGA News**, after retirement, certificate required)
- ☐ 300.00 EUR Corporate Member (includes 3 printed copies of **Mineralium Deposita**) (for industry only, no academic)

Applications **until September 30th** will be processed for the current year. **From October 1st** membership starts with the following year.

Donation for the SGA Educational Fund

- ☐ I want to donate _____ EUR to the SGA Educational Fund and
- ☐ agree that my (or company) name as donor will be published in SGA media/conferences
- ☐ wish to remain anonymous

* ☐ I agree to the SGA data privacy policy as published at <https://e-sga.org/contact-us/data-privacy-policy>

If my application is approved, I authorize the "Society for Geology Applied to Mineral Deposits" to charge the above amount (please tick) to the given credit card:

- ☐ VISA ☐ MASTERCARD/EUROCARD

Card Holder* _____ Expiry date (MM/YY)* _____

Card No* _____ 3-digit security code* _____

Signature* _____ Place and date: _____

(If you do not intend to pay by credit card, please make a note here and an invoice will be issued after acceptance of your application)

Sponsor (SGA member):

Name

Place

Date

Signature

Send the membership application form to:

Dr. Jan Pašava, SGA Executive Secretary, Czech Geological Survey, Klárov 131/3, CZ-118 21 Praha 1, CZECH REPUBLIC
Phone: ++(420)-2-51085506, Fax: ++(420)-2-51818748, e-mail: secretary@e-sga.org

Please note that bank charges will not be covered by SGA.

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